5. Ice-dammed lakes and the marine limit in the north of Västmanland and the south of Dalecarlia.

By

Ernst Ingmar.

(With Pl. VI.)

As no investigations have been made as to the occurrence of ice--dammed lakes in the north of Västmanland and adjacent parts of Dalecarlia, I made investigations in the autumn of 1924 and the summers of 1925, 1926 and 1927 in order to ascertain whether and to what extent ice-damming had occurred at the melting of the land-ice within this region. There being no statements either about the marine limit within great parts of this region, circumstances connected with this limit were also examined by means of the following methods: 1) erosion and accumulation shore--marks were searched for and measured; 2) the level for the marine limit thus obtained were put in relation to the mouths of the outlets of the ice-lakes and to the level surfaces of the glacio-fluvial marginal deltas and ose-plains. The completion of the field-work and the publishing of the results having been delayed owing to illness in my family, I will now only give a short summary of the results hitherto obtained. The field-work continues.[1]

[1] In the description accompanying the recently published geological map-sheet of Malingsbo (G. S. of Sweden, Ser. A a, no. 168) part of my working-district has been touched upon. As I have thus been forestalled in the publishing of my results by the Geological Survey of Sweden, I wish to point out: firstly that my work has been carried out quite independent of the map-works of the G. S. of Sweden, and secondly that — before the G. S. of Sweden — I had investigated, measured, and in parts mapped down the localities described by both of us. Thus, in the autumn of 1925 I could show the outlets of the ice-lakes at Tvikbo and Nykolningskullarna to the State geologists Professor H. Munthe and Mr. A. Högbom, D. Sc., who at the time did not know of these ice-lakes. Also the Ribäcken ice-lake and the south part of the Björsjö ice-lake had then been examined by me, and also all the localities at the marine limit the measures of which are given in my work on the map-sheet of Malingsbo. That also my material from my fieldwork had been treated before the G. S. of Sweden published the map-sheet of Malingsbo, can be testified by Mr. A. Gavelin, director-in-chief at the Geological Survey of Sweden, to whom — in the autumn of 1928 — I showed the manuscript of a long treatise, and by Mr. G. Lundqvist, State geologist, D. Sc., who in the winter of 1929—30 was so kind as to read it through.

Shore-marks at the Marine Limit.

At the places (see the figures Pl. VI) about which no other indications are given, the shore-marks consist of erosion terraces, cleanwashed boulders or gravelly and pebbly beaches. The shore-marks have been measured on the top of the beaches and in the angles of the erosion terraces. The measuring has been made by means of a levelling mirror and a Paulin aneroid.

1. Slokafallet, 6 km. N.E. of Skinnskatteberg, 174,5 m.
2. Matkullen, in the valley of the Hedströmmen, 2 km. N.W. of Lake Storsjön, 178 m.
3. The mouths of the outlet of the Ribäcken ice-lake, 1 km. W. of Baggå, 173 m.
4. The marginal delta S.E. of Lake Ljustjärn, Malingsbo, 180,5 m.
5. Marginal deltas and ose-plains on the western shore of Lake Malingsbosjön, S. of Lake Bondbergstjärn, 181—181,5 m.
6. Ose-plain on the western shore of Lake Malingsbosjön by the road to Näset, 182,5 m.
7. The marginal delta N.W. of Lake Malingsbosjön, 183,5 m.
8. Gärdsjöbo, north part of Lake Malingsbosjön, 183,5 m.
9. The delta at the outlet of the Oppsveten ice-lake at Rosveden, 182 m.
10. The mouths of the outlet of the above lake 1 km. N.E. of Gärdsjöbo, 181 m.
11. Landsberget, W. of Lake Åmänningen, 175 m.
12. Hanaberget, 9 km. W. of Lake Åmänningen, 177,5 m.
13. Orreberget, 2 km. N.W. of Lake Dagarn, 179,5 m.
14. The mouth of the outlet of the Lexen ice-lake at Billsjön, 178 m.
15. The hill W. of the high road at the northwest arm of Lake Billsjön, 180,5 m.
16. Högbyn, 3 km. N.E. of Billsjön, 179 m.
17. Bromsberget, 2 km. N.N.E. of Billsjön, 180 m.
18. Jättesåsarna, 3 km. W. of Västanfors, 180,5 m. (Fig. 1.)
19. Högåsen, W. of Lake Södra Barken, 181,5 m.
20. The mouths of the outlet of the Lexen ice-lake on the northern slope of Högåsen, 180,5 m.
21. Storberget, S.W. of Lake St. Lexen, 181,5 mm.
22. The hill, 218 m. high, between Lake Södra Barken and Lake Busjön, 181,5 m.
23. Nykolningskullarna, W. of Lake Södra Barken, 183,5 m.
24. The mouth of the outlet of the Oppsveten-ice-lake on the northern slope of Nykolningskullarna, 181,5 m.

25. Grästjärnsberget, 6 km. W. of Lake Södra Barken, 184,5 m.
26. Vanberget, 4 km. W. of the church village of Söderbärke, 184 m.
27. The hills 4 km. S.W. of Smedjebacken, 186 m.
28. Uvberget, 2 km. N. of Smedjebacken, 190 m.
29. Gäsberget, 7 km. N.N.E. of Smedjebacken, 192 m.
30. Norsberget, W. of Lake Nedre Hillen, 188 m.
31. The railwaystation at Håksberg, 4 km. N. of Ludvika, 191,5 km.
32. The mouths of the outlets of the marginal ice-lake at Gräsberg, 2—3 km. N. of Lake Övre Hillen, 190 m.

Fig. 1. The erosion terrace of the marine limit on the southern side of Jättesåsarna.

33. Dagkarlsbo, W. of Lake Haggen, 188 m.
34. Hagberget, W. of Lake Vessman, 189,5 m.
35. The elementary school at Sörvik, E. of Lake Vessman, 192 m.
36. The outlet deltas of the Olsjön ice-lake at Rävvåla, 191—196 m.
37. Uvberget, S.W. of Lake Bysjön, Grangärde, 198 m.
38. Stensbo, at the northern part of Lake Vessman, 197 m.
39. Bergsbo, 2 km. E. of the railwaystation at Grangärde, 200 m.
40. Libergen, 3 km. N.N.W. of Lake Åmänningen, 178,5 m.
41. The hills 1 km. W. of Lake Trätten in the parish of Norberg, 180—180,5 m.
42. Klacksberg, 2 km. N.W. of Norberg, 182 m.
43. Sjulsboklint, on Dalälven, 8 km. S.S.E. of Hedemora, 188 m.
44. The hill 3 km. S. of Hedemora, 189 m. (?)

45. Lövsjöberget, 8 km. W.S.W. of Hedemora, 192 m.(?)

46. The mouths of the outlets of the Murbo ice-lake, 2 km. W.S.W. of the railwaystation at Sellnäs, 199 m.

47. The outlet of the ice-lake at Björka, Gagnev, 194 m. (Fig. 2).

48. Esjöberget, Gagnev, 203,5 m. (Fig. 2).

49. The mouths of the outlet of the marginal ice-lake at Hedby—Brända, 5 km. W. of the church of Gagnev, 202,5 m. (Fig. 2).

Below the marine limit, especially about Lake Barken and Lake Åmänningen, several shore-marks have been observed and measured which — in contrast to the shore-marks at the marine limit — must be regarded as synchronous formations. Between the levels of 120 and 160 meters these shore-marks lie close together and are clearly developed even at places where the surging of the waves must have been quite weak.

The Direction of the Ice-movement.

Striæ, radial and terminal moraines show that the ice-movement during the period of melting generally came from N.N.W. About Lake Barken and Lake Vessman the direction of the ice-movement was N. 15°—25° W., exceptionally N. 30°—39° W. To the west of Lake Vessman the ice-movement took a more northerly direction, at times with a deviation eastwards. Striæ have been measured here from N. 14° W.—N. 16° E.

Near Nås in the valley of Väster-Dalälven large, much weathered striæ with a direction N. 32°—37° W. have been observed; at Björbo large grooves in N. 18° W. and at Brötjärna several striæ from N. 4°—19° W.; at the last-mentioned place the smallest deviation westwards occurred among the narrowest and finest striæ.

Ice-dammed Lakes.

With the direction which — according to the observations of striæ related above — the ice-movement took during the period of melting, the formation of large ice-dammed lakes was as a rule not possible, as most of the larges valleys open towards the south and the south-east. Into the Barken depression opens a series of fissure valleys, and in several of them the passes are situated above the marine limit of the region; consequently there has been ice-damming here. After Lake St. Lexen I have named the most south-easterly of these ice-lakes

The Lexen Ice-lake.

(I Pl. VI.)

The earliest pass of the outlet of the Lexen-ice-lake is situated 300 m. N.N.E. of Lake Bredsjön at a height of 206 m. The mouth of the outlet

was at the marine limit (see M. L.-place 14) near the smelting-house at Billsjö. This outlet served till the ice-border reached the northern slope of Högåsen, where the ice-lake was tapped through marginal outlets, the mouths of which reach down to the marine limit (see M. L.-locality 20). Gravel is found at several of the mouths. The highest shore-marks are situated at a height of 207 m., shore-marks from many of the tapping stages have also been observed. Glacio-fluvial deposits are found in the northern part of the basin of the ice-lake, but are of no great thickness.

The Bjursjön and Oppsveten Ice-lakes.

(II, III Pl. VI.)

In the valley which nowadays is in part occupied by the Oppsveten Lake and whose water empties itself through the Höglund River, an ice-lake was dammed up; the earliest pass of its outlet is situated in the depression to the south of Torstjärnsberget at a height of 192,5 m. The mouth of the outlet was in the innermost part of that arm of the ice-sea that penetrated into the valley of the Hedströmmen River (see M. L.-localities 9—10). A somewhat smaller ice-lake, the Bjursjön ice-lake, was tapped into the Oppsveten ice-lake from the east, its water formerly emptied itself into the Lexen ice-lake, and, after that this lake had been tapped, into the arm of the ice-sea that penetrated into the lowest parts of the basin of the last mentioned lake. The pass of the outlet of the Bjursjön ice-lake towards the Lexen ice-lake is situated at a height of 220 m. and its shore-marks at that of 221 m. The Oppsveten ice-lake was tapped through a marginal outlet on the northern slope of Nykolningskullarna into the arm of the ice-sea that penetrated into the Barken depression (see M. L.-locality 24). At the mouth there was plenty of gravel. Numerous shore-marks from this ice-lake are found at a height of 193—197 m. In the southern part of the basin of the ice-lake there is a small ose. In the region of the outlet of the ice-lake towards Gärdsjöbo the topography of the moraine is generally broken and irregular. Terminal moraines are pushed closely together between the outlet of the ice-lake and the slopes of the moraines south of it.

The Marginal Ice-lake at Gräsberg.

(IV. Pl. VI.)

About 8 km. N.N.E. of Ludvika, in the valley that stretches northward from the region about Ludvika and whose southern parts are occupied by Lake Övre Hillen, a small insignificant marginal ice-lake has been formed, the lateral outlets of which east of the village of Persbo are

particularly well developed. The mouths of the outlets reach down to the marine limit (see M. L.-locality 32). Gravel and sanddeltas are found at most of them.

The Ribäcken Ice-lake.

(V. Pl. VI.)

In the sharply defined valley which opens into the valley of the Hedströmmen River, 4 km. S.E. of Malingsbo, a small ice-lake had been dammed up, the outlet of which was at first towards the Harald Lake over a pass at a height of 210—211 m. On the slopes W. of Baggå, where this ice-lake was tapped to the ice-sea, a very interesting erosion-landscape was formed. The outlets were partly subglacial and were pressed down below the marine limit, partly marginal and ended at the marine limit (see M. L.-locality 3). Subglacial rivers, rich in water, fell into the ice-lake; they left glacio-fluvial deposits in the western part of it.

The Björsjö Ice-lake.

(VI. Pl. VI.)

After the tapping of the Ribäcken ice-lake the subglacial rivers that had fallen into that ice-lake formed vast deltas in the innermost part of the arm of the ice-sea that penetrated into the valley of the Hedströmmen River. The level surfaces of the marginal deltas and the ose-plains were generally formed up to the marine limit (see M. L.-localities 4—7). The northernmost of these deltas forms the northwestern shore of Lake Malingsbosjön. N.W. of this delta the glacio-fluvial deposits have been formed above the marine limit, and between Lumsen and Gäddtjärn they have, together with remains of ice embedded in the deposits, dammed up the valley, so that an ice-dammed lake, the Björsjö ice-lake, was formed when the ice-border moved north of this huge accumulation of glacio-fluvial deposits.[1] When the ice-lake was formed, the passes of the outlets were situated at a height of about 190 m., but while the ice-lake was existent they were eroded to 182,5 m. The Björsjö ice-lake, which penetrated into the larger part of the basin of the Haggen, Snösjön and Hällsjön Lakes, was tapped subglacially into the ice-sea on the slopes E. of Hagge. There are numerous shore-marks of the ice-lake at a height of 189—196 m. Glacio-fluvial deposits are found in many places, above all in the southern part of the old basin of the ice-lake.

[1] The glacio-fluvial deposits in the valley of the Hedströmmen River have in all probability caused great changes in the præ-glacial hydrography of the region.

The Grängesberg Ice-lake.
(VII. Pl. VI.)

The two valleys converging towards Grängesberg from N. and N.E. have been ice-dammed, and it is possible that this ice-lake penetrated into the basin of the Hörken Lakes, too. The Grängesberg ice-lake was tapped in a north-easterly direction to

The Klenshyttan Ice-lake.
(VIII. Pl. VI.)

The outlet of this ice-lake — with a pass at the height of 214,5 m. — first flowed to the Björsjö ice-lake and after the tapping of this lake to the arm of the ice-sea which penetrated into the basin of the Björsjö ice--lake. The Klenshyttan-ice-lake was tapped marginally to the ice-sea along the steep declivity 1,5 km. N.E. of the railwaystation at Blötberget. At a height of 216—217 m. there are numerous shore-marks within the basin of this ice-lake.

The Nitten Ice-lake.
(IX. Pl VI.)

The topography in the south-western part of the parish of Grangärde made the damming of two ice-lakes possible. The westernmost of them, the Nitten ice-lake, first emptied itself towards the south through the deep valley of the Nittälven. The pass of the outlet is situated immediately to the north of Lake St. Nitten at a height of 284,5 m. When the retreating ice-border reached the flat slope of the moraine at Torsberg, a new marginal outlet was opened, which fell into the Olsjön ice-lake and the pass of which is situated at a height of 271 m. The remnant of the ice-lake, which in the course of the sinking, had divided itself into two parts, was tapped W. of Råskmora and N. of Skattlösberget into the Olsjön ice-lake. In the basin of the Nitten ice-lake, especially in its north-western part, there are vast glacio-fluvial deposits, the plane surfaces of which are generally situated at a height of 292—294 m.

The Olsjön Ice-lake.
(X. Pl. VI.)

As has been mentioned above, the Nitten-ice-lake was tapped in an easterly direction into another ice-lake, the Olsjön ice-lake, which had been dammed up in that depression, the lowest parts of which are occupied nowadays by the Noren and Olsjön Lakes. The outlet of this ice-lake, the pass of which is situated 500 m. S.E. of the Olsjön Lake at a height of

215 m. and which has then passed through a canyon some 15—20 m. deep, formed a vast delta in the ice-sea (see M. L.-locality 36). The Olsjön ice-lake was tapped subglacially into the ice-sea near Norhyttan. Its shore-marks are situated at a height of 220—224 m. In the north-western part of the ice-lake region there are vast glacio-fluvial deposits, the plane surfaces of which are on the same level.

The Ice-lakes in the Valley of Västerdalälven.

(Fig. 2.)

The earliest ice-lake in the drainage area of Västerdalälven was dammed up in the valley which joins Västerdalälven from the south at Nås. The first outlet of this ice-lake of any duration was formed S.E. of Lindesnäs. Its lowest pass is situated at a height of 280—281 m. When the ice--border had retreated to the northern slope of Svanberget, a new outlet was formed here, the pass of which eventually lay at a height of 260 m. The outlet N. of Svanberget served till the ice-border had melted on the northern slope of Birtjärnsberget when an outlet was formed S.E. of Birtjärnsberget with a pass at a height of 254 m. The ice-lake drained through the Birtjärn outlet extended from Nås to the east part of the parish of Floda, where — at Trollkäringholn — it was tapped into an ice-lake that had been dammed up in the valleys — sloping northward — south of Mockfjärd; its outlet was 3 km. W. of Lake Tansen, the pass at a height of 243 m. A canyon, through which the rivulet Lungmyrån now flows, is eroded in the southern part of this outlet. (Fig. 3.) Through the tapping at Trollkäringholn an ice-lake was formed, which by degrees extended from Brötjärna in the parish of Gagnev to Nås and in all probability to Dala-Järna and Vansbro, too. Thus it measured about 5 Swedish miles. In the western part of the basin of the ice-lake there are vast glacio-fluvial deposits, which in many places were formed up to the surfaces of the ice-lakes. About the southern parts of the ice-lakes described above I have measured numerous shoremarks from the various ice-lake stages; thus there are shore-marks at the height of 287—289, 261—262, 255—258, and 244—250 m. The northernmost limit of the last ice-lake stage has not yet been determined. The final tapping into the ice-sea was at the village of Björka in the parish of Gagnev, where a huge erosion ravine was cut out, partly in bedrock (see M. L.-locality 47).

In the flat valley which joins Västerdalälven from the south at Äppelbo, an ice-lake was dammed up; its water flowed at first towards the south to Svartälven, the pass at a height of about 309 m. The ice-lake was tapped in an easterly direction on the northern slope of Knösvallen.

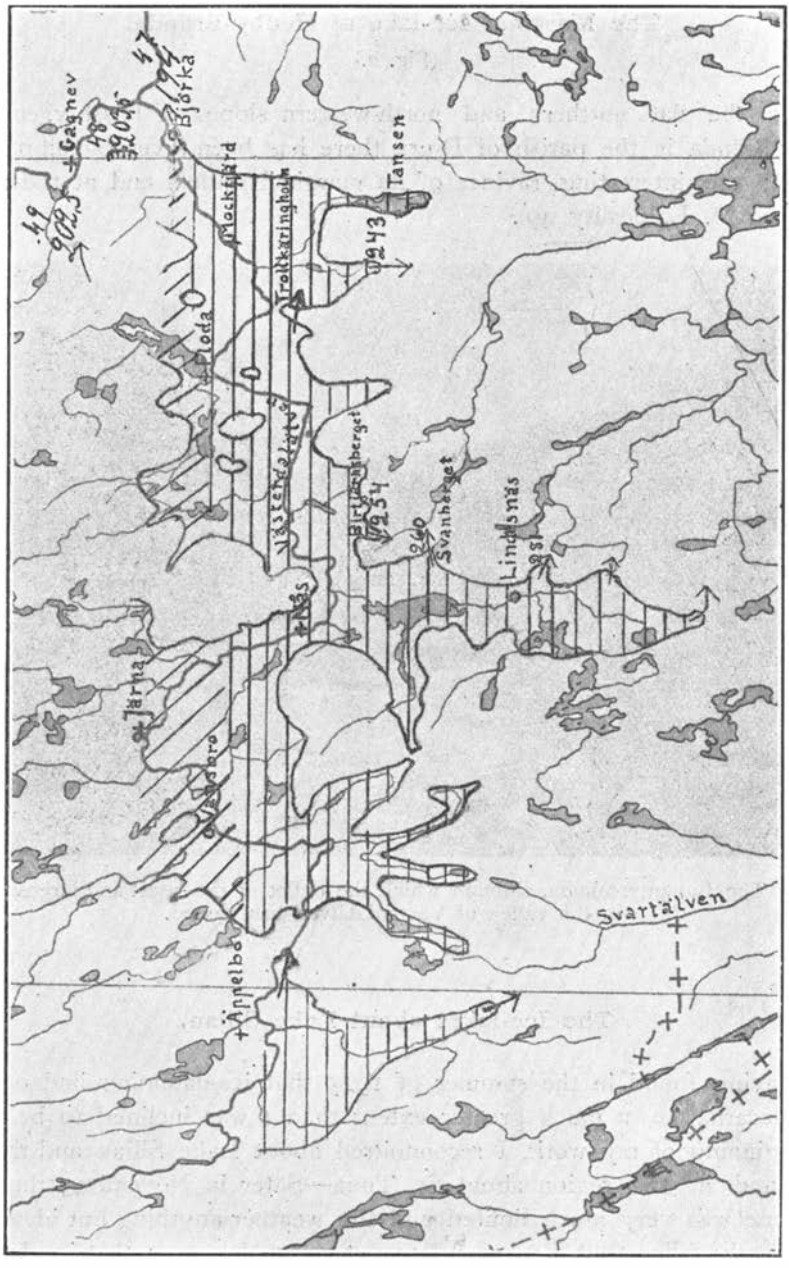

Fig. 2. Ice-dammed lakes in the drainage area of Västerdalälven. The obliquely lined region in the north indicates a region that has probably been ice-dammed. Scale 1 : 500000.

The Marginal Ice-lake at Hedby-Brända.

(Fig. 2.)

On the flat northern and north-western slopes of Hissberget W. of Hedby-Brända in the parish of Djura there has been a very small marginal ice-lake; the interesting ravines of its marginal outlets end at the marine limit (see M. L.-locality 49).

Fig. 3. The Lungmyrcanyon, through which the outlet of the latest and largest ice-lake in the valley of Västerdalälven has passed.

The Ice-lakes about Lake Siljan.

Having found in the summer of 1925 that ice-damming had occurred in Dalecarlia to a much greater extent than I was inclined to believe at the beginning of my work, I reconnoitred about Lake Siljan and the Orsa Lake and in the region about St. Tuna—Säter in November, that year. The time was very much limited and the weather anything but ideal, snow had already fallen, but I managed to determine, however, that ice-damming had occurred in many places. Thus, for instance, the valley extending from Lake Insjön towards Lake Hälgsjön has been ice-dammed, and on both sides of the southernmost arm of Lake Siljan — Österviken — there have been nunatakk-lakes and marginal ice-lakes. There were ice-lakes in the valley of Lake Brossen, too, and in the flat depressions east of Altsarbyn at

Rättvik which are now occupied by Råtjärnmoor and Grissmoor. Near Röjeråsen N.W. of Rättvik there was a fairly large nunatakk-lake. The largest and most interesting of all the ice-lakes about Lake Siljan, however, is the one that was dammed up in the basin of the Ore and Skattungen Lakes (Fig. 4). The outlet of this ice-lake was S. of the S. Ockran Lake, where a deep and broad erosion ravine was cut out; the pass of the outlet is situated at a height of 245 m.[1] To judge from the few shore-

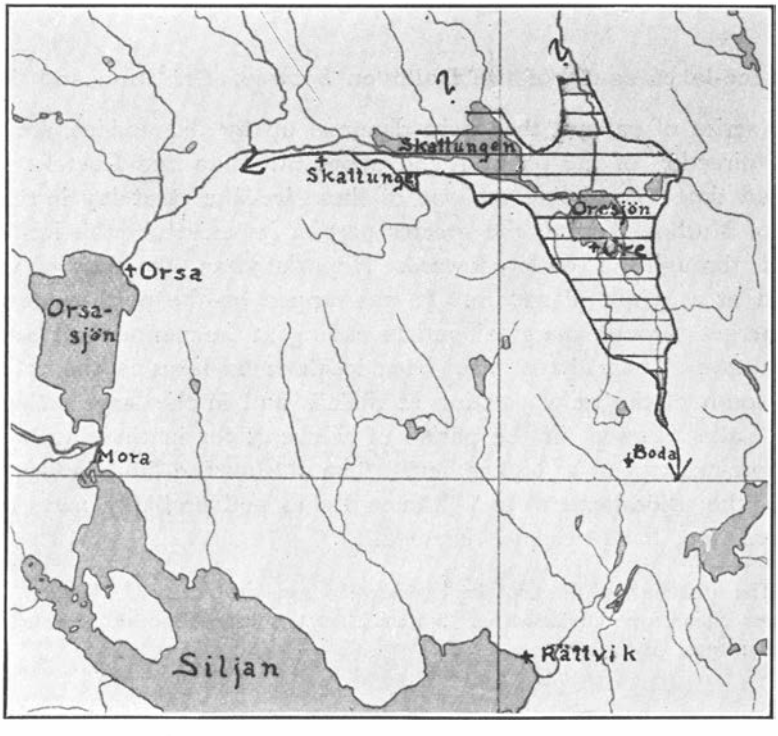

Fig. 4. The Ore-Skattungen ice-lake. Scale 1 : 500000.

marks that I had time to examine, it seems that the surface of the ice-lake was situated at a height of about 255 m. The ice-lake was tapped towards Orsa. S.W. of Lake Siljan, in the valleys of the Ejen, Brasjön and Långsjön Lakes, a fairly large ice-lake was dammed up; the earliest passes of its outlets are situated at a height of 280—290 m. in the southern and south-eastern parts of the ice-lake region. The ice-lake was tapped round about the northern slope of Fårberget. In the northwestern part of this ice-lake there was the mouth of the outlet of an ice-lake, which was dammed up in the basin of the Våsjön Lake. Lake Fjärden and Lake

[1] All the elevation values about Lake Siljan are doubtful, the measures having been taken in a high gale by means of an aneroid.

Jugen, too, W. of Lake Siljan have been ice-dammed.[1] I have also observed traces of small ice-lakes and marginal ice-lakes on the slopes S. of the Ore and Skattungen Lakes, at Sundbäck in the parish of Orsa, Indor in the parish of Våmhus, Gopshus in the parish of Mora, and at the church village of Älvdalen. Even if these ice-lakes were very small, they are very interesting, because their marginal outlets give us good guidance at the fixing of the marine limit, which has never been determined exactly in these parts.

The Ice-lakes south of the Dalälven between St. Tuna and Säter.

A series of valleys, that were dammed up by the land-ice, are drained in the direction of the plains round about St. Tuna and Gustafs. I have only had time to examine the one of these ice-lakes that lay in the valley south of Murbo. During the greater part of its existence this ice-lake was drained through an outlet towards Koppslahyttan, the pass of which is situated at a height of 227 m. It was tapped on the north-western slope of Dyberget through marginal outlets ending at the marine limit (see M. L.-locality 46). There have also been ice-dammed lakes in the valley that opens south of the railwaystation at Sellnäs and in the large valley round about Lake Ulvsjön in the parish of Silvberg; for in these valleys there are shore-marks on a higher level than the marine limit in this region. Finally the Björkljustern and Rämen Lakes and probably parts of Lake St. Norn, too, have been ice-dammed.

[1] The existence of this ice-lake has already been proved by G. Schotte, »Beskrivning över Siljansfors försökspark». Statens skogsförsöksanstalts exkursionsledare. IV. Stockholm 1922, page 12.

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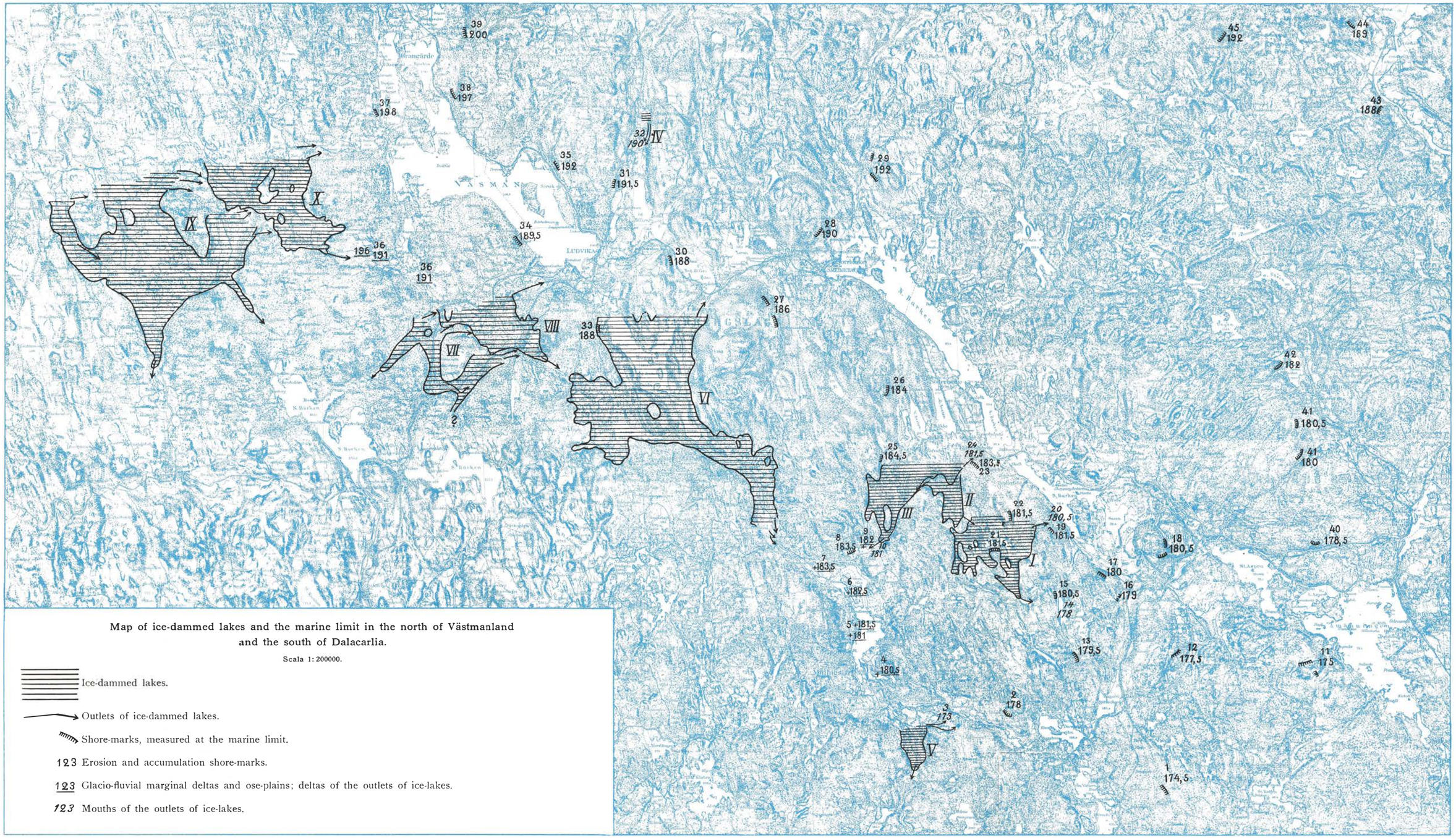

Map of ice-dammed lakes and the marine limit in the north of Västmanland and the south of Dalacarlia.

Scala 1: 200000.

Ice-dammed lakes.

Outlets of ice-dammed lakes.

Shore-marks, measured at the marine limit.

123 Erosion and accumulation shore-marks.

123 Glacio-fluvial marginal deltas and ose-plains; deltas of the outlets of ice-lakes.

123 Mouths of the outlets of ice-lakes.