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Geological description of Nittsjö and its environs in Dalarne.

By

Elsa Warburg.

(With Pl. 15.)

General description of the Silurian of Dalarne.

The Palæozoic district of Dalarne consists, on the whole, of an angular-shaped depression-area N. of and by the lake Siljan, which lake forms the S. and the SW. part of this depression. The W. part is formed by the Orsa lake and the surrounding Palæocoic beds. In the NE. there is the Ore lake and the lake Skattungen, and between the Skattungen and the Orsa lake the depression is indicated by the valley of the Ore river.

This angular-shaped depression seems to have been formed by a series of faults, parallel to the border of the so enclosed Archæan massive, the s. c. central-cupola, which for the most part consists of granite. The faults have generally taken place inside the Palæozoic area, not between the granite and the younger rocks, as is indicated by the fact that the granite generally is overlaid by the Obolus conglomerate and the other layers in their original order (see the sections Fig. 2 and 3). Also the occurrence of Archæan horsts in the middle of the Palæozoic area (f. i. at Nittsjö and at Boda) goes to prove the same. Some exceptions from this rule

are, however, met with f. i. within the excursion district at the railway-cutting at Sjurberg (see p. 441 and the fault at the right side of fig. 3).

Because of these numerous faults the dip of the beds is often very steep, and sometimes they are found inverted. For this reason and also because of the fact that the ground generally is covered, it has been very difficult to interpret the

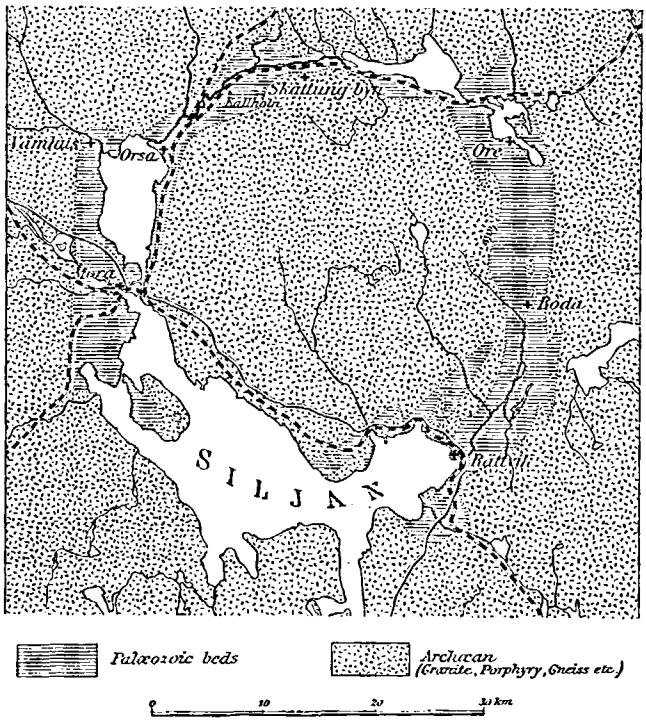


Fig. 1. Map showing the Palæozoic district of Dalarne.

geology of this district and the mutual ages of the different beds. This last question can, however, be considered as settled after much disputing especially as to the age of the Orsa sandstone and the Leptæna limestone.

With regard to the number and directions of the faults it seems very probable that many new and partly unexpected facts will be proved by coming researches. Already now, one

might say that the faults are considerably more irregular and have more varying directions than what is indicated on the older maps. MURCHISON[1] is very right in calling this »a con-

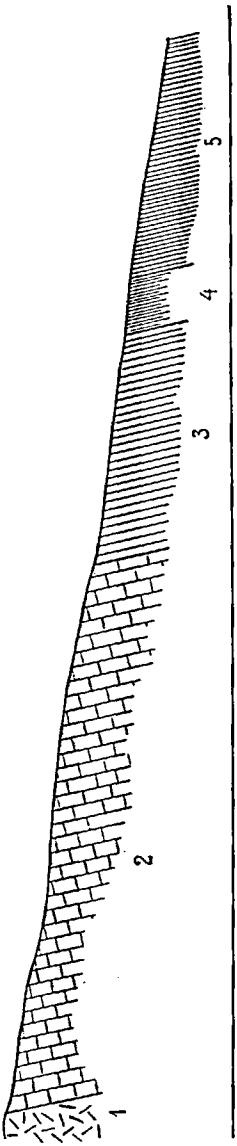


Fig. 2. *Section at Nittsjö.* (Scale 1:1 000).
1. Granite. — 2. Ceratopyge, Orthoceras and Chasmops limestones. — 3. Trinucleus shales. — 4. Brachiopod shales. — 5. Upper Graptolite shales.

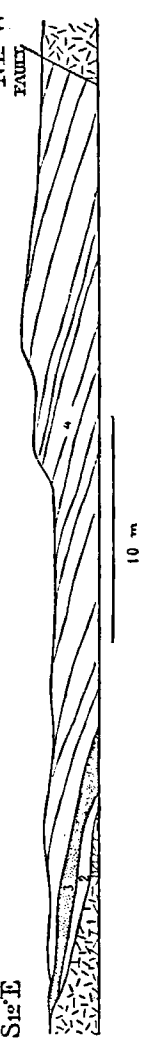


Fig. 3. *Section in the railway-cutting at Sjurberg.* The west wall. (According to H. HEDSTRÖM).
1. Fresh granite. — 2. Weathered granite. — 3. Obolus conglomerate and Glauconite sand. — 4. Ceratopyge, Planilimbata and Limbata limestones.

[1] Quart. Journ. Vol. III. 1847.

fused and broken district». Possibly it will also be proved, that sunken Silurian areas occur inside the great central granite-massive. This district is not connected with the Silurian in the NW of Dalarne, this latter belonging to the Norrlandian Silurian area, which in the N. follows the great overthrust area and has its greatest development in Jämtland, and of which only the S. end reaches Dalarne.

There exists no Silurian district within the mainland of Sweden, which has such an East Baltic character as that of Siljan. Especially the occurrence of the Leptæna limestone is remarkable. Also the Trinucleus horizon is partly developed with a Baltic facies, the gray limestone and, more especially, the Masur limestone, which is very like the Masur limestone of the Northbalticum. The Siljan area shows the greatest likeness with that last area and with the Westbalticum (Öland and surroundings).

The divisions and subdivisions of the Silurian occurring within the Siljan area, are shown in the adjoined table.

The Cambrian is quite wanting, and the oldest Palæozoic bed belongs to the Ceratopyge region. In fact, this Obolus conglomerate has only more seldom the character of a true conglomerate. Often it is consisting of the weathered ingredients of the substratum.

The conglomerate seems to be of the same age as the Obolus sandstone in Östergötland and the lowest zone of a the Dictyograptus shales. Whether the Glauconite sand corresponds to the Glauconite shales of South Sweden is difficult to decide, but in favour of such an opinion speaks its place, as well as its richness in glauconite. But if so, the *Obolus Apollinis* Eichw. which is found in the Glauconite sand must reach higher up than does the corresponding subzone of the Dictyograptus shales, or otherwise the brachiopods (and not only the fragment of Archæan rocks) would only occur secondary in the bed in question.[1] The Ceratopyge

[1] Wiman, Om Ceratopygeregionen inom Siljansområdet. G. F. F. Bd 28.

Devonian or Gotlandian.	*Orsa sandstone.*	*Orsa sandstone.*	
Gotlandian.	*Upper Graptolite shales.*	*Retiolites shales.*	
		Rastrites shales.	
Ordovician.	*Leptæna limestone.*	*Leptæna lmst*, partly substituted by *Brachiopod shales* or »*Klingkalk*».	
	Trinucleus shales.	*Red Trinucleus shales.*	
		Gray limestone	
		Black Trinucleus shales.	
		Masur limestone.	
	Chasmops limestone.	*Macrurus limestone.*	
		Cystidean limestone.	
	Orthoceras limestone.	*Ancistroceras lmst.*	Upper gray Orthoceras lmst.
		Chiron lmst.	
		Platyurus lmst.	Upper red Orthoceras lmst.
		Gigas lmst.	
		Asaphus lmst.	Lower gray Orthoceras lmst.
		Limbata lmst.	Lower red Orthoceras lmst.
		Planilimbata lmst or *Phyllograpt. shales*	Green Orthoceras lmst.
	Ceratopyge limestone.	*Ceratopyge limestone.*	
		Glauconite sand (Obolus »gruskalk»)	
		Obolus conglomerate.	

limestone is with certainty found only in the railway-cutting at Sjurberg, where also the two former beds are well exposed (see p. 442, where the three beds are described).

At Skattungbyn TÖRNQUIST[1] has seen Phyllograptus sha-

[1] Öfversigt öfver bergbyggnaden inom Siljansområdet i Dalarne. S. G. U., Ser. C. N:o 57.

les in a cutting, that later on has become overgrown. The substratum for the Silurian is here porphyry. Upon this there is a layer of green limestone, one foot thick, with embedded angular pieces of porphyry. Then follow green Phyllograptus shales with slabs of limestone. WIMAN interprets the limestone beneath the shales as Ceratopyge limestone. In the shales are found graptolites such as: *Tetragraptus serra* BRONGN., *T. quadribrachiatus* HALL., *T. curvatus*, TQT. *Phyllograptus densus* TQT. *Dichograptus octobrachiatus* HALL., *Didymograptus minutus* TQT., *D. gracilis* TQT., *D. decens* TQT., and further some brachiopods. In the limestone slabs HOLM has found some trilobites: *Pliomera Törnquisti* HOLM, *Megalaspis dalecarlica* HOLM, *Niobe læviceps* DALM., *Ampyx pater* HOLM, *Agnostus Törnquisti* HOLM, *Trilobites brevifrons* HOLM. [1]

In this place the Phyllograptus shales substitute the Planilimbata limestone, but generally this zone, as well as the rest of the Orthoceras limestone, is developed as a limestone facies.

The Orthoceras limestone is exposed at several places within the excursion district, f. i. at the railway-cutting and on the promontory at Sjurberg, and at Granmor.

The Planilimbata and Limbata limestones are poor in fossils; of trilobites there are found: *Meglaspis limbata* BOECK., *Niobe læviceps* DALM., *Nileus Armadillo* DALM., *Megalaspis planilimbata* ANG.

In the Asaphus limestone the fauna is richer including f. i. *Asaphus expansus* (LIN.) WAHLENB., *A. vicarius* TQT., *Megalaspis polyphemus* var. *Törnquisti* SCHMIDT, *Illænus Esmarki* SCHLOTH., *Nileus Armadillo* DALM., *Orthis callactis* DALM., *Orthisina adscendens* PAND., *Lycophoria nucella* DALM., *Bucania planorbiformis* (LINRS.) KOKEN, *Salpingostoma cristatum* (LINRS.) KOKEN, *Lytospira Angelini* LINDSTR., *Ortoceras vaginatum* SCHLOTH.

In the Gigas and Platyurus limestones the cephalopods

[1] HOLM: Ueber einige Trilobiten aus dem Phyllograptusschiefer Dalekarliens. Bih. K. V. Akad. Handl., Stockholm 1882.

are very numerous, (*Endoceras belemnitiforme* HOLM, f. i., occurs in the Platyurus limestone), but the trilobites are relatively very rare; *Megalaspis Gigas* ANG. and *Asaphus platyurus* ANG. are, however, found in resp. zones. The limestone beds are separated by layers of red shales of very varying thickness (often nearly invisible). According to TÖRNQUIST the fauna of the shales is the same in the upper as in the lower parts, but different from that in the limestone. In the shales are found several trilobites, such as species of the genera *Agnostus*, *Remopleurides*, *Cybele*, and others. The fauna of the Chiron limestone is rather rich: *Nileus Armadillo* DALM., *Ill. Chiron* HOLM, *Asaphus tecticaudatus* STEINH., *A. brachyrachis* REMELÉ, *A. densistrius* TQT., *Megalaspis formosa* TQT., *Endoceras bellemnitiforme* HOLM, a. o., and also in the Ancistroceras limestone some fossils are found: *Ill. crassicauda* WAHLENB., *Nileus Armadillo* DALM., *Asaphus rusticus* TQT. a. o.

The lower part of the Chasmops limestone, the Cystidean limestone, has a thickness of at least 15 *m* and contains a considerable number of fossils, especially cystideans and trilobites, f. i. *Chasmops Odini* EICHW. and some other species of the same genus and of the genera *Illœnus* and *Asaphus*, further *Leptœna convexa* PAND., *Caryocystis granatum* GYLLENH. a. o. (see p. 448).

Then follows Macrourus limestone. Its thickness is only about 9 *m*, and it consists of beds of limestone, interstratified with layers of shales. The fauna is about the same as in the Cystidean limestone as to the cystideans and brachiopods, with regard to the trilobites *Chasmops macrourus* itself is not found in Dalarne but instead *Ch. maximus* SCHMIDT; further might be mentioned *Illœnus Linnarssoni* HOLM and *Ill. parvulus* HOLM.

The Masur limestone (also called the »Knyckelkalk») consists of a gray, very hard and knobby limestone, intersected with calcareous spar. The thickness of the bed is about 9—15 *m*. There are no fossils found, but the Masur

limestone is easily recognized because of its peculiar appearance. It is very like the Masur limestone, which occurs in the North Baltic district, only a little darker.

The black Trinucleus shales have a thickness of about 6 *m* and are rather bituminous, and between the thin layers there are several well preserved fossils (see p. 447).

The gray limestone reaches, according to TÖRNQUIST, a thickness of 5—9 *m* and is rather rich in fossils, but these occur generally only as fragments. Sometimes a part of this zone can be developed with Masur limestone facies. (For the fauna of these two last zones see p. 447.)

The red Trinucleus shales are, with regard to the fauna, not so well developed here as in other parts of Sweden. The fossils are rare and generally badly preserved. Of trilobites there are found only: *Remopleurides dorsospinifer* PORTL., *Proetus brevifrons* ANG., *Agnostus trinodus* SALT., and perhaps a few more. The shales have a thickness of 15 *m*, are very calcareous, weather easily, and occur often as gravel or irregular pieces.

It is possible that some gray limy shales occurring in this area faunistically belong to the red Trinucleus shales. Within the excursion district the Trinucleus shales occur f. i. at Nittsjö (p. 443) and at Amtjärn (p. 447).

Of all the rocks occurring in the Silurian of Dalarne there is none, of which the place and origin has caused so much dispute as the Leptæna limestone. For faunistical reasons its place is now proved to be between the Trinucleus and the Upper Graptolite shales, and also its origin seems to have got its explanation by NATHORST.[1] According to him the Leptæna limestone is to be considered as old reefs, only at some places developed as such, at other places substituted by »Klingkalk» (klinglimestone). According to STOLLEY, lithogenous algæ are frequently found in the Leptæna limestone.[2]

The »Klingkalk» is a peculiar black-bluish, very hard

[1] Sveriges Geologi 1894, p. 141.

[2] Naturwissenschaftliche Wochenschrift, Bd. XI. N:r 15.

and tough rock, which clinks for the stroke of the hammer, (whence its name). It is rather like the limestone, which occurs in the Brachiopod shales in Västergötland. The »Klingkalk» is very seldom exposed and poor in fossils. This is also the case with the Brachipod shales which, in this district, are really found only at the section at Nittsjö (p. 444).

The Leptæna limestone, on the other hand is more often exposed than any other rock belonging to the Silurian of Dalarne. This in consequence of its mode of occurrence, as small hills and ridges in the landscape. Within the excursion district this rock is found, f. i., at the church of Rättvik, at Amtjärn, Glisstjärn, and Sätra. Only at Amtjärn it is seen in contact with other beds, but its place here is certainly secondary and caused by faults. The appearance of this rock is varying: white, light or dark gray, greenish, light-red, brick-red, brownish or nearly black, sometimes hard and compact, sometimes forming layers, sometimes with, sometimes without thin shales. In some places the rock is very bituminous, often containing big nodules of bitumen. Often the Leptæna limestone is very rich in fossils, both with regard to individuals and with regard to species, and such rich beds can alternate with beds very poor in or quite destitute of fossils. The beds are not only locally different but the same bed, with the same fauna, can be found at different places; to make several subdivisions of the Leptæna limestone would, however, meet with great difficulties, as it is very hard to decide the mutual connection of the beds because of the manner in which the rock occurs.

One bed consists of red limestone with layers of shales. This bed is very rich in crinoid-stems, brachiopods and corals, and also pelecypods and bryozoans occur. Trilobites, on the other hand, are very rare. This rock weathers easily and is then very difficult to distinguish from weathered red Trinucleus shales.

That part of the Leptæna limestone which consists of rather thin layers of limestone interstratified with greenish or reddish shales is, with regard to the fauna, related to the first named bed. In the limestone there occur very many brachiopods and cystideans remarkably well preserved. (Compare the section at Amtjärn, p. 448.)

Most of the trilobites (especially the *Illænus*-species) are found in the light pinkish-gray limestone, which is often quarried, f. i. at Kallholn. This limestone is not everywhere fossiliferous, but when this is the case, there are, as a rule, enormously much fossils, some parts of the rock consisting almost only of them, mostly of pygidia and head-shields of the great species of the genera *Illænus* and *Bronteus*. Not only trilobites but also numerous brachiopods, gastropods and pelecypods are found in this limestone.

The brownish limestone which is quarried f. i at Kulsberg contains also, as a rule, portions rich in fossils. The fauna is here, however, generally another than the one occurring in the light limestone. In the former species of the genera *Chirurus*, *Lichas*, and *Sphæroxochus* among the trilobites, and further some big pelecypods, gastropods and cephalopods form the greatest part.

In the reddish limestone of that kind which occurs at Amtjärn (p. 448) there are, as a rule, very little fossils.

This is also often the case with a grayish white limestone occurring, f. i., at Östbjörka. Small portions of this are, however, sometimes rather rich in brachiopods belonging only to two or three species. There is a certain likeness between this rock and the white and light-red, sometimes somewhat crystallined limestone, which occurs at Boda. The fauna is here, however, richer, especially in small fossils (ostracods and small, probably young, trilobites a. o.).

Some of the fossils, found in the Leptæna limestone, are mentioned in connection with the description of the Kulsberg (p. 449). Other important species are: *Lichas laxatus* M'Coy.,

Chirurus speciosus His., *Sphærocoryphe granulata* Ang., *Sphærocochus mirus* Beyr., *Lichas affinis* Ang., *Bronteus laticauda* Wahlenb., *Bumastus nudus* Ang., *Isocolus Sjögreni* Ang., *Harpes costatus* Ang., *Pleurotomaria dalecarlica* Koken, *Pleurotomaria leptænarum* Koken, *Euomphalus obtusangulus* Lm., *E. nitidulus* Lm., *Cyclonema angulosum* Lm., *Platyceras harpa* Lm., *Loxonema dalecarlicum* Lm., *Subulites nitens* Lm., *Meristella crassa* Sow., *Athyris Portlockiana* Dav., *Camerella angulosa* Tqt., *C. dispar* Tqt., *Orthis concinna* Lm., *O. Verneuiliana* Lm., *Leptæna Schmidti* Tqt., *Favosites Forbesi* E. H., *Proheliolites dubius* Fr. Schm., *Propora conferta* E. H., species of the genus *Halysites*, *Ptychophyllum craigense* M'Coy, *Syringophyllum organum* L. a. o.

Except in Dalarne the Leptæna limestone occurs in the North and West Baltic areas. Of the 24 species described from Öland (amongst which the three trilobites), 16 occur in Dalarne. As to the fauna of the North Baltic Leptæna limestone it is as yet very little known. To the contemporaneous East Baltic formations, the Borkholmer bed (F_2) and the upper part of the Lyckholmer bed (F_1), the Leptæna limestone shows many analogies; species common to F_2 are 20, to F_1 32, to $F_2 + F_1$ 37 in number. That a larger part of the Leptæna limestone fauna occurs in F_1 than in F_2 depends upon the fact, that the former bed is much richer in fossils than the latter, and in reality there is comparatively a greater percentage of the named fauna in F_2 than in F_1, 24 % and 21 % resp. There is also a great likeness between the Leptæna limestone and the Etage 5 in Norway, at least 35 species being common to the two faunas, and also as to the frequent changes of facies the two areas resemble each other. Especially with the crystalline Coral limestone of Ringerike there is a great analogy.[1]

To the fauna of the Keisley limestone[2] in England and

[1] Kiær: Faunistische Uebersicht der Etage 5 des norwegischen Silursystems.

[2] Reed: Quart. Journ. Vol. 53, 1897.

to that of the Kildare limestone in Ireland the fauna of the Leptæna limestone seems to be still nearer related. Several species are found only at these three places.

That the fauna of the Leptæna limestone shows so little analogy to the contemporaneous fauna of the Brachiopod shales in other parts of Sweden is due to the difference in the facies of these two rocks.

Only some zones of the Rastrites shales are found as solid rock and, otherwise, parts of them only as boulders of different kinds. TÖRNQUIST[1] has, however, made the following division of the shales, beginning with the oldest zone:

Zone	with	*Monograptus leptotheca*	LAPW.
Blocks	»	»	*cfr. gregarius* LAPW.
»	»	»	*Sedgwicki* PORTL.
Zone	»	»	*turriculatus* BARR.
Shales	»	»	*proteus* BARR.

The lowest part of the Retiolites-shales consists of thick, yellowish to reddish-gray layers, sometimes alternating with thinner shales. The upper part consists of gray, rather soft shales with smaller or larger ellipsoids, often very rich in graptolites, such as *Monograptus priodon* BRONN., *M. spiralis* GEIN., *M. cultellus* TQT, and several others. Also a few trilobites: *Encrinurus schisticola* TQT., *Calymmene Blumenbachi* BRONGN., and *Arethusina Konincki* BARR., are found in the Retiolites shales.

Within the excursion district these shales are well exposed at the s. c. Lerberget (the clay-mountain) S. of Amtjärn (see p. 446).

The Orsa sandstone [also called the »Slip (grinding) sandstone»] is a white, yellow, light-red, or gray, loose sandstone, containing much felspar and covering great areas of the Palæozoic district of the Siljan environs. Thus its mode of occurrence is different from that of the older Palæozoic rocks, which the sandstone seems to cover discordantly.

[1] Lunds Universitets Årsskrift XXVI.

Within the excursion district the rock is exposed NE. of the brick-yard at Nittsjö and N. of this occurrence there is a breccia between the sandstone and the granite (see p. 446). The sandstone is younger than all the fossiliferous Silurian rocks, but it has been impossible to determine its age, as fossils are wanting, and the sandstone nowhere is seen in contact with the Silurian rocks just mentioned.

Possibly it is a formation of upper Silurian age, comparable to the Öved sandstone in Scania, which it petrographically resembles, but generally it has been considered as being of Devonian age, analogous to the »Old red sandstone» in Britain and in the Kristiania district.

Description of the excursion district.

On the limited space, which the map embraces and which will be visited during the Congress-excursion, most of the peculiarities are to be seen, which are characteristic for the Silurian region of the Siljan environs.

In the middle of this limited district there appears an extended elevation of a generally gray to dark or light red, coarse-grained, young granite. On each side of this elevation there is a depression, covered with shales and limestones.

Of these small Silurian areas the eastern one does not show much of interest. The whole of this depression is mostly covered with Quaternary deposits, and nowhere on its western border the contact between the Silurian and the granite can be seen. Therefore, this border has had to be drawn entirely from the topography, in which however, especially in the SW. part, the contact between the Archæan and the Silurian appears very clearly. The slope from the granite edge is very steep (possibly there is a fault) and covered with blocks of granite. On the granite a fir-forest is growing. In the NE. part, on the other hand, it is much more difficult

to fix the limit, as also the granite area towards the Backa village is cultivated and the contact between the Silurian and the granite covered with so much sand, that it is quite impossible to see where the granite begins, and where the difference in height only is due to these heaped masses of sand.

This border can perhaps best be seen at a distance, f. i. from the Lerdalshöjden, the highest point of the granite hill, which borders the Silurian depression to the east.

Along this border (which is not seen on the excursion map), the Orthoceras limestone is exposed at several places. At one place, in a little brook, even the contact was laid bare, so that near the granite the Obolus conglomerate and also red Orthoceras limestone could be seen. Now only the granite and the limestone are visible, as there is a mill on the spot where the conglomerate should be. A little further to the north (in the village Alsarbyn), at Jones' farmyard by the roadside, is a wall of Archæan rock with an uncommonly well developed fault-breccia, of which, however, the greater part has been taken away and used for mending the roads.

Beneath the sandcovered elevations the ground is very flat and consists partly of rather swampy, partly of cultivated ground, the Storängen. In this arises a rock of Leptæna limestone, covered with fir trees.

Also further to the south, near the church at Rättvik, such a rock is to be seen. Here the state of things is rather peculiar. NE. of the church, in the southern railway-cutting, there is a section in a non-fossiliferous limestone, which continues in a small ridge.

This rock is an ordinary grayish-white Leptæna limestone, which is said to be well fit for burning. The same limestone can be seen on the road between the rectory and the tenant's house and also a little further to the east, near a small brook, where there is a knob of the same rock.

Quite near and west of the just mentioned ridge there is another hill of limestone, separated only by a slight depression from the former.

The limestone here, though also without fossils, is different from the other, inasmuch as the same is very sandy and is said to be unfit for burning. This rock is evidently in communication with the lime-sandstone on the by-way and at the shore (NW. and W. of the church). In the fields between the former and the rectory the limestone can be seen on several places. On the by-way the rock is rather like the lime-sandstone in the hill, but quite at the shore it becomes more and more sandy and shows a varying appearance, in some places being very like some varieties of the Orsa sandstone. In one place it consists of reddish shales with green spots. The strike of the shales is N. 70° E., and the layers have a vertical position. It is not possible to see the strike of the Leptæna limestone in the ridge, but the direction of the ridge itself is about the same as the strike of the shales.

It is quite evident that the different kinds of lime-sandstones are connected with each other and very likely also with the Leptæna limestone east of the lime-sandstone. At the western side of the ridge, in some holes in the ground, I have seen pieces of sandstone and further to the NW., just north of the railway-road, where the road slopes towards a brook, there is a little rock of lime-sandstone. TÖRNQUIST has indicated all as Leptæna limestone on his map, and I dare say, it is most probable, that all the different rocks really are varieties of Leptæna limestone, which to the west, for some reason or other, has become more like a sandstone. Evidently the interpretation of the rock is much more difficult, as all the different limestones are quite devoid of fossils.

Neither does this peculiar occurrence seem to give any assistance for the interpretation of the origin of the Leptæna limestone.

North of the church, a little to the east of the road between the same and the farm Lugnet, TÖRNQUIST[1] has seen some pits, digged in the Retiolites shales, but those pits I have not been able to find again.

The elevation which separates this Silurian belt from the one of the Nittsjö valley, is not an unbroken granitic massive, for in some places at least, there occur small Silurian areas, depressed through faults. Last summer, when cutting a trench for some water-pipes in the north-eastern part of the village Sjurberg, red Orthoceras limestone was found. Quite near to this place there could be seen several blocks, some from former cuttings when laying down waterpipes, some from the excavation for a cellar.

Among the blocks there were Gigas and Asaphus as well as Limbata and Planilimbata limestones, and further Glauconite sand, the former and the Limbata and Planilimbata limestones chiefly being found at the refuse heap from the cellar, that is to say, in the SW. part of the Silurian. Just W. of the cellar there arises a hill of granite, the eastern slope of which, further to the north, becomes very steep. There the border possibly turns into a fault-line. Probably the Silurian continues towards the NW. in the deep depression, which follows the granite. Also east of this depression, in the southern fields on the hill-slopes, beneath the farm Templet, a gray Silurian limestone can be seen. In the northern field the granite is exposed quite near to this limestone. Near the shore the ground is covered, and from the topography no conclusions can be drawn as to how far the Silurian reaches.

Beneath the western houses in Sjurberg there are some railway-cuttings in a coarse-grained, reddish granite, which rock also outcrops at the shore. At the NW. side of the exposed granite the inclination is very steep, and it is evidently here, that TÖRNQUIST[1] has found Obolus conglomerate

[1] S. G. U. Ser. C. N:r 57.

and possibly some of the lower part of the Orthoceras limestone. The occurrence is now hidden by the railway-embankment, and higher up the ground is covered.

Further to the NE. in the same depression there has been a clay-pit and the clay may have derived from some Upper Graptolite shales, but nothing can be said about it with certainty. These two occurrences of Silurian and the one that will next be spoken of, show, that the rock-ground of this tract is more confused and complicated, than one has thought, and it is very possible that even within the limited space, which is embraced by the excursion map, other discoveries, leading in the same direction, will be made.

When continuing along the railway, one comes to another cutting in the solid rock, which is of great interest, inasmuch as Silurian beds, depressed through faults in the surrounding granite, occur here in two different places, as is already earlier described in the literature.[1]

The section shown in the NW. depression is very important (see fig. 3, p. 427). As the beds dip towards the lake the best section is in the south-western cutting. On the other side there is only very little of the Silurian left. The fault is very distinct, quite without a breccia but with a sharp fissure instead.

The following horizons can be stated in the section.

Limbata limestone	3,00 *m*
Planilimbata limestone	3,08 »
Ceratopyge limestone	0,14—0,16 »
Glauconite sand	0,10 »
Obolus conglomerate	0,15—0,80 »
Weathered granite	0,10—0,40 »
Fresh granite	

[1] Hedström: Geologiska notiser från Dalarne. I. Geol. Fören. Förh. Bd 16. — Hedström: Till frågan om fosforitlagrens uppträdande och förekomst i de geologiska formationerna. Ibid. Bd 18. — Wiman: Om ceratopygeregionen inom Siljansiluren. Ibid. Bd 28.

The weathered granite consists of a greenish mass with grains of felspar, quartz, and mica.

The Obolus conglomerate has the ordinary appearance of this rock and consists of smaller and larger granitic fragments of different kinds, cemented to a brownish-gray mass, also containing grains of phosphorite and scattered shells as well as fragments of shells of *Obolus Apollinis* EICHW.

A few single fragments of this brachiopod are also to be seen in the Glauconite sand. This consists chiefly of grains of glauconite and pieces of a greenish-gray clay-shale with balls of felspar and quartz. Around the *Obolus* fragments there occur also a few grains of phosphorite. In consequence of its richness in glauconite the bed has a blackish-green colour.

The following bed is considered by WIMAN (l. c.) as being real Ceratopyge limestone. It is a greenish-gray, dense limestone, partly rather rich in glauconite (especially the lower parts of the limestone), partly relatively free from grains of that kind. Even here one can find small pieces of *Obolus* shells, phosphorite and a considerable number of fragments of granite. Possibly not only these latter, but also the *Obolus* shells and the phosphorite have come from the underlying beds, and thus their occurrence in the Ceratopyge limestone is secondary.

Besides the *Obolus* fragments this bed contains also some badly preserved shells of other brachiopods, and several specimens of *Lycophoria laevis* STOLLEY. On the occurrence of this latter WIMAN has stated the age of this bed. (Ibid., p. 453.)

The Orthoceras limestone, especially the Limbata limestone, is very poor in fossils. The latter is cut by the fault.

Probably this wedge of Silurian beds continues also on the promontory, on the west side of which there are mighty beds of Orthoceras limestone from the Platyurus to the Planilimbata limestone, dipping 20° towards the Siljan. Also in the fields

between the railway and the lake, red Orthoceras limestone can be seen, but neither here nor at the lake have I seen the lower horizons or the contact with the granite.

It is only a narrow strip of granite, which separates the just mentioned Silurian wedge from the Nittsjö valley. This depression in the granite, covered with Silurian beds, goes from the northern end of the Rättvik bay in a north-easterly direction. How far it reaches one has not been able to decide positively, but most certainly a good way further than what is shown on the excursion map.

NE. of the saw-mill at Vikarbyn, Orthoceras limestone has been quarried here and there on the hill-side, and in the fields below one finds pieces of different limestones, probably among others also pieces of Chasmops limestone. The Orthoceras limestone dips about 30° towards the valley.

On following the hill in a NE. direction one finds Silurian rocks of different kinds at several places, until one comes to a narrow road, which ascends steeply from one of the south-western houses in the village Nittsjö. On the top of the hill granite is to be seen, and both in the road and in the surrounding fields there are raised Silurian beds (fig. 2, p. 427). The Orthoceras limestone is not exposed in the former but is found near the granite, f. i. further to the NE. and in the fields also Cystidean limestone occurs.

The following beds are exposed in the road (see fig. 2, p. 427):

Gray limestone	8,8 *m.*
Black Trinucleus shales	1,5 »
Gray, somewhat shaly limestone . . .	5,25 »
Masur limestone	1,09 »
Gray lime-shales	5,75 »
Red » »	14,45 »
Brachiopod shales	5,5 »

The beds are nearly vertically raised.

In the field north of the road (where at the occasion water-pipes were being laid down) TÖRNQUIST has seen Rastrites shales close to the Brachiopod shales and on the former Retiolites shales. Thus an uncommonly complete series of layers is found here.

Of the gray limestone, which occurs highest up in the road, there is not much to be seen. It may belong to the upper part of the Chasmops limestone or correspond to the Masur limestone.

The black Trinucleus shales have their usual appearance, although here of an extraordinary little thickness, some part of the shales being perhaps substituted by the just mentioned gray limestone.

The gray shaly limestone is probably the gray limestone which normally occurs between the black and the red shales. An interesting peculiarity is the development of a Masur limestone-facies in the upper part of this horizon (compare p. 428).

Both the gray and the red lime-shales correspond probably to the red Trinucleus shales, that thus, in this place, have a thickness of more than 20 *m*.

Of the greatest interest, however, are the Brachiopod shales. They are gray shales with sparely occurring beds of limestone. Here and there the shales are very quartziferous. Between the layers one can find loose specimens of *Ptychophyllum craigense* M'Coy and in the shales sometimes a small *Orthis* and pieces of crinoid-stems. No other fossils have been found, but it is possible, that in the future one will find Brachiopod shales in this district with a better developed fauna.

These same series of beds are also found in the fields NE. of the road. The black Trinucleus shales have a greater thickness in the former places than in the road. Also in an ascent of the road, leading from Nittsjö to Rättvik, some of these layers are to be seen, and west of this road red Orthoceras limestone occurs in one or two places very

near the granite. Further down in the village, clay, derived from the Upper Graptolite shales, has been taken at several places; probably the ground in nearly the whole of the Nittsjö valley consists of these shales, which supposition is indicated by the softly formed and gently undulating landscape.

The Silurian follows the granite ridge, which passes south of the Nittsjön towards the village Sätra. In the hillslope, south of the Nittsjön, red Trinucleus shales are laid bare. At Sätra the Leptæna limestone is exposed at some places, and evidently at least the SE. houses in the village are built on granitic ground, the N. and NW. on Silurian, but the boundary line between the latter and the Archæan is difficult to fix, as the ground is covered and rather flat as far as to the granite hill, upon which the village Backa is situated. Against the granite here occur probably the same beds as in Nittsjö. In the brook, by which the Igeltjärn runs out into the Hosjön, red Trinucleus shales, poor in, or quite without fossils, are exposed. The same shales are also found in pits in the hillslope. Perhaps this Silurian district communicates with that at Rättvik through a depression between the hill at Backa and the village Sätra, but most probably it is only a comparatively small enlargement of the Silurian towards the SE., and probably the granite occurs, as is indicated on the map.

Also on the W. side of the Nittsjö valley, one can follow the Silurian beds along the granite-ridge. At Vikarbyn (just west of the western limit of the excursion-map) there is a nearly complete series from the Obolus conglomerate to the red Trinucleus shales. The strike is about from the SW. to the NE. Just E. of Vikarbyn the contact between the granite and the Silurian is covered by Quaternary deposits, but appears again at Trollskuran, a narrow valley about 400 *m* in length and with steep walls, the western one consisting of granite, the eastern of thick beds of Orthoceras limestone which, in one place, is broken. The limestone is

somewhat inverted, and the strike is about the same as in Vikarbyn. The distance between the granite and the limestone changes. In some places at the bottom of the valley it is only a few *m.* Nearest to the granite there is Gigas and thereupon Platyurus and Chiron limestone, and on the other side of the Chiron limestone there is another cleft (neither so deep, nor so long as the real Trollskuran). What kind of rock there is in the SE. wall of this second cleft cannot be seen, as the same is nowhere exposed.

The continuation of the layers to the NE. is only exposed in a few places, and their relation to the granite cannot be seen.

NE. of the Nittsjö village there arises a great horst of granite, on which the villages Vestberg and Rofgärdet are situated. The horst is bounded by faults, at least to the W., on which side there is a light-red to white Orsa sandstone exposed in some small quarries, just N. of the brickyard at Nittsjö. To the S. and to the N. of this exposure blocks of sandstone are so common in the moraine that it is likely that the solid rock here also consists of Orsa sandstone, which lies against the Archæan and probably continues towards the N. in a narrow wedge between the Archæan and the younger rocks. Also further down in the valley this sandstone can be seen in the moraine. Even the contact between the granite and the sandstone is exposed in a pit in the wood further to the N., the eastern wall of which consists of a very handsome breccia between the sandstone and the Archæan.

N. of the breccia there is a cutting in the upper Graptolite shales, called Lerberget (the clay mountain). The shales go close to the horst, and it is not possible to see whether the Orsa sandstone continues between the shales and the granite, but very likely that is the case. The shales consist of the upper layer of the Retiolites shales. The ellipsoids are partly very big and the fossils rather

rare, but remarkably well preserved. There are found amongst others: *Retiolites Geintzianus* Barr, *Monograptus priodon* Bronn, and *M. subconicus* Tqt.

Further N., close to the brook, by which the Amtjärn discharges into Nittsjön, Rastrites shales have been seen.

Between the Lerberget and the brick-yard, there is a small railway, and when following the same to the south, one comes to a cutting in red Trinucleus shales, which turn into gray shales. Both the red and the gray shales are without fossils, and in the gray ones there is a bed of limestone, like the Masur limestone.

When following the railway across the brook, one will find, just opposite the Lerberget, a quarry in the Leptæna limestone. In the entrance to the same younger horizons are exposed, and on the other side of the Leptæna limestone one can see Chasmops limestone.

The succession from east to west is the following:

1. Gray limestone . . . . . 4 *m*
2. Black Trinucleus shales . . . . . 6 »
3. Grayish green Trinucleus shales with limestone . . . . . 3,70 »
4. A mixture of shales and nodules of limestone . . . . . 4,35 »
5. Light reddish Leptæna limestone . . 6,85 »
6. Green and red Leptæna limestone with red shales . . . . . 7—8 »
7. Chasmops limestone.

The gray limestone is very poor in fossils, and there are only found a few indistinct fragments, a pygidium of a *Trinucleus* and a small *Orthis*.

Some parts of the black shales are very rich in those fossils which are generally found at this horizon, f. i. *Trinucleus seticornis* His., *Calymmene trinucleina* Linrs, *Remopleurides radians* Barr., *Orthis argentea* His., *Leptæna quinque-costata* M'Coy and graptolites.

The fossils in the green Trinucleus shales are not very abundant and generally rather fragmentary. Parts of them are the same as those found in the black shales, f. i. *Calymmene* and *Trinucleus*, but here is also found a pygidium of *Pseudosphæroxochus laticeps* LINRS, which trilobite generally belongs to the fauna of the red Trinucleus shales or corresponding layers.

In the fourth layer, which looks rather like a breccia with fragments, evidently belonging to the Leptæna limestone, one has found a considerable quantity of specimens of a Cystidean: *Sphæronis* sp.

The light Leptæna limestone is the rock which is quarried, and the same is rather poor in fossils, as is generally the case with this kind of limestone.

The red and green limestone forms the back-wall of the quarry. Between the limestone beds there are thin layers of red shales. These layers contain numerous fossils, mostly brachiopods, f. i. *Orthis lyckholmiensis* WYSOG., *Orthis Actoniæ* SOW., *Leptæna corrugatella* DAV.

The Chasmops limestone is the Cystidean limestone, and there the following fossils are found: *Chasmops* sp., *Platystrophia dorsata* HIS., *Monticulipora petropolitana* PAND., and *Echinosphærites aurantium* GYLLENH.

Among blocks of the limestone at the quarry, pieces of red Trinucleus shales have been found, and the workmen declared that these shales had been cut through at the entrance. Thus these red shales should have had their place east of the gray limestone, and Rastrites shales, Retiolites shales, Orsa sandstone, and Archæan granite follow on the other side of the brook. This section is the only place where the Leptæna limestone is found in contact with other beds, but it is quite clear, that its occurrence here must be secondary and depending on faults which must have taken place at least on both sides of the named rock.

The gray limestone, east of the black shales, is probably the one, which generally occurs between the red and the

black shales. The green shales with limestone might correspond to the lower part of the Trinucleus shales. Most of the fossils speak for it, but the occurrence of the *Pseudosphæroxochus laticeps* is very difficult to understand.

Between this bed and the Leptæna limestone there must have been a fault. The fragments in the breccia of shales and limestone belong partly to the Leptæna limestone, partly to the younger horizons. The faults must have formed very acute angles with the planes of the layers.

NE. of the quarry, on the opposite side of the lake Amtjärn, N. of the granite-horst, red Orthoceras limestone, dipping 70° towards the NW. is exposed, and further to the north Chasmops limestone with *Echinosphærites aurantium* GYLLENH. can be seen in the channel, which is cut from the lake Glisstjärn to the Amtjärn.

From the SE. end of the Glisstjärn there extends an oblong hill of Leptæna limestone, the Kulsberg, in the NW. part of which there is a quarry. The limestone is here for the most part brownish-gray and contains rather much bitumen, which sometimes surrounds and impregnates the fossils. In most parts of the quarry the limestone is poor in fossils, but at some places, especially on the NW. side, there are, on the other hand, plenty of fossils. Rather commonly occur f. i.: *Illænus Linnarssoni* HOLM., *Ill. fallax* HOLM., *Ill. gigas* HOLM., *Sphæroxochus conformis* ANG., *Sph. mirus* BEYR., *Platymetopus planifrons* ANG., *Ambonychia* sp., *Subulites* sp. and other gastropods, brachiopods, and cephalopods.

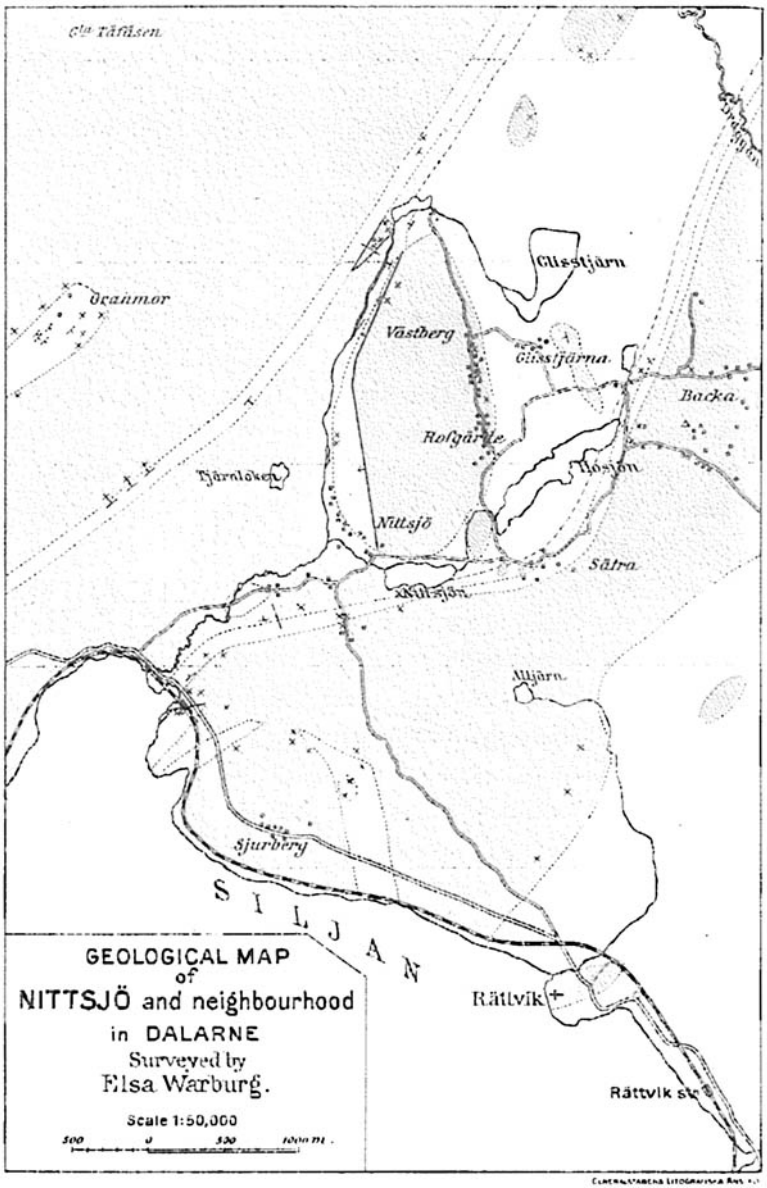
On the limestone in the NW. part of the quarry there occur black Trinucleus shales, probably not as a part of the solid rock, but as some sort of local moraine. Such a moraine of these shales occurs also on the Leptæna limestone at another locality, viz. at Sätra (see below). The fields N. of the quarry consist partly of a reddish, weathering gravel containing small pieces of red, shaly Leptæna limestone.

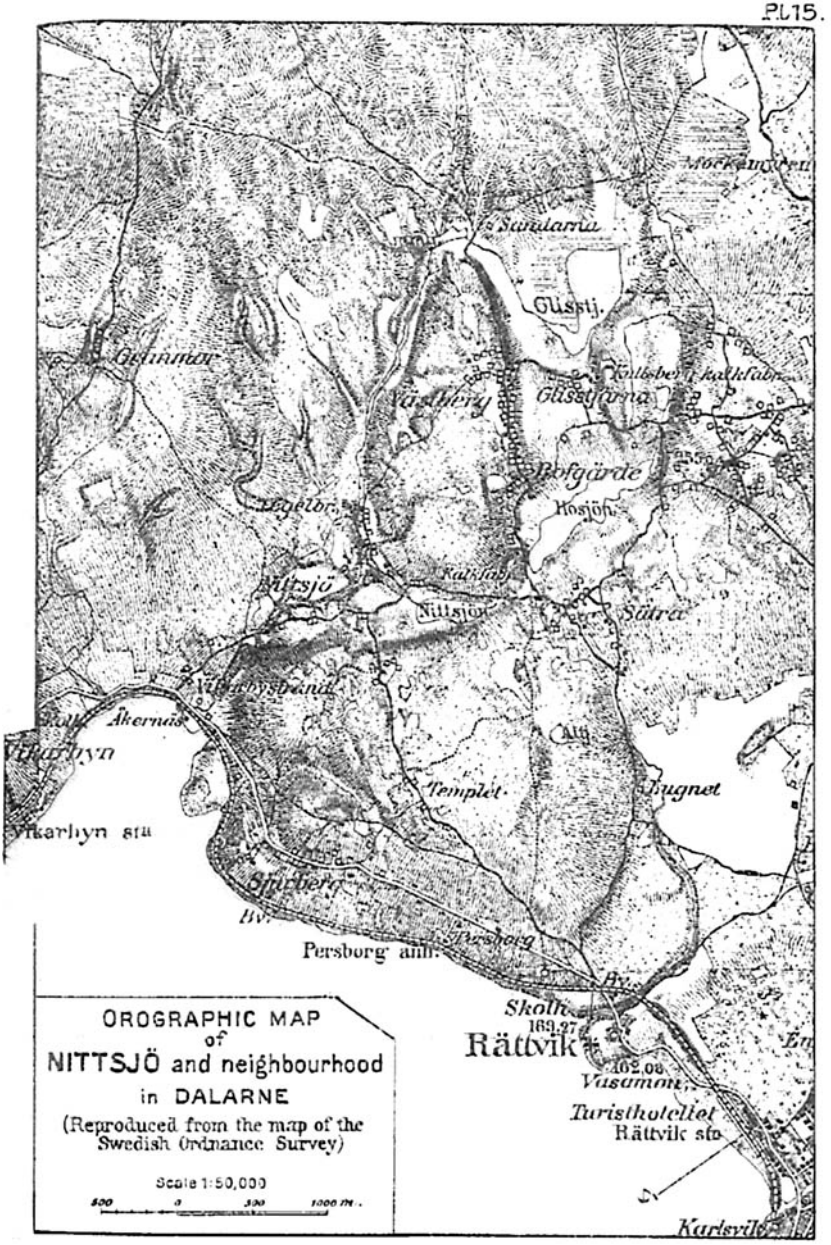
Also N. of the Glisstjärn this rock has been broken, both in a limestone hill (the western occurrence) and in some pits here and there in the wood (the eastern one), and at Sätra at the SW. and of the Hosjön there is a quarry in the big elevation of Leptæna limestone. This is generally poor in fossils, but also here there are some rather rich parts. At some places the limestone, which dips towards the NW., is very bituminous and quite black, and at one place there is a local moraine of black Trinucleus shales as at Kulsberg.

At the NW. slope of the hill red Orthoceras limestone occurs. Also at the SE. hillside this rock is found here and there, but these occurrences are probably only blocks and not part of the solid rock. SE. of the elevation the Leptæna limestone is exposed here and there. Possibly these small occurrences communicate with the limestone in the elevation, and perhaps the same rock extends still further towards the east. When sinking a well, belonging to one of the north-eastern houses in the village, they found a limestone, which the owner described as being quite like the Leptæna limestone, but it might very well be some other kind of limestone.

In the NW. part of the small district, shown on the excursion-map, there occurs at Granmor another Silurian area. This belongs evidently to the one extending through Öja and Stumsnäs down to the Siljan. At Granmor only the Orthoceras limestone is found, but of this both red and gray beds are exposed at several places. The succession seems to be repeated through faults. The dip is generally about 25° towards the SE.

Both a little S. and a little N. and NW. of the limestone there is granite, which proves that the Silurian area is quite narrow at this place.





GEN. STAB. LIT. ANST.