GEOLOGINEN TUTKIMUSLAITOS

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ON THE RELATION BETWEEN THE STONES OF THE ESKERS AND THE LOCAL BEDROCK IN THE AREA NORTHWEST OF TAMPERE, SOUTHWESTERN FINLAND

BY
ARVO MATISTO

WITH 9 FIGURES AND 3 TABLES IN THE TEXT

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ABSTRACT

The study deals with stone counts and morphologic indices based on both measurements and visual estimates of the cobbles of sixteen samples taken from the eskers located in the area between Kankaanpää and Tampere, southwestern Finland.

In the light of the lithology and morphology of the esker cobbles, conclusions have been drawn regarding the provenance of this material. The predominant share of it has been derived from north-northwest, northwest and north, commonly from a distance under 20 km and mostly during the late stage when the movements of the thinned ice sheet were controlled by the local topography. In addition, the possibilities of applying morphologic techniques to a task of this kind have been reviewed.

Finally, a comparison has been made with the results of earlier studies.

CONTENTS

INTRODUCTION

Geological researchers in Finland have paid scant attention to the relation between the coarse fraction — pebbles, cobbles and boulders — of eskers and the local bedrock. Not even the sometimes quite animated exchange of views on the origin of the eskers has added appreciably to our fund of knowledge on this matter.

The first researcher in this country to focus attention on the nature and origin of the coarse fraction of the eskers of Finland was Hellaakoski (1930) in his study on the Laitila esker. Subsequently, this line of research was pursued further by Okko (1945) and Virkkala (1958), the former investigating the lithology of the esker of Mikkeli and the latter that of the esker of Hämeenlinna. All three investigators reached the common conclusion that the coarse fraction of the eskers had not been transported as long distances as had previously been generally supposed, but that a substantial part of it was usually derived from bedrock located only a few kilometers away.

While participating in 1946—48 in petrographic explorations by the Geological Survey in the areas of the map sheets of Ikaalinen, Viljakkala—Teisko and Tampere, I attempted to determine the type of the bedrock in localities with few outcrops on the basis of the evidence provided by the boulders in the till and the cobbles of the eskers. However, not until the lithologic maps were completed was it possible to make accurate comparisons between the coarse fractions of the eskers and the local bedrock in the region under investigation. In September, 1956, the author had an opportunity to carry out sixteen stone counts of eskers in the region. The locations and the lithologic results of these stone counts are shown by the appended map (Fig. 1).

In order to obtain additional data on the effect of the transport distance on esker cobbles of various sizes and differing composition, I carried out, in addition to the usual stone counts, morphologic measurements of the cobbles in order to compute the indices of flatness and asymmetry, and I also visually estimated their degree of roundness and sphericity.

Since no morphologic studies of this kind had previously been attempted in Finland, I performed this part of the work chiefly in an experimental spirit, without being able to estimate the results in advance.

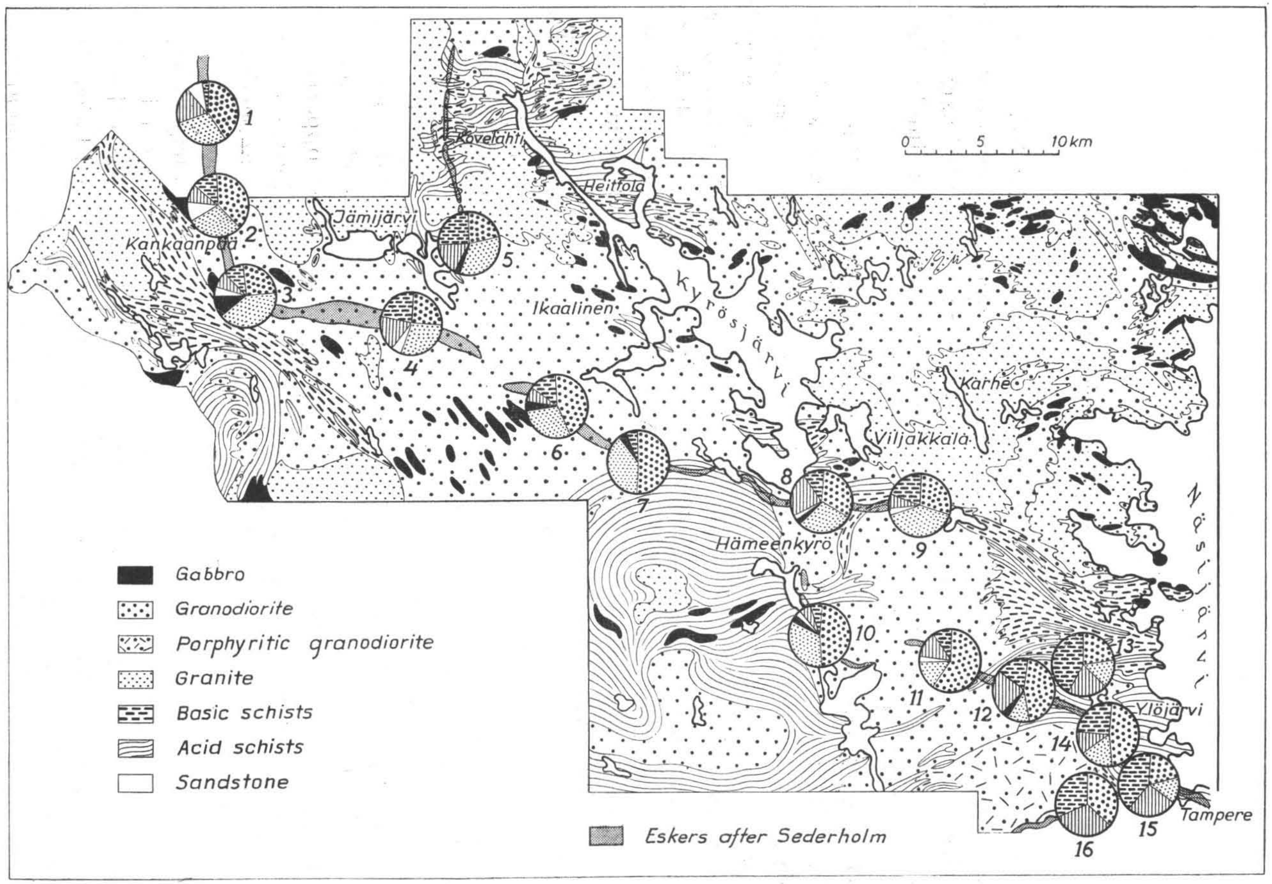

Fig. 1. Results of the stone counts.

RESEARCH METHODS

Specification of the rock types could not be as detailed as in the lithologic maps of the area (Sederholm 1903, Huhma—Salli—Matisto 1952, Simonen 1953 and Matisto 1961). Consequently I found it most expedient, for the purpose of the present study, to classify the various rocks occurring in the area as follows:

Gabbros	peridotites gabbros diorites quartz-diorites
Granodiorites	granodiorites oligoclase gneisses
Granites	microcline granites porphyritic granites
Basic schists	basic tuffites and lavas uralite and plagioclase porphyrites
Acid schists	phyllites mica schists quartz-feldspar schists mica gneisses
Sandstones	sandstones

I chose gravel pits in the eskers as sampling points. The cobbles were chosen so that they corresponded in size to the relative abundance of the different sizes occurring at each sampling point. This was done because I felt that at this stage of my work a comparison between the lithology and morphology of cobbles from different sampling points might have a certain significance. The same could not, however, be expected of the cobbles occurring at the different sampling points — not as such, at any rate — for the points are not situated in analogous positions in respect to the esker formations, the location of the gravel pits having been determined exclusively by practical considerations.

At each sampling point I determined the type of rock composing the cobbles and, in addition, measured the diagonals A, B, C and the distance

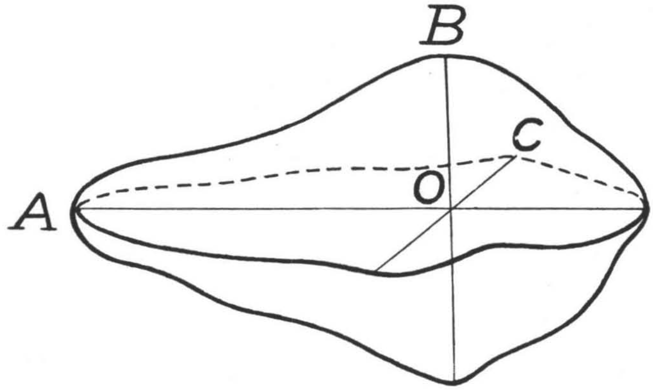

Fig. 2. Values for calculation of morphologic indices. According to Cailleux (1945).

AO (Fig. 2). The measurement was performed in a lidless wooden box from which one end board and one side board had been removed and the bottom and remaining side board were covered with millimeter paper provided with centimeter numbering and protected by a plastic sheet. By means of this measuring box, and by using a ruler as a further aid, the required values could be easily and speedily projected on a graduated scale.

The degree of roundness (R) and sphericity (S) of the cobbles was determined visually on the basis of the accompanying chart (Fig. 3).

A report on the observations made at one point has been appended with the morphologic measurements explained above (Table 1).

The classifications of the grain size of various loose surficial deposits applied in practice (Pettijohn 1949, p. 16) would have divided the stones into so few size classes that a comparison of the interrelationships between the size and form of the cobbles and the distances they had been transported would have proved inconclusive. Hence, the author, using the maximum diagonal as the basis of division, ended up after numerous experiments with the following classification:

1. 2— 6 cm
2. 6—10 »
3. 10—14 »
4. 14—18 »
5. 18—22 »
6. 22< »

Because the main part of the stones investigated belong to the size class of cobbles, this term will be used in this paper for all specimens treated.

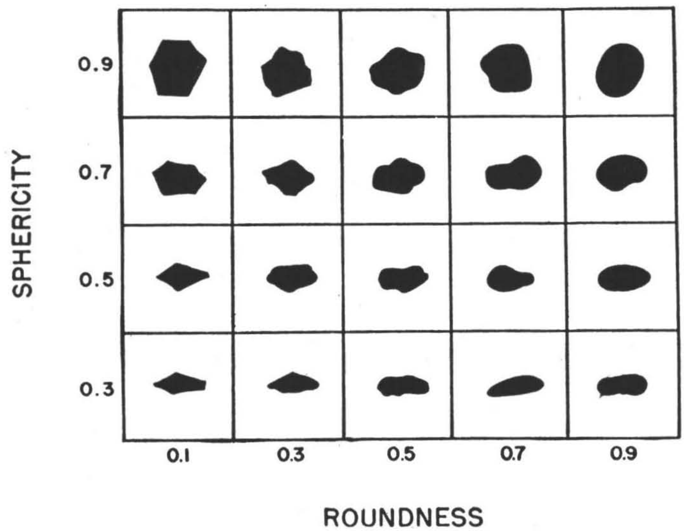

Fig. 3. Visual chart for estimating roundness and sphericity. With permission of W. C. Krumbein and L. L. Sloss: Stratigraphy and sedimentation, W. H. Freeman and Company, San Francisco, 1951.

The indices of flatness (F) and asymmetry (A) of the cobbles have been calculated after Cailleux (1945), from the values A, B, C and AO, presented in Fig. 2. The index of flatness (F) is obtained from the formula $\frac{A+B}{2\,C}$. Since $A > B > C$, this index $= 1$ for a perfect sphere, and it increases from this figure as the degree of flatness increases toward the extreme value of 10. The index of asymmetry has been computed from the formula $\frac{AO}{A}$. In the case of a wholly symmetrical cobble ($AO = \frac{A}{2}$) $= 0.5$, and it increases as the degree of asymmetry increases toward the extreme value 1.

Appended is the same stone count as in Table 1, but grouped by cobble size according to the different rock types and including the indices of flatness (F) and asymmetry (A) as well as the visually determined degree of roundness (R) and sphericity (S) (Table 2). Since the treatment of such an abundance of material in this form, too, would have been exceedingly troublesome, I computed the means of the various indices (F, A, R and S) by rock type and size class; thereby, I obtained the appended stone count values for each observation as the basis on which to carry out the study proper (Table 3, Localites 1—16). These tables also give the total mean values of the different indices and the abundance of the various rock groups at each locality.

INTERPRETATION OF THE OBSERVED MATERIAL

In the following, an interpretation of the observed material as treated in the manner described is given for each sampling point and each class of rocks. Here it is primarily limited to the separate estimation, on morphologic and lithologic grounds, of the distance and the direction the cobbles of the eskers had been transported. The values obtained have been marked for each kind of rock on a separate map (Figs. 4—8) in such a way that the estimation made on a morphologic basis is marked with a broken line, and the one made on a lithologic basis with a continuous line in an open sector. Especially in conflicting cases, the results yielded by these different procedures have been critically reviewed. If, for instance, the lithologic interpretation has suggested various possibilities in regard to the direction and the distance the material had been transported, the likeliest has been chosen on the basis of the morphologic indications. In contradicting cases, an effort has been made to explain the contradictory result arrived at by morphologic means as being due to a differing mode of transportation.

GABBROS

GENERAL REMARKS ON THE MORPHOLOGY OF THE GABBRO COBBLES

Comparing the morphologic indices of the gabbro cobbles on the basis of size, the results are somewhat contradictory. On the whole, large cobbles are less flattened, more asymmetrical and more rounded than small cobbles. In respect to sphericity there appears to be no consistency.

Locality	F	A	R	S
8	1.2	0.6	0.9	0.8
5	1.4	0.6	0.9	0.7
7	1.5	0.7	0.8	0.7
6	1.7	0.7	0.8	0.5
3	1.8	0.6	0.8	0.7
10	1.7	0.5	0.7	0.7
12	1.6	0.6	0.4	0.4

Since there is a rather limited quantity of large gabbro cobbles in the eskers, the inconsistencies in the results are probably largely due to the insufficiency of the material for the purpose of a statistical analysis of this kind. Thus, it has been necessary to be content with carrying out the morphologic interpretation of the gabbro material on the basis of the means covering the entire stone count of the different indices. These have been arranged in the accompanying table according to a diminishing index of roundness (R).

The table shows that a decrease in roundness is in general accompanied by increasing flatness and this, as might be expected, by a decrease in the degree of sphericity. In respect to asymmetry, there is neither a distinct variation or regularity.

There are clear petrographic grounds for the aforementioned morphologic consistency of the gabbro cobbles. In general, gabbros are structurally homogeneous rocks with unoriented textures, and they are often characterized by joints cutting each other perpendicularly. Thus, gabbro cobbles are quite likely to appear symmetrical already in their primary state, and the change in shape taking place during transportation accordingly depends principally on abrasion.

Considered in the light of each individual sampling point, the following conclusions may be drawn on the basis of the morphology and lithology of gabbro cobbles:

Localities 1 and 2.

MORPH.: Gabbros absent.

LITH.: The absence of gabbros is understandable when it is noted, according to the general geological map of Sederholm (1903), that the sector extending northward in a broad angle from these points is totally lacking in basic plutonic rocks. On the other hand, the absence of gabbro cobbles at Locality 2 eliminates the possibility that the material might have been carried from the west, for to the west-northwest of the point there is a gabbro massif several square kilometers in area which would have had to leave a clear mark on the lithology of the esker. The most likely direction of transport is therefore from the northern sector parallel to the local esker.

Locality 3.

MORPH.: The mean roundness suggests that the material was transported a moderate distance. The small cobbles are generally less abraded than the larger ones.

LITH.: The remarkably high gabbro content indicates indisputable transportation from the northwest from the gabbro formations situated in the immediate vicinity of Locality 3 and on the western side of Locality 2.

Since the transportation distance, as judged by the lithologic evidence, is so short, the reason for the fairly high degree of morphologic change exhibited by the cobbles probably ought to be chiefly sought in the mode of transportation.

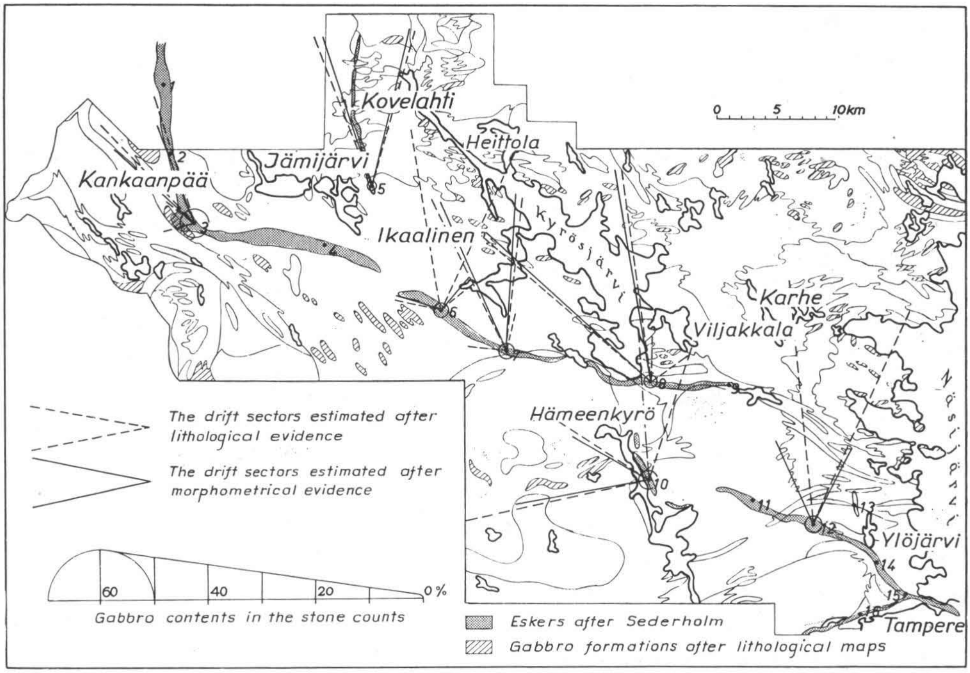

Fig. 4. Probable provenance of the gabbro cobbles.

L o c a l i t y 4.

MORPH.: Gabbros absent.

LITH.: Since gabbro occurrences are situated to the west of the immediate vicinity, the lack of gabbros may be regarded as plain evidence that no transportation took place from the west.

L o c a l i t y 5.

MORPH.: The marked roundness and slight flatness of cobbles indicate that they had been transported moderate distance.

LITH.: The minor gabbro material probably originated from the small, presumably only partially exposed, gabbro massifs situated in the area of Kovelahti in the direction of the esker extending north from the sampling point.

L o c a l i t y 6.

MORPH.: The degree of roundness is the same as at Locality 7, but the greater flatness and lower sphericity suggest a more local material probably derived from small, covered gabbro massifs.

LITH.: The slightly larger amount of gabbro, as compared with Locality 5, is likely to have originated from the Heittola—Ikaalinen area just as easily as from apparently existent, though covered, small gabbro massifs. The latter alternative is however also supported by the morphology.

Locality 7.

MORPH.: A slighter flatness and a higher degree of sphericity suggest a longer transportation distance than in case of Locality 6.

LITH.: Just as in case of Locality 6, the gabbro cobbles may here be regarded as having originated either from covered local massifs or those situated west of Ikaalinen. The morphology tends to suggest the latter possibility.

Locality 8.

MORPH.: Slight flatness as well as marked sphericity and roundness provide good evidence of transportation over a long distance.

LITH.: Morphology excludes the nearby gabbros of Viljakkala from among the possibilities. On the other hand, an anomalous transportation direction from the northeast is also presupposed. What remains, therefore, is a movement occurring from the Ikaalinen area, a movement apparently promoted by the advance of the continental ice sheet across the basin of Lake Kyrösjärvi.

Locality 9.

Gabbros absent.

Locality 10.

MORPH.: Mean index values indicate a short transportation distance. On the basis of this evidence the cobbles would seem to have originated from the gabbros in the southwestern part of Hämeenkyrö.

LITH.: Judging by the gabbros alone, transportation from the massifs situated in the southwestern part of Hämeenkyrö is highly possible. This possibility is also supported by the morphology of the cobbles. Still, this direction is unlikely for two reasons: Massifs located so near by and which are of such a relatively large size ought to have left, in the event of a westerly movement, a stronger stamp on the lithology of the esker material. The possibility of a westerly transportation is even more firmly ruled out by the fact that cobbles which might indicate derivation from the very extensively veined gneiss formation located on the western side are totally lacking. Accordingly, the massifs of Viljakkala remain the most likely sources of the gabbros. The lack of morphologic deformity in the cobbles despite the longer distance involved may be attributed to the mode of transportation.

Locality 11.

MORPH.: Gabbros absent.

LITH.: The lack of gabbros lends support to the view that the gabbro material of the preceding Locality 10 originated from the north. In the event of a predominantly westerly transportation, one would have expected the influence of the gabbros to have likewise extended to this locality.

Locality 12.

MORPH.: The low roundness and sphericity suggest a short transportation distance.

LITH.: At first sight the source of the cobbles might be considered to be the gabbro formations situated at a relatively great distance northward, in the Karhe area. This conclusion, however, is in radical disagreement with the extremely plain morphologic evidence. The most plausible conclusion, therefore, is that the cobbles here are not gabbros at all, for the most part, but have originated from the coarse-grained, gabbro-like varieties of the basic volcanic formation extending north of the locality.

Localities 13—16.

Gabbros absent.

GRANODIORITES

GENERAL REMARKS ON THE MORPHOLOGY OF THE GRANODIORITE COBBLES

If we place the stone counts in order of a decreasing index of roundness, we shall notice that the increase in flatness does not follow the decrease in degree of roundness as was the case with the gabbros. This has a natural explanation. The internal structures of all the granodiorites in the area are generally oriented in different degrees, being in some cases positively schistose. That is why the granodiorite cobbles are asymmetrical in various ways in their primary form, and abrasion has not been able to eliminate this characteristic.

Locality	F	A	R	S
6	1.8	0.6	0.8	0.6
1	1.8	0.6	0.8	0.5
4	2.0	0.6	0.8	0.5
10	1.5	0.6	0.7	0.7
2	1.6	0.6	0.7	0.7
16	1.7	0.6	0.7	0.6
7	1.8	0.7	0.7	0.6
3	1.9	0.6	0.7	0.6
8	2.2	0.6	0.7	0.5
11	1.6	0.6	0.6	0.6
15	1.6	0.7	0.6	0.6
9	1.7	0.5	0.6	0.5
5	1.8	0.6	0.6	0.6
12	1.9	0.6	0.5	0.6
14	1.7	0.6	0.4	0.5
13	2.0	0.6	0.4	0.5

Locality 1.

MORPH.: The marked roundness indicates transportation over a long distance. The low sphericity is, to be sure, at odds with this conclusion, but it can be attributed to the asymmetry of the original form.

LITH.: The amount of granodioritic material is conspicuously large (36 %). This is natural, for a very broad sector consisting of infracrustal rocks extends northward from the area of Kankaanpää. On the general geological map of Sederholm (op. cit.), to be sure, it is totally marked in the color of red granite. Nowadays, however, it is known that there is at least as much granodiorite as red granite in this area. Accordingly, a wide-angled northern sector evidently must be sought to explain the transportation of the cobbles.

Locality 2.

MORPH.: The index of roundness points to a shorter transportation distance than in the cases of Locality 1 and at the same time indicates a distinct decline from the average, and especially so on the part of the smaller cobbles.

LITH.: When the sampling point is situated on granodiorite, the contribution of short-distance or local material is natural. On the other hand, the slight effect on the stone count of granite and schist formations situated west of the point excludes the possibility of transportation from the west and indicates transportation from nearly due north.

Locality 3.

MORPH.: The mean of the index of roundness remains the same as in the preceding observation, but it is higher in cobbles of medium size. A longer transportation distance, in this case seems to be accompanied by an increased flatness.

LITH.: The granodiorite content is still conspicuously high, but compared to the foregoing observations a marked decline has nevertheless taken place. Since the sampling point is situated on granodiorite, this decline can only be explained by the fact that the direction of ice advance here had turned more to the west. The substantial increase in the schist material also indicates this.

Locality 4.

MORPH.: The degrees of roundness and flatness bear witness to transportation over a long distance. The considerable flatness of the small cobbles particularly supports this view.

LITH.: Since the locality is situated on granodiorite, it is difficult on a lithologic basis to determine to what extent local material and material from the north have contributed to the abundant granodioritic content.

Locality 5.

MORPH.: The low degree of roundness and low sphericity of the largest and smallest cobbles, in particular, bespeak the fact that at least a notable proportion of the granodiorite material originated locally.

LITH.: Considering that the locality is situated at the northern edge of an extensive granodiorite formation, the granodiorite content is surprisingly high (22 %). It is apparent that a portion of the material, perhaps primarily the cobbles of medium size as indicated by the morphology, have originated from the areas of Kovelahti farther north.

Localities 6 and 7.

MORPH.: Although the mean roudness of the cobbles at Locality 7 is slightly lower than at Locality 6, the morphologic indices of both are relatively analogous. Since both points are situated in the center of the granodiorite area, they must include an abundance of local or short-distance material as well as a considerable quantity of material from farther away, which evens out the foregoing index means.

LITH.: The locations of these localities clarifies the abundant granodiorite content (45 and 50 %). Even though material of more distant origin is included, the observations incontrovertibly bear witness to the substantial contribution of local material.

Locality 8.

MORPH.: The relatively moderate degrees of roundness and sphericity, especially of the larger cobbles, testify to transportation over a moderate distance.

LITH.: Compared to the foregoing observation points, a notable decrease in the granodiorite content has occurred in favor of the schists of Viljakkala. This excludes the possibility of transportation from the west and indicates a northerly movement guided by the basin of Kyrösjärvi.

Locality 9.

MORPH.: Expressly the lower roundness and lower flatness indicate a distinctly shorter transportation than in the preceding case. The small cobbles and also to some extent the medium-sized ones, are only slightly rounded and flattened.

LITH.: The continuous decrease in the granodiorite content in favor of both the schists and granite of Viljakkala indicates transportation from the north-northwest.

Locality 10.

MORPH.: The index of roundness suggests transportation over a medium distance and, with respect to the smallest cobbles, over a longer distance. The slight flatness and the high sphericity may be partially due to the unoriented structure of the rock.

LITH.: The location of this point in relation to the granodiorite massif has added considerably to the quantity of this rock type in the stone count. Since the extensively distributed veined gneiss occurring in the west contributes nothing to the lithology of the esker material, both the fact of transportation from the north and the substantial representation of the local material are reinforced.

Locality 11.

MORPH.: All three factors, low roundness, pronounced flatness and low sphericity equally testify to quite short transportation.

LITH.: The granodiorite content rising to a maximum (60 %) in the center of a granodiorite area does not provide any significant indications of the direction of transport but does, on the other hand, bear witness to the noteworthy contribution of local material or material originating from nearby.

Locality 12.

MORPH.: Low roundness and low sphericity testify more forcefully than even in the foregoing, to the local origin of the material. Compared to the previous localities, the rather high index of flatness may be accounted for by the schistose structure of the rock.

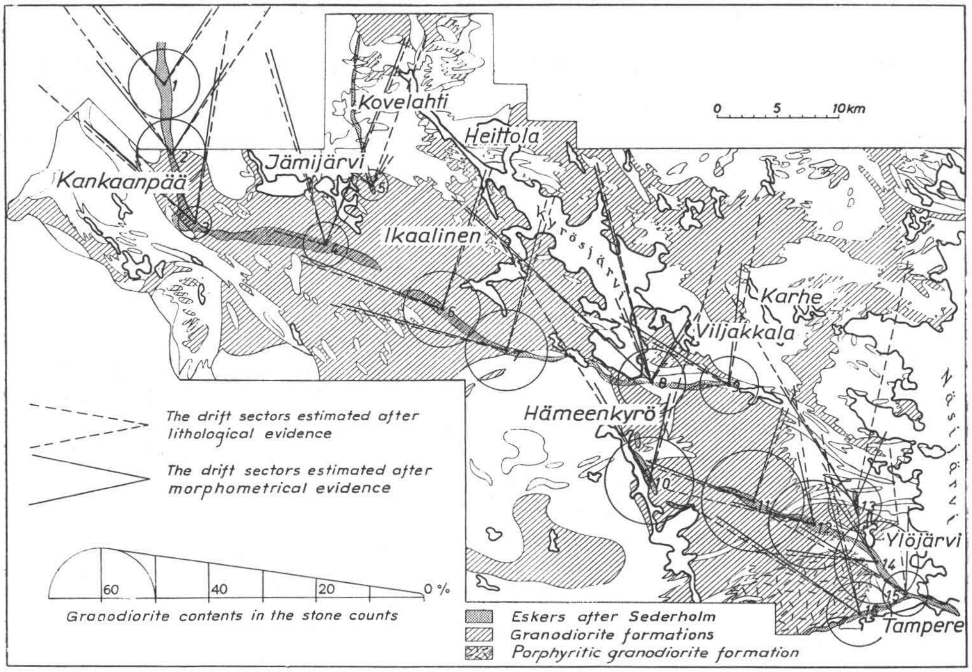

Fig. 5. Probable provenance of the granodiorite cobbles.

LITH.: The contribution of material from the schist formation extending northward from the locality has caused a marked decrease in the granodiorite content, which clearly indicates a north-northwesterly direction of transportation.

Locality 13.

MORPH.: The low indices of roundness and sphericity bespeak a very short transportation distance or local origin.

LITH.: The position of the point in relation to the granodiorite formations plainly suggests derivation from the intrusives to the north in the southeastern part of the Karhe district, thereby negating the indications given by the morphology. To be sure, the relatively small amount of granodiorite might be explained on the basis of a movement from the west-northwest; but this again would be in clear conflict with the occurrence of schist material derived from the north.

Locality 14.

MORPH.: Exceptionally low roundness and sphericity indicate transportation over a very short distance.

LITH.: An abundant granodiorite content incontrovertibly points to transportation from the northwest.

Locality 15.

MORPH.: The low degree of sphericity among the cobbles of medium size, the low roundness of the smallest and largest, and the slight flatness of all size classes equally bear witness to transportation over a short distance.

LITH.: A granodiorite content substantially below the preceding and more specifically, the type of granodiorite, indicate transportation from the northwest, roughly in the direction of the esker.

Locality 16.

MORPH.: The morphologic indices of the cobbles indicate transportation over a longer distance than in the preceding case.

LITH.: Both the position of the sampling point and the abundance of granodiorite indicate transportation from the northwest. It is especially noteworthy that although the sampling point is situated at the southeastern margin of an occurrence of porphyritic granodiorite, this rock is totally missing from the stone count and is met with only as a very occasional over-sized boulder on the summit of the esker. This suggests that the granodiorite material would have had to travel at least from the southwestern side of the aforementioned porphyritic granodiorite.

GRANITES

GENERAL REMARKS ON THE LITHOLOGY OF THE GRANITE COBBLES

In respect to the granites, the result given by the stone counts is quite surprising. The granite content of Localities 1 to 10 is in the same quantitative class despite the fact that the points are situated in markedly differing positions in relation to the granite formations of the district. A more detailed examination, however, yields evidence of the transportation undergone by the material, and expressly the observations farthest to the southeast (11—16) bear witness to the maximum distances traveled by the granite material.

Locality	F	A	R	S
6	1.5	0.6	0.8	0.7
10	1.6	0.6	0.7	0.7
1	1.7	0.7	0.7	0.6
15	1.8	0.6	0.7	0.7
7	1.9	0.6	0.7	0.6
4	1.9	0.6	0.7	0.5
8	1.6	0.6	0.6	0.6
12	1.8	0.6	0.6	0.6
3	1.9	0.7	0.6	0.6
14	1.6	0.6	0.5	0.6
2	1.7	0.5	0.5	0.6
5	1.7	0.6	0.5	0.5
9	1.7	0.6	0.4	0.5
11	1.8	0.6	0.4	0.5
13	2.1	0.6	0.4	0.4

GENERAL REMARKS ON THE MORPHOLOGY OF THE GRANITE COBBLES

Taking into account what has been stated concerning the transportation of the granite cobbles, no very precise results are to be expected from an interpretation of the morphology of the cobbles. To an extent this is also undoubtedly due to the fact that the structural properties of granites vary greatly in different regions and even within different parts of the same massif. Granites are generally homogeneous rocks, but a weak orientation is in many cases characteristic. Especially near contacts with schists, they are likely to appear positively schistose. Accordingly, the primary form of the cobbles has naturally varied and has played a part in the morphologic changes caused by transportation.

If we study the foregoing table in which the granite cobble counts are placed in order of diminishing mean degree of roundness, we can nevertheless note certain regularities. For example, the increasing flatness indicates an obvious tendency to follow the decrease in roundness and a parallel decrease in sphericity is even more evident.

Locality 1.

MORPH.: The mean index values point to transportation over a medium distance.

LITH.: The considerable granite content points, just as in the case of the granodiorite in the foregoing, to the broad northerly area of acid plutonic rocks, but it does not afford any possibility of determining the exact transportation distance or direction.

Locality 2.

MORPH.: The low roundness and low degree of sphericity equally indicate a short transportation distance.

LITH.: Just as in the case of Locality 1, the high granite content points to the broad-angled northern sector.

Locality 3.

MORPH.: The mean index values indicate somewhat longer transportation than in the foregoing case.

LITH.: The marked increase in the granite content plainly shows that additional material had been obtained from the granite occurrences of the nearby Kankaanpää—Jämijärvi area.

Locality 4.

MORPH.: The degree of roundness among the various fractions differs greatly. Among the mean indices, attention is drawn to the low index of sphericity. This is apparently due to the oriented structure of the granite, while, on the other hand, it is also suggested by the pronounced, irregular flatness.

LITH.: The abundant granite content is surprising and hard to interpret. Had the transportation taken place from the west, one would expect the decrease in the amount of granite to be greater in relation to Locality 3. The northern sector thus appears to be the most likely source.

Locality 5.

MORPH.: The mean index values, notably the low degree of roundness and sphericity, suggest transportation of a shorter distance than in the preceding case.

LITH.: The high granite content and an origin from the northern sector are understandable in view of the fact that the locality is situated to the south of extensive granite occurrences.

Localities 6 and 7.

MORPH.: The factor of roundness, both as a mean value and in respect to the fractions of different sizes, testifies to longer transportation than in the preceding case. The conclusion is supported by a moderate sphericity.

LITH.: Considering the position of the sampling points deep inside the granodiorite area, the high granite content is difficult to interpret in any way other than that the stone content of the esker includes such an abundance of material from a considerable distance that it is capable of raising the percentage of granite to the observed level.

Locality 8.

MORPH.: The mean index values testify to a conspicuously short transportation. The slightly lower degree of roundness of medium-size cobbles indicates too, that the smaller fraction has traveled a longer distance. This tendency would, of course, be still more conspicuous had not the fractions of closer and those of more distant origin evened out the means.

LITH.: The high granite content, in agreement with the morphology, points to transportation from the nearby Viljakkala granite and also from the granites of the more distant Heittola—Kovelahti district.

Locality 9.

MORPH.: The low roundness and sphericity consistently give evidence in all size classes of short transportation.

LITH.: The large quantity of granite evidently originated from the granites of the nearby Viljakkala—Karhe area.

Locality 10.

MORPH.: The mean indices reveal wear to a moderate degree, indicating transportation over a medium distance. The indices of the different size fractions are very nearly equal in value. This indicates that the smaller fractions traveled a longer distance than the coarse ones.

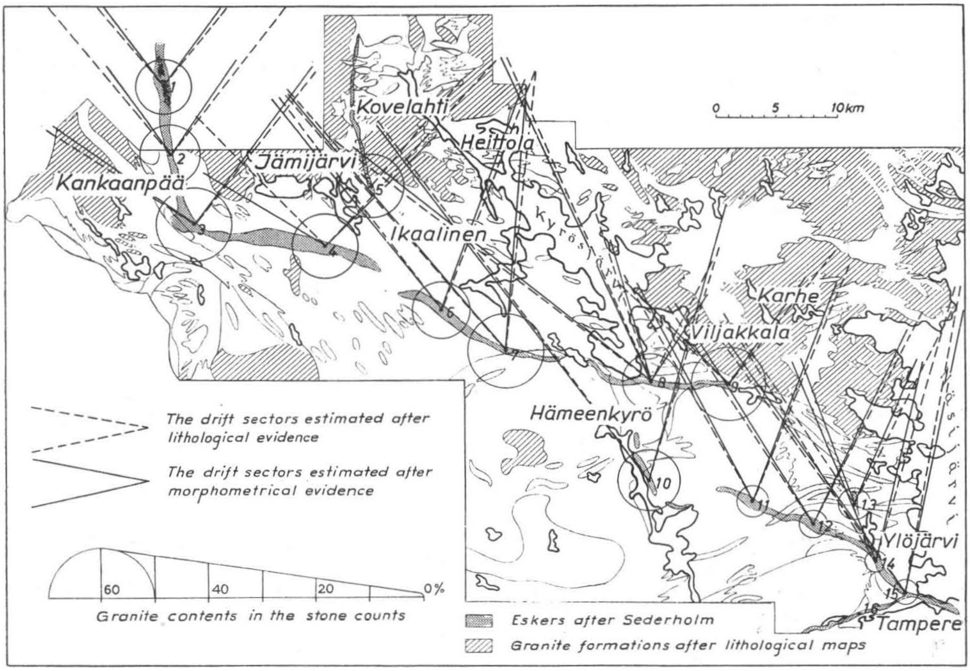

Fig. 6. Probable provenance of the granite cobbles.

LITH.: The granite content of this locality, which even exceeds that of Locality 8, is surprising. It is apparent that the transportation which took place along the basin of Kyrösjärvi contributed most of the material which therefore originated at quite a distance. The Heittola—Kovelahti area seems to be the closest source.

Locality 11.

MORPH.: All the indices indicate that the material is less abraded than at the preceding locality, and therefore it originated from a closer area.

LITH.: The low granite content indicates that the material had not traveled as far as in Localities 1—10. In other words, this reveals the maximum distance traveled by the material, at least at this point. The most likely points of origin of the material remain the granites situated to the east and southeast of Viljakkala.

Locality 12.

MORPH.: The mean index values are about the same as in Locality 11. To be sure, the degree of abrasion, especially in the case of the smallest cobbles, is higher.

LITH.: The low granite content demonstrates here, as in the case of Locality 11, the maximum limit of transportation.

Locality 13.

MORPH.: The mean index values testify to a conspicuously short transportation.

LITH.: The increase in granite content as compared to Localities 11 and 12 points to transportation from the area between Viljakkala and Näsijärvi. Moreover, it reduces the possibility of westerly transportation; in such a case, there ought to be a decrease in contents upon proceeding in a southeasterly direction, whereas in reality there is an increase.

Locality 14.

MORPH.: The mean index values suggest a slightly longer distance than in the foregoing.

LITH.: On the same grounds as the preceding case, the lithology here indicates transportation from the north, from the area lying between Viljakkala and Näsijärvi.

Locality 15.

MORPH.: The same tendency as in the preceding case is evident here.

LITH.: The morphologic indication is understandable, for the locality is situated farther south, i.e., farther from the granites. Transportation from the north is thus probable here also.

Locality 16.

MORPH.: Granites absent.

LITH.: The absence of granites may, on the one hand, indicate the maximum limit of the transportation distance, which would accordingly have been exceeded here, or a change of the transportation direction to one from the northwest.

BASIC SCHISTS

GENERAL REMARKS ON THE MORPHOLOGY OF THE BASIC SCHIST COBBLES

Compared to the plutonic rocks considered in the foregoing, a striking feature of these schists is a rise in the index of flatness and a decrease in the degree of sphericity. This need not have anything to do with the length of the transportation distance, but it may instead be due to the distinct schistose structure of the rock, and as a consequence the cobbles are likely to be originally exceedingly flat.

If, however, we study the accompanying table in which the morphologic mean index values of the basic schist cobbles of the different stone counts have been arranged in accordance with diminishing roundness, we shall notice that the degree of flatness increases and sphericity diminishes as the degree of roundness decreases. It thus appears evident that increasing abrasion of schists tends to decrease the degree of flatness and promote sphericity. The deviations from this tendency appearing in the table are easy to explain as being due to the difference between the original form and the internal structure of the cobbles.

Locality	F	A	R	S
7	1.8	0.6	0.8	0.4
12	1.6	0.5	0.7	0.6
10	1.6	0.6	0.7	0.6
6	1.9	0.7	0.7	0.6
2	2.0	0.6	0.7	0.5
3	2.1	0.6	0.7	0.5
8	2.1	0.7	0.7	0.5
4	2.0	0.6	0.7	0.4
11	1.5	0.6	0.6	0.7
9	1.8	0.7	0.6	0.5
15	1.9	0.6	0.6	0.5
5	2.0	0.6	0.6	0.5
1	3.9	0.6	0.6	0.3
16	1.8	0.6	0.5	0.5
14	2.0	0.6	0.5	0.5
13	2.2	0.6	0.5	0.4

Locality 1.

MORPH.: Since very few basic schist cobbles are represented in this stone count, chance may play a bigger role than statistical probability. At any rate, the results of the measurements show that the small cobbles have undergone conspicuously greater abrasion than the larger ones. The mean values point to transportation over a medium distance.

LITH.: The point of origin of the minimal quantity of basic schists would admirably fit the few basic schist formations indicated on the general geological map of Sederholm (1903) at the upper course of Pukanluoma, southeast of Honkajoki (north of Fig. 7)

Locality 2.

MORPH.: The indices for the different sizes of cobbles are relatively analogous and indicate transportation over a medium distance.

LITH.: The augmented share of basic schists points, besides to the schists of Honkajoki mentioned in the foregoing, to the northernmost part of the Kankaanpää schist sequence. This signifies transportation from the northwest or north-northwest. A movement from more to the west would certainly have caused a greater increase in the proportion of the schists under consideration in the stone count. Even a normal dispersion, one might think, would have brought about such a result, but obviously the local topography prevented the material from moving up from the low-lying schist formation to the level of the sampling point.

Locality 3.

MORPH.: The mean index values are quite analogous to the preceding observation. Distinct differences prevail between the various size groups, with the larger cobbles exhibiting more wear as expected.

LITH.: Since the observation point is located nearly at the extreme eastern margin of an extensive formation of basic schists, the only possibility is transportation from either the northwest or the north-northwest.

Locality 4.

MORPH.: The morphology of the predominant part of the cobbles, particularly of the smaller ones, reveals considerable abrasion and, accordingly, transportation over a long distance.

LITH.: Had the transportation taken place from the west, it would be highly illogical for the point situated farther from the basic schists to have a higher content of these schists than in the case of Locality 3, located in the immediate vicinity of the occurrences. The most plausible avenue of approach here too remains the northern one.

Locality 5.

MORPH.: The mean index values of the different size fractions as well as of the entire stone count indicates short transportation.

LITH.: The abundance of basic schists and the position of the point support the conclusion encouraged by the morphology. Likewise, the situation of the point at the southern end of the northward oriented esker indicates transportation from the area of Kovelahti.

Locality 6.

MORPH.: The mean index values all indicate longer transportation than in the preceding case.

LITH.: The basic schists of this observation appear to have originated mostly in the Kovelahti area, to the north-northwest. This conclusion is supported by the decrease in the amount of schists as compared to Locality 4.

Locality 7.

MORPH.: Judging especially by the index of roundness, longer transportation than even in the preceding case is most likely.

LITH.: Transportation from the north is evident on the same grounds as in Locality 6.

Locality 8.

MORPH.: The indices of the different size fractions are fairly analogous and they suggest transportation over a medium distance. There is a possibility, however, that fractions originating at varying distances have levelled out the averages.

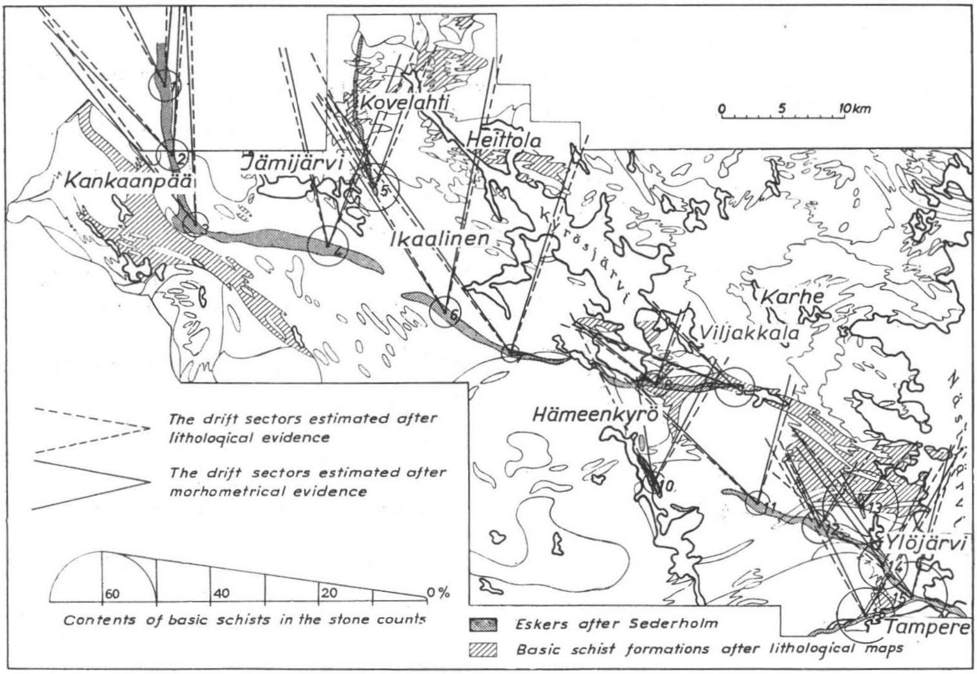

Fig. 7. Probable provenance of the basic schist cobbles.

LITH.: The schist situated on the southern side of Viljakkala is prominently expressed in the stone count. The schist on the western side of Viljakkala probably also contributed cobbles to the esker.

Locality 9.

MORPH.: The mean index values testify to a short or medium transportation.

LITH.: The schist formations of Viljakkala are probably here also the original source of the material and thus a west-northwesterly transportation direction is the only possibility.

Locality 10.

MORPH.: The indices reveal only slight changes in shape and accordingly indicate a relatively short transportation.

LITH.: The only possible avenue of approach for the small quantity of schist material is a northerly one. Hence, the indications given by the morphology and the lithology are in sharp conflict. It is possible that transportation with the firm continental ice sheet, as guided along the basin of Kyrösjärvi, provided no opportunity for the erosive action of streams of meltwater despite the long distance traveled—at least from as far as the schist formations situated on the northern side of Viljakkala.

Locality 11.

MORPH.: The mean index values of the smaller fractions which comprise the majority of the cobbles, suggest transportation over a long distance.

LITH.: Judging also on the basis of the lithology, transportation from the north over a fairly long distance remains the only possibility.

Locality 12.

MORPH.: The evidence of long transportation is quite clear here as well, particularly on the part of the smaller cobbles. The larger ones, on the other hand, have undergone relatively little abrasion.

LITH.: A substantially greater content of basic schists, as compared to Locality 11, indicates the nearby formation extending to the north as the source.

Locality 13.

MORPH.: The degrees of roundness, sphericity and flatness bespeak equally in all size classes of either a local or nearby derivation.

LITH.: The notably high schist content may be attributed to the fact that the locality is situated at the southern margin of an extensive schist formation.

Localities 14—16.

MORPH.: The mean index values indicate relatively short transportation. The small cobbles of Localities 15 and 16, however, appear to have traveled somewhat farther.

LITH.: The abundant basic schist material at these localities has undoubtedly originally come from the schist area of Ylöjärvi spreading out to the north. Possibly the schist bed situated between points 15 and 16 has made a further contribution.

ACID SCHISTS

GENERAL REMARKS ON THE MORPHOLOGY OF THE ACID SCHISTS COBBLES

Since the acid schists constitute, in respect to both rock type and structure, perhaps the most heterogeneous class of rocks considered in the present study, no appreciable conformity to rule should be expected of them in respect to their morphologic properties. If, nevertheless, we examine the accompanying table, arranged again according to a diminishing degree of roundness, we notice that a decrease in roundness is accompanied by increasing flatness and also a slight reduction in the degree of sphericity. And, in spite of everything, this occurs fairly consistently. This tendency would be even more marked if we vere to separate certain localities such as 2, 10 and 11, whose acid schists are for the most part veined gneisses and differ most conspicuously from the rest in structure, and which accordingly respond differently to abrasion.

The most striking difference in comparison with the morphology of the other groups of rocks discussed in the foregoing is a greater flatness and a conspicuously low degree of sphericity.

Locality	F	A	R	S
15	2.1	0.6	0.8	0.5
6	1.8	0.7	0.8	0.5
2	1.6	0.6	0.8	0.6
8	2.4	0.6	0.7	0.5
3	2.3	0.7	0.7	0.5
5	2.0	0.6	0.7	0.6
11	2.7	0.5	0.7	0.6
14	2.5	0.6	0.6	0.4
16	2.3	0.6	0.6	0.4
12	2.3	0.6	0.6	0.5
1	2.3	0.6	0.6	0.5
4	2.1	0.5	0.6	0.5
9	2.2	0.5	0.5	0.4
10	1.5	0.6	0.5	0.7
13	2.5	0.6	0.4	0.4

Locality 1.

MORPH.: The mean index values clearly bear the stamp of transportation over a medium distance. If, on the other hand, the indices of the different size classes are studied, they will be perceived to vary considerably. The irregularity in the indices is due, at least in part, to the fact that certain quartzitic and veined gneissose varieties associated with the sandstone formation of Lauhavuori but which cannot be classed as sandstones on the basis of their petrography, differ from each other in structure and composition.

LITH.: The broad sector extending northward includes only small, scattered occurrences of acid schists. They can scarcely account for the considerable content (18 %) demonstrated by the stone count. It is evident that a substantial part of this material consists of the veined gneissose and quartzitic varieties associated with the sandstone of Lauhavuori (Simonen and Kouvo, 1955). These thus have a definite source and, in a sense, the character of »fossil boulders».

Localities 2 and 3.

MORPH.: The indices again vary as in the preceding case, but nevertheless bear witness to transportation over a longer distance. This is only natural, considering that the points are situated farther from Lauhavuori.

LITH.: The lithology is in harmony with the morphology, the content having decreased in accordance with the increased distance.

Locality 4.

MORPH.: The mean index values indicate short transportation. Lauhavuori can no longer be considered as the source of the cobbles.

LITH.: The proportional increase in the amount of acid schists and the change in variety (compared with Localities 1—3) suggest the Jämijärvi schist formation in the north as the source.

Locality 5.

MORPH.: Especially the degree of roundness of the predominating medium-sized cobbles, and also partly the indices of flatness and sphericity, testify to transportation over a short distance. The index of roundness which reveals exceptionally great wear in the case of a very few of the largest and smallest cobbles, cannot appreciably affect the total mean value or the general tendency.

LITH.: Transportation southward in the direction of the esker which lies to the north appears to be the only possibility.

Locality 6.

MORPH.: The indices of roundness, in particular, indicate transportation over a distinctly longer distance than in the preceding case.

LITH.: The gradual decrease in content from the levels of Localities 4 and 5, in agreement with the morphology, indicates longer transportation from the area of Jämijärvi—Kovelahti.

Locality 7.

MORPH.: Acid schists absent.

LITH.: The total absence of acid schists is somewhat surprising. On the other hand, it is in harmony with the view expressed in Locality 6 and demonstrates that here the maximum distance of the transportation from the Jämijärvi—Kovelahti area has been exceeded.

Locality 8.

MORPH.: The indices of roundness indicate unexpectedly heavy abrasion, particularly in comparison to the great flatness and low degree of sphericity. The last mentioned can, however, be due to the primary shape of the cobbles.

LITH.: Evidently the Viljakkala schist extending to the west and east shores of Kyrösjärvi has impressed its strong stamp on the lithology of the esker material. The high index of roundness, which is in conflict with this, is probably due to the effects of streams of meltwater. Still, it is also likely, as also partially indicated by the morphology, that material has also been borne across the Kyrösjärvi basin from the area of Heittola.

Locality 9.

MORPH.: All three factors, sphericity, roundness and flatness, here testify to relatively short transportation.

LITH.: The low schist percentage indicates transportation from the area of Viljakkala to the northwest.

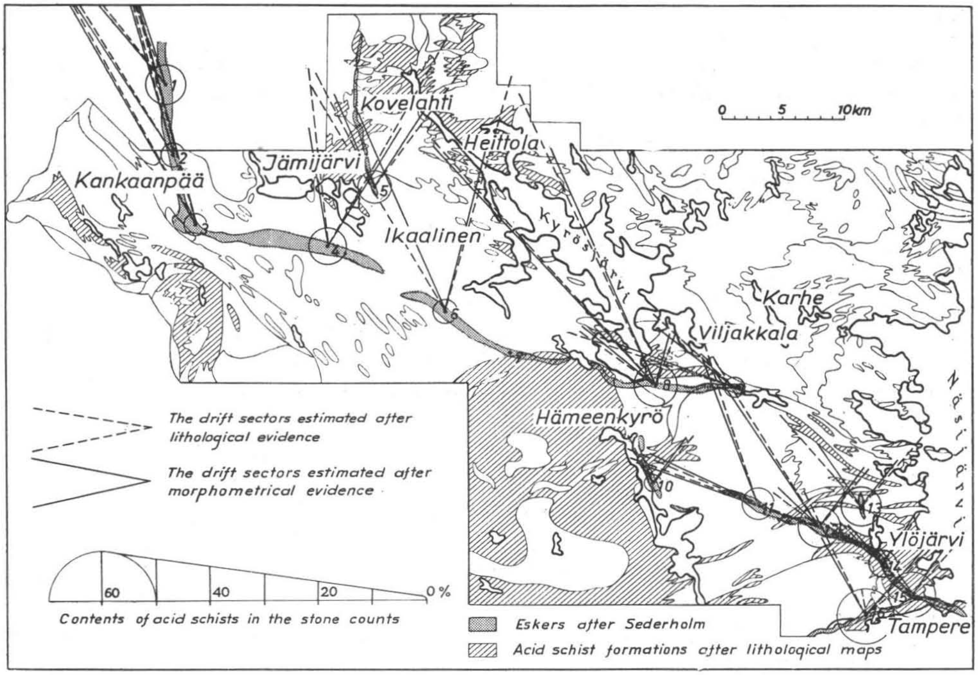

Fig. 8. Probable provenance of the acid schist cobbles.

Locality 10.

MORPH.: The mean index values suggest short transportation.

LITH.: A narrow northerly transportation zone from the nearby schist formation situatéd to the north apparently prevailed here. The influence of the extensive veined gneiss area to the west is not evident.

Locality 11.

MORPH.: The morphology of the small and the medium-sized cobbles points to long transportation. The very largest, even though moderately flat, probably originated from nearby.

LITH.: The abundance of acid schists is surprising. The direction of their arrival is difficult to estimate, but the most likely appears to be one following the trend of the esker.

Locality 12.

MORPH.: The changes in shape of especially the prevailing small-sized cobbles suggests a more nearly local material than in the preceding case.

LITH.: Transportation in a direction corresponding to the esker is possible here too, but undoubtedly the schist beds situated nearby to the north must have also contributed material.

L o c a l i t y 13.

MORPH.: The marked flatness, low sphericity and low roundness revealed by the indices of the different size classes as well as the means testify to relatively local material.

LITH.: The occurrence of schist material in abundance has been most probably derived from local and nearby schist formations.

L o c a l i t i e s 14—16.

MORPH.: The indices of sphericity and flatness particularly impress the schist material with a short-distance stamp. In the case of Locality 15, however, the more pronounced roundness of all the cobbles testifies to material of more distant origin.

LITH.: The contribution of nearby and local schist is obvious.

SANDSTONES

ON THE MORPHOLOGY OF THE SANDSTONE COBBLES

If, after the familiar fashion of the preceding groups of rocks, we place the stone counts in order of decreasing roundness of the sandstone cobbles, we shall observe that hardly any regularity exists in the other mean index values. Particularly striking, moreover, is the fact that the morphological changes do not correspond in this case to any known transportation distance from the sandstone formation of Lauhavuori. This is, to be sure, understandable, considering the scarcity of sandstone cobbles in these stone counts. Hence, in the first place, pure chance may play a bigger part than statistical probability. In the second place, a contributing factor may be a different mode of transportation, and, thirdly, various kinds of sandstone are likely to have a different capacity for resisting abrasive action during transportation. It can only be remarked with regret that no conclusions based on morphology can be drawn concerning this most diagonostic cobble material — in respect to locality of origin — of the entire area under study, other than a decrease in size away from the point of original departure. This

Locality	F	A	R	S
10	1.5	0.6	0.9	0.7
2	1.6	0.6	0.8	0.7
8	1.7	0.6	0.8	0.5
1	1.9	0.6	0.8	0.7
3	1.9	0.8	0.8	0.7
4	2.0	0.6	0.8	0.4
11	1.2	0.6	0.5	0.7
9	1.8	0.7	0.4	0.6

decrease in size and increase in the number of sandstone blocks closer to the sandstone formation of Lauhavuori, outside the area now under study, are brought out quite clearly in the study by Simonen and Kouvo (1955) of the sandstones of Finland.

ON THE LITHOLOGY OF THE SANDSTONE COBBLES

Since the only known sandstone occurrence in the entire area under examination is situated in the locality of Lauhavuori, Isojoki, all the cobbles met with in the stone counts must be regarded as having originated from this formation. The presence in greatest abundance of sandstones in the most northwesterly observation points and only sporadically in the observations from the central and southeastern parts of the area supports the view that all the cobbles met with must be traced to Lauhavuori. No separate map has been drawn for the sandstone because, first, Lauhavuori lies outside the area under survey (about 40 kilometers from locality 1 to N 23°W) and, second, certain sandstone varieties included in the group of acid schists appear in conjunction with them in Localities 1—3, giving exact data concerning the avenue of approach and distance traveled by the material. Scattered observations from elsewhere — individual cobbles have been met with even as far as the southeastern side of Tampere — merely reveal that occasional transportation took place even over such long distances.

THE RANGE OF USE OF THE MORPHOLOGIC METHOD

The stone material of the eskers is initially transported with the ice flow in the manner of moraine. The interpretation of the observed material has shown that both lithological and morphological computations of the provenance of the cobbles are in good agreement. This indicates that the stone material has already during this transportation yielded to shape-changing processes. Transportation within the body of the ice sheet has the least effect on the shape of stones. In other positions they have not only been crushed and fractured, but also changes in shape have resulted. These rough shapes are then principally rounded and worn smooth only when the material is exposed to the action of meltwater. The study has thus shown that the transportation of cobbles during the formation of the eskers, exceptions not included, has in this area been very short.

In the foregoing, mention has been made of the fact that there has not always been a sufficient quantity of cobbles in all the size classes at each locality. In such cases, chance is likely to have played a bigger part than statistical probability in the morphologic mean indices for the various size classes.

Among different kinds of rock and even among different varieties of the same rock class, the shape of the cobbles differs at the very initial stage owing to differences in structure and resistance to abrasion, and hence tend to undergo changes in different ways while being transported equal distances under the same conditions.

In addition to differences in structure and durability, different modes of transportation have also resulted in the morphologic indices not proving comparable in all respects to each other. Especially during transportation within the ice flows whose movements are controlled of by suitable topography, the change of shape of the stones can be very slight even over long distances.

Already during the planning stage of this study, I ventured to assume that the aforementioned factors would prove so significant that no appreciable results could be achieved by measurements of asymmetry. For the same reason I abandoned the measurements of bluntness indices. In order to check the validity of my assumptions, however, I performed the measurements required and computed the asymmetry indices. My assumptions proved to be correct, for no regularity could be noted in this value.

Notwithstanding the varying schistosity of diverse rock types, the degree of flatness follows pretty well the diminishing roundness. On the other hand, this flatness index naturally accompanies quite well the changes of sphericity as both indices reveal the same morphologic feature. The roundness (visually estimated) is most consistently in best agreement with lithological observations. This is particularly so in regard to the biggest cobbles. Twenhofel (1945) has shown that in traction movements the rounding of larger particles is rapid compared to smaller ones. The roundness indices in the different size classes can also be used to draw conclusions of transportation distances in cases in which the bigger stones are more angular than the smaller ones. This view Twenhofel's may also be applied in the framework of this study to the transportation of material during the moraine stage.

As apparent in the detailed interpretation of the material, the lithologic and the morphologic results often agree fairly closely. In contradictory cases, it is possible through a critical comparison of the two methods, to arrive at a certain or at least plausible conclusion regarding the locality of origin of the material. In summary, it may be stated that in work of this kind, the determination of morphologic indices has a special, considerable importance, if only in complementing the lithologic method. However, when a wholly homogeneous rock and similar conditions of transportation are not involved, one might be content with either a mere visual estimation of roundness and sphericity or by supplementing this with the measurements required for the computation of the index of flatness, but leaving the measurements for the indices of bluntness and asymmetry undone.

PROVENANCE OF THE COBBLES OF THE LOCAL ESKERS

After carrying out a critical comparison of the results yielded by the morphology and lithology of the various kinds of rocks, I have marked on the accompanying map (Fig. 9) with unbroken lines the most likely direction of advance and distance traveled by the coarse fraction of the esker in each locality. In positive cases, I have drawn several lines to the same point when the observations have shown that material has been transported from different distances and even from different directions.

The map shows that the transportation of coarse fractions in sufficient abundance to make an impression on the stone count has taken place in the northwestern part of the region (the sandstone of Lauhavuori and varieties of it in Localities 1—3) from a distance of more than forty kilometers. If the sporadic sandstone blocks met with as far as Tampere are also taken into account, the distance exceeds 100 km. It should be noted regarding the same observations, however, that it is the more local material that actually impresses its stamp on the lithology of the esker. The gabbro, granodiorite, granite and basic schist cobbles demonstrate in Localities 2 and 3 that the transportation distance of the material is mainly within the limits of 2—20 km and averages 10—14 km.

Moving eastward to Localities 4 and 5 in the Jämijärvi area, we may note the same tendency. The average transportation distance remains between 10 and 16 km. Taking into account Localities 6 and 7, we may state, expressly on the basis of the granitic and granodioritic material, that quite local rocks do not predominate but that the lithologic composition of the esker receives its actual character from material originating as far away as twenty kilometers or more. This conclusion is not, of course, universally valid. There are local variations in abundance, being due probably in the main to the varying conditions determining the movements of the continental ice sheet. Thus, for instance, on the basis of the granodioritic, granitic, gabbroid and basic schist material, one may judge transportation to have taken place from as far as the Ikaalinen, Heittola and Kovelahti areas, with the continental ice sheet having been guided along the basin of Kyrösjärvi and that of the fork in the lake extending to the western side of Ikaalinen.

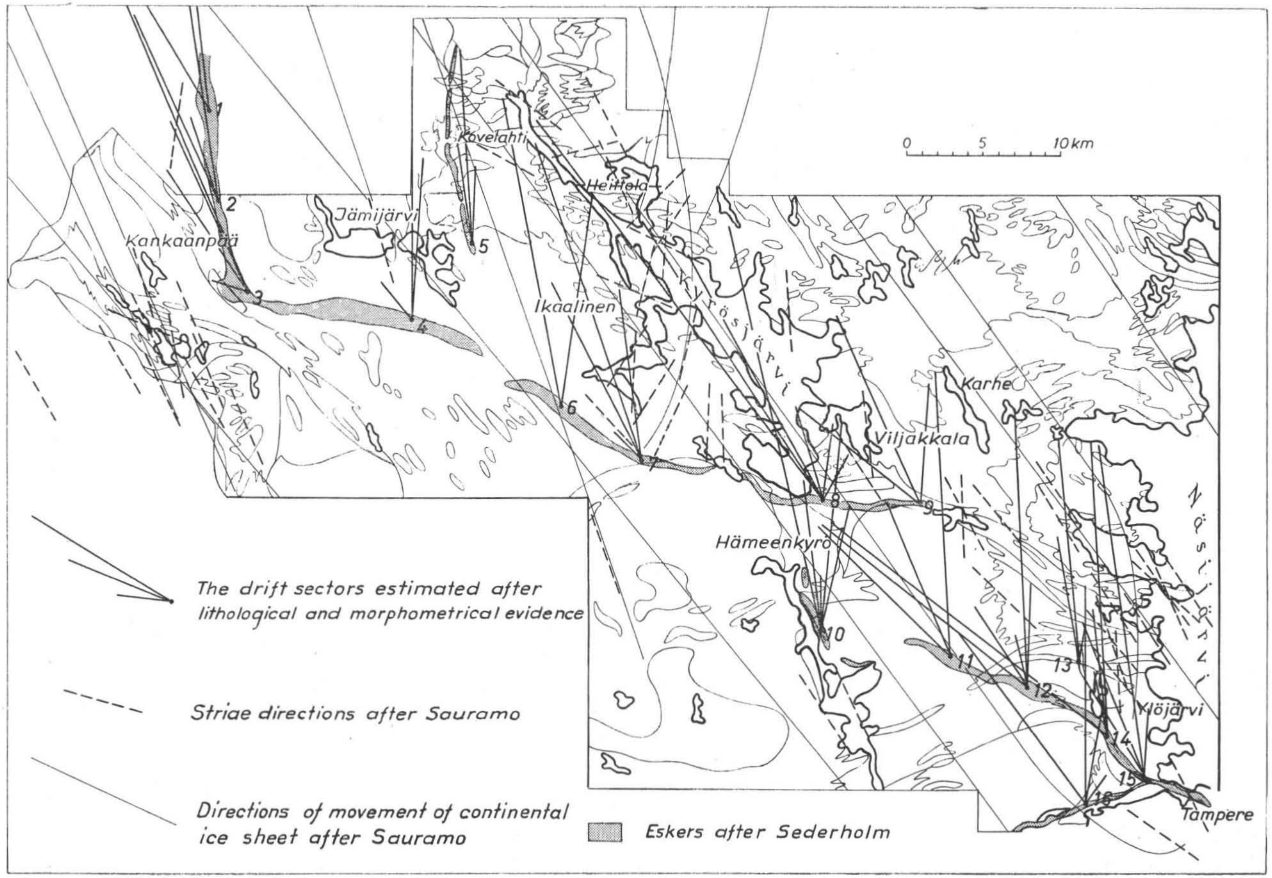

Fig. 9. Provenance of the coarse fraction of the eskers.

Transportation directed by the basin of Kyröjärvi may also be observed between Viljakkala and Hämeenkyrö in Localities 8 and 9. Specifically on the basis of the grabbroid, granodioritic and acid schist material, the average distance traveled exceeds twenty kilometers. On the other hand, the occurrences of numerous rocks demonstrate that relatively local material, originating from a distance of 5—8 km, is a prominent part of the lithology of the esker.

The guiding influence of the Kyrösjärvi waterway appears to extend all the way to Locality 10, situated in the southern part of Hämeenkyrö. Since cobbles from the broad veined gneiss area situated west of the point are very rare in the stone count, the transportation must have taken place strictly from the north. The distances traveled remain here, however, quite modest (8—10 km), except for the granitic material which must have been transported at least fifteen kilometers, i.e., from the massifs of the Viljakkala area, though on the basis of the morphologic properties of the cobbles, some originated from as far away as the Kovelahti area. The remarkably high granite content of Locality 10 is a splendid example of what a tremendous effect favorable topography can have on the movement of a continental ice sheet and the transportation of debris. This is made all the more evident by the low granite contents at Localities 11—16, which remain notably low despite the fact that they are situated either closer to or at least as close to the broad granite massifs as is the Viljakkala granite found nearest Locality 10.

On the basis of its position in relation to the bedrock of the area, Locality 10 is of interest. Its granitic material incontrovertibly bears witness to transportation from the north. On the other hand, judging by the acid and basic schists in particular, and also in part by the granodiorites, transportation from the northwest definitely appears to have occurred. This discrepancy may, perhaps, be explained as having been caused by movements of the continental ice sheet at different times and in different directions. This idea is by no means new. Worthy of deliberation, furthermore, is the point of view that all the material was originally transported from the north but that it was subsequently transported westward by streams of meltwater during the formation of the west-trending esker.

The observations in the Ylöjärvi—Tampere area clearly demonstrate that the decisive share of the coarse fraction of the eskers was transported either from nearby or from a distance of, at the most, 7—8 km. However, the granite content, albeit inconsiderable, testifies to the contribution of material from farther away (10—12 km) as well. Only the granodiorite in this area, which deviates from the other results, gives a clear indication of transportation from the northwest or the west-northwest, with the rest of the cobbles unmistakably pointing to a northerly route. Here this conflict cannot easily be blamed on meltwaters, especially since the granodiorite of Locality 16 cannot have traveled in line with the esker but must have come from the northwest from behind the porphyritic granodiorite formation situated in between at a distance of eight kilometers.

It would seem evident that at an earlier stage, while still thick, the direction of flow of the continental ice sheet had been in a rather straight line from the northwest toward the southeast. It was only later, after the glacier ice had thinned, that it began to submit to the pressures of the region's local topography. The absence of porphyritic granodiorite in Localities 15 and 16 may thereby be partially explained. The porphyritic granodiorite erratics met with on the southern side of the Tampere line of lakes had evidently been transported during earlier movements of the continental ice sheet. The thin layer of the ice of later stages evidently was trapped in the high topography of the porphyritic granodiorite area and melted in place without having been able to carry the debris further.

COMPARISON OF THE RESULTS TO EARLIER STUDIES

The directions in which the esker cobbles, primarily as moraine, had been transported, should to some extent indicate also the directions of movement of the glacier ice in the region. This is so in spite of the fact, as pointed out earlier, that streams of meltwater may in certain cases have played a small part in transporting glacial drift and that the present study, with this in view, has not been supplemented by stone counts of the till.

On the accompanying map (Fig. 9) I have marked, in addition to the results given by this study, the striation trends and directions of movement of the glacier ice in the region according to Sauramo (1924). A comparison of these directions will show that regionally they agree fairly well.

Accordingly, the avenues of approach at Localities 1—3 correspond closely to the lines depicting the direction of movement of the continental ice sheet. Furthermore, the transportation of gabbro material from the west-northwest, as at Locality 3, receives support from certain striation trends measured on the southern side of Kankaanpää. Likewise, the dispersion of the boulder fan consisting of Lauhavuori sandstone so as to extend as far as Tampere is thereby explained.

The relatively constant northerly directions of transport of Localities 4—6 do not wholly agree with the rather scarse striae observations and descriptions of the directions of flow of the continental ice sheet. On the other hand, despite their straight character as drawn on the maps they demonstrate fairly clearly the directing influence of the Kyrösjärvi waterway on the movement of the glacier ice; not only along the main course all the way to Locality 10 in the southern part of Hämeenkyrö, but also along the side-channels running southwestward from Ikaalinen and southeastward from Viljakkala to Localities 7 and 9.

The directions of movement of the continental ice sheet, reinforced by the striae observations, help explain the transportation not only from the north but also from the northwest, as indicated by Localities 11, 12, 14 and 16. On the other hand, Sauramo in only one instance showed a curve which deviated from the general pattern of ice movement, indicating that the ice in the Ylöjärvi—Tampere region was guided in a southerly direction along the basin of Näsijärvi. This is in spite of the fact that Sauramo, in the explanatory text of the Tampere map sheet, specifically emphasizes this influence, which is also manifested in the present study.

The new study by Virkkala (1960) on the glacier movements in the Tampere region is based on striations and till fabric. It covers, unfortunately, only the area of the Localities 10—16. According to Virkkala the oldest glacier movement has been westerly. In agreement with the results of the study on hand, he further indicates, that the strongest movement took place from the northwest and the youngest one, apparently guided by the basins of greater lakes, from the north.

Previous studies have demonstrated that eskers running parallel to the flow of the continental ice sheet and those situated perpendicular to its margin have been created by streams of meltwater during the retreat of the ice. The formation named Hämeenkangas, between the Localities 3—4 and 6—9, to which Virkkala (1956) found an arched extension reaching all the way to the edge of Näsijärvi, had been exclusively described as an end moraine (Sauramo, 1924). Opinions on the origin of Pinsiönkangas, between the Localities 11—15, have differed specifically for the part of it near Tampere; Wiik (1876) and Herlin (1891) regarded it as an end moraine formed by glacier ice that had advanced along the basin of Näsijärvi. Berghell (1892) viewed it as an authentic esker which evolved as a result of the action of streams of meltwater while the continental ice sheet still covered the region. Sauramo (1924), for his part, took a stand amounting to a compromise. On the one hand, he saw in it features characteristic of an end moraine but, on the other hand, he drew attention to the formation's anomalous position in relation to the edge of the prevailing ice sheet and to the sorted aspect and stratified structure of the material, features which are representative of a genuine esker. Recent research appears in ever-increasing measure to accept E. Hyyppä's (1954) theory concerning the origin of eskers in canyon-like crevasses in the continental ice sheet, crevasses formed along depressions following tectonic rupture and movement zones. In the bedrock of the Tampere region, precisely in the locality of the esker in question, is a rupture zone manifested as a steep depression which is oriented in the same direction as the esker. It thus seems highly probable that the eastern end of Hämeenkangas in the Tampere region represents an esker which evolved according to Hyyppä's theory, notwithstanding the fact that its primary material might be deposited by glacier ice whose flow had been guided by the basin of Näsijärvi.

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Table 1. An example of a report originally drawn up in the field. Locality 2, Kankaanpää, Niinisalo.

Rs = rock species. A, B, C and AO = the quantities from Fig. 1. R and S = roundness and sphericity as visually estimated.

gb = gabbro, gd = granodiorite, gr = granite, bs = basic schists, as = acid schists, ss = sandstone.

N:o	Rs	A	B	C	AO	R	S	N:o	Rs	A	B	C	AO	R	S
1	gr	14	9	7	9	0.5	0.5	51	gd	4	4	4	2	0.3	0.9
2	gr	12	12	7	6	.7	.5	52	gd	13	11	7	7	.7	.7
3	gd	7	6	5	4	.9	.9	53	gr	5	5	2	4	.3	.3
4	gd	11	9	8	6	.9	.9	54	gr	4	4	4	2	.7	.9
5	gd	12	11	11	7	.9	.9	55	ss	3	2	2	2	.9	.9
6	ss	17	12	11	9	.9	.9	56	bs	3	3	2	2	.7	.9
7	ss	6	6	5	3	.9	.7	57	gr	3	2	2	2	.3	.5
8	bs	8	7	5	4	.7	.5	58	gr	5	4	3	3	.3	.7
9	gd	14	12	8	9	.7	.7	59	bs	4	4	1	1	.9	.3
10	gd	7	6	3	4	.7	.3	60	gd	4	4	2	3	.5	.5
11	gr	8	6	4	5	.3	.5	61	gr	10	5	4	6	.5	.5
12	as	5	5	2	3	.9	.3	62	bs	3	2	3	2	.9	.7
13	gd	7	5	4	5	.7	.5	63	gd	6	4	3	4	.7	.5
14	gd	9	8	4	5	.9	.5	64	gr	6	4	2	4	.5	.3
15	as	3	3	3	1	.5	.9	65	ss	6	4	3	3	.7	.7
16	gd	6	5	4	4	.7	.7	66	ss	15	10	7	10	.9	.7
17	gr	7	5	3	4	.5	.5	67	gd	7	4	3	4	.7	.7
18	as	4	2	2	2	.9	.7	68	as	6	5	3	4	.7	.3
19	gr	6	4	3	3	.9	.9	69	gd	7	5	3	4	.5	.3
20	bs	5	5	2	3	.9	.3	70	gd	5	5	4	3	.5	.5
21	bs	5	3	3	3	.5	.5	71	gr	9	5	3	5	.3	.5
22	bs	3	3	1	2	.9	.5	72	gd	5	5	3	3	.5	.5
23	gd	6	5	3	4	.7	.7	73	bs	6	4	2	4	.3	.3
24	gr	6	5	3	3	.7	.7	74	gr	8	6	4	5	.5	.5
25	gr	7	6	4	4	.3	.5	75	gd	9	6	5	6	.5	.7
26	gr	17	10	9	9	.5	.7	76	gd	11	9	6	6	.5	.7
27	gr	15	13	9	7	.5	.7	77	gr	4	4	3	2	.7	.5
28	gd	4	4	3	2	.9	.7	78	gd	6	4	4	4	.5	.7
29	gr	7	6	4	4	.7	.5	79	as	6	4	3	4	.9	.5
30	gr	6	4	3	4	.5	.5	80	gr	7	6	4	4	.3	.5
31	gd	11	8	6	8	.5	.5	81	gr	6	4	3	3	.7	.5
32	as	10	7	5	6	.7	.7	82	bs	13	8	5	9	.9	.9
33	gd	9	6	5	6	.5	.7	83	gd	4	3	3	2	.9	.9
34	ss	6	5	3	3	.5	.3	84	as	7	6	6	4	.5	.7
35	gr	8	5	5	5	.9	.7	85	gd	7	6	5	4	.5	.5
36	gd	5	3	2	3	.5	.5	86	bs	5	3	2	3	.3	.3
37	gd	5	4	2	2	.7	.3	87	gr	8	8	6	4	.3	.7
38	gd	4	3	3	2	.9	.9	88	gd	4	4	4	2	.7	.9
39	ss	7	5	4	4	.9	.9	89	gr	3	2	2	1	.5	.9
40	as	7	4	4	4	.9	.9	90	gd	5	4	3	3	.7	.5
41	bs	7	5	5	4	.7	.7	91	gr	7	6	3	4	.7	.5
42	gr	7	5	3	5	.3	.3	92	gd	3	2	2	2	.9	.7
43	gr	9	6	3	5	.3	.5	93	bs	4	3	2	2	.3	.5
44	gd	7	6	4	4	.7	.5	94	gr	4	4	3	3	.5	.5
45	gd	12	7	5	6	.7	.5	95	gd	8	6	5	4	.7	.7
46	as	10	6	5	5	.9	.5	96	gr	8	5	4	6	.5	.7
47	gd	4	4	3	2	.5	.5	97	ss	9	9	6	5	.9	.9
48	ss	4	3	2	2	.9	.7	98	bs	4	2	1	2	.9	.5
49	ss	5	3	2	3	.9	.5	99	gr	7	4	4	4	.3	.7
50	gd	4	4	4	2	.3	.9	100	gd	8	7	5	5	.9	.9

Table 2. The stone count from Table 1. grouped according to rock types and size of stones with calculated morphological indices of flatness (F) and asymmetry (A) and visually estimated roundness (R) and sphericity (S).

Granodiorite

Ø 2—6 cm

F	A	R	S
1.3	0.5	0.9	0.0
2.0	.6	.5	.5
2.3	.6	.7	.3
1.2	.5	.9	.9
1.3	.5	.5	.5
1.0	.5	.3	.9
1.0	.5	.3	.9
2.0	.8	.5	.5
1.2	.6	.5	.5
1.7	.6	.5	.5
1.2	.5	.9	.9
1.0	.5	.7	.9
1.5	.6	.7	.5
1.7	.7	.9	.7
1.5	.5	.7	.7

Ø 6—10 cm

F	A	R	S
1.5	0.7	0.7	0.5
2.2	.6	.7	.3
1.3	.6	.9	.9
2.1	.6	·9	.5
1.4	.7	.7	.7
1.8	.7	.7	.7
1.5	.7	.5	.7
1.6	.6	.7	.5
1.7	.7	.7	.5
1.8	.6	.7	.7
2.0	.6	.5	.3
1.5	.7	.5	.7
1.3	.7	.5	.7
1.3	.6	.5	.5
1.5	.6	.9	.9

Ø 10—14 cm

F	A	R	S
1.2	0.5	0.9	0.9
1.0	.6	.9	.9
1.6	.7	.5	.5
1.9	.5	.7	.5
1.7	.5	.7	.7
1.7	.5	.5	.7

Ø 14—18 cm

F	A	R	S
1.6	0.6	0.7	0.7

Granite

Ø 2—6 cm

F	A	R	S
1.3	0.8	0.5	0.5
1.2	.5	.5	.9
1.3	.5	.7	.5
1.5	.6	.3	.7
1.3	.7	.3	.5
1.0	.5	.7	.9
2.5	.8	.3	.3

Ø 6—10 cm

F	A	R	S
1.8	0.6	0.3	0.5
2.0	.6	.5	.5
1.7	.5	.9	.9
1.8	.5	.7	.7
1.6	.6	.3	.5
1.6	.6	.7	.5
1.7	.7	.5	.5
1.3	.6	.9	.7
2.0	.7	.3	.3
2.5	.6	.3	.5
2.0	.7	.5	.3
2.3	.6	.3	.5
1.8	.6	.5	.5
1.6	.6	.3	.5
1.7	.5	.7	.5
1.3	.5	.3	.7
2.2	.6	.7	.5
1.6	.8	.5	.7
1.4	.6	.3	.7

Ø 10—14 cm

F	A	R	S
1.7	0.5	0.7	0.5
1.9	.6	.5	.5

Ø 14—18 cm

F	A	R	S
2.4	0.6	0.5	0.5
1.5	.5	.5	.7
1.6	.5	.5	.7

Basic schists

Ø 2—6 cm

F	A	R	S
2.0	0.6	0.9	0.3
1.6	.6	.5	.5
3.0	.5	.9	.5
1.5	.7	.7	.9
4.0	.8	.9	.3
1.1	.7	.9	.7
2.0	.6	.3	.3
1.8	.5	.3	.5
2.0	.5	.9	.5

Ø 6—10 cm

F	A	R	S
1.5	0.5	0.7	0.5
1.2	.6	.7	.7
2.5	.7	.3	.3

Ø 10—14 cm

F	A	R	S
2.1	0.7	0.9	0.5

Acid schists

Ø 2—6 cm

F	A	R	S
2.5	0.6	0.9	0.3
1.0	.5	.5	.9
1.5	.5	.9	.7

Ø 6—10 cm

F	A	R	S
1.4	0.6	0.9	0.9
1.8	.7	.7	.3
1.7	.7	.9	.5
1.1	.6	.5	.7

Ø 10—14 cm

F	A	R	S
1.7	0.6	0.7	0.7
1.6	.5	.9	.5

Sandstone

Ø 2—6 cm

F	A	R	S
1.3	0.7	0.9	0.9
1.0	.6	.9	.5
1.8	.5	.9	.7

Ø 6—10 cm

F	A	R	S
1.2	0.5	0.9	0.7
1.8	.5	.5	.3
1.5	.6	.7	.7
1.7	.5	.7	.7
1.5	.5	.9	.9

Ø 14—18 cm

F	A	R	S
1.8	0.7	0.9	0.7
1.3	.5	.9	.9

Table 3. The mean values of the stone counts and morphologic indices by rock type and also by size classes. Explanations as in Table 1 and 2.

Locality 1. Kankaanpää, Hietaharju.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	9	1.9	0.6	0.7	0.4	12	1.9	0.7	0.5	0.5	1	3.0	0.6	0.9	0.3	7	2.5	0.6	0.5	0.3	4	1.7	0.7	0.6	0.5
6—10	—	—	—	—	—	17	1.7	0.7	0.6	0.5	15	1.7	0.7	0.6	0.5	—	—	—	—	—	7	2.0	0.7	0.6	0.4	3	1.7	0.7	0.6	0.5
10—14	—	—	—	—	—	8	1.9	0.6	0.7	0.5	4	1.7	0.6	0.7	0.7	1	4.8	0.7	0.3	0.3	1	1.8	0.6	0.9	0.7	2	2.0	0.6	0.9	0.5
14—18	—	—	—	—	—	1	1.6	0.6	0.9	0.5	3	1.7	0.6	0.8	0.6	—	—	—	—	—	2	2.6	0.6	0.5	0.4	1	2.1	0.5	0.9	0.7
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2.4	0.7	0.7	0.5	—	—	—	—	—
22<	—	—	—	—	—	1	1.7	0.7	0.9	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	36%	1.8	0.6	0.8	0.5	34%	1.7	0.7	0.7	0.6	2%	3.9	0.6	0.6	0.3	18%	2.3	0.6	0.6	0.5	10%	1.9	0.6	0.8	0.6

Locality 2. Kankaanpää, Niinisalo.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	15	1.5	0.6	0.6	0.7	7	1.4	0.6	0.4	0.6	9	2.1	0.6	0.7	0.5	3	1.7	0.5	0.8	0.6	3	1.7	0.6	0.9	0.7
6—10	—	—	—	—	—	15	1.6	0.6	0.7	0.6	19	1.8	0.5	0.5	0.5	3	1.7	0.6	0.6	0.5	4	1.5	0.6	0.8	0.6	5	1.5	0.5	0.7	0.7
10—14	—	—	—	—	—	6	1.5	0.6	0.7	0.7	2	1.8	0.5	0.6	0.5	1	2.1	0.7	0.9	0.5	2	1.6	0.6	0.8	0.6	—	—	—	—	—
14—18	—	—	—	—	—	1	1.6	0.6	0.7	0.7	3	1.8	0.5	0.5	0.6	—	—	—	—	—	—	—	—	—	—	2	1.5	0.6	0.9	0.8
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	37%	1.6	0.6	0.7	0.7	31%	1.7	0.5	0.5	0.6	13%	2.0	0.6	0.7	0.5	9%	1.6	0.6	0.8	0.6	10%	1.6	0.6	0.8	0.7

Locality 3. Kankaanpää, Kuninkaanlähde.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	3	1.7	0.5	0.7	0.8	12	1.8	0.6	0.7	0.8	10	2.0	0.7	0.5	0.6	2	1.9	0.7	0.5	0.4	2	1.8	0.7	0.9	0.6	2	1.8	0.8	0.8	0.7
6—10	8	1.9	0.6	0.8	0.7	8	2.1	0.6	0.7	0.5	23	1.9	0.6	0.5	0.5	4	2.3	0.6	0.8	0.5	7	2.8	0.7	0.5	0.4	3	2.0	0.7	0.8	0.6
10—14	—	—	—	—	—	3	1.7	0.6	0.8	0.6	6	2.4	0.7	0.5	0.4	4	2.2	0.6	0.9	0.6	—	—	—	—	—	—	—	—	—	—
14—18	—	—	—	—	—	—	—	—	—	—	1	1.5	0.6	0.7	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	1	1.6	0.7	0.9	0.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	1	1.9	0.7	0.9	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12%	1.8	0.6	0.8	0.7	23%	1.9	0.6	0.7	0.6	41%	1.9	0.7	0.6	0.6	10%	2.1	0.6	0.7	0.5	9%	2.3	0.7	0.7	0.5	5%	1.9	0.8	0.8	0.7

Locality 4. Jämijärvi, Soininharju.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	15	2.1	0.5	0.7	0.5	18	1.8	0.6	0.5	0.5	18	2.3	0.6	0.8	0.4	9	1.9	0.7	0.6	0.5	3	2.2	0.6	0.8	0.4
6—10	—	—	—	—	—	6	2.0	0.6	0.8	0.5	14	1.8	0.5	0.6	0.5	3	1.7	0.6	0.6	0.4	7	2.4	0.5	0.6	0.4	1	1.8	0.6	0.7	0.3
10—14	—	—	—	—	—	3	1.8	0.7	0.8	0.6	1	2.3	0.6	0.9	0.5	—	—	—	—	—	1	1.9	0.6	0.7	0.7	—	—	—	—	—
14—18	—	—	—	—	—	—	—	—	—	—	1	1.7	0.6	0.9	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	24%	2.0	0.6	0.8	0.5	34%	1.9	0.6	0.7	0.5	21%	2.0	0.6	0.7	0.4	17%	2.1	0.5	0.6	0.5	4%	2.0	0.6	0.8	0.4

Locality 5. Jämijärvi, Järvensivu.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	1	1.5	0.5	0.9	0.7	5	1.7	0.6	0.6	0.6	18	1.5	0.6	0.5	0.6	14	1.6	0.5	0.7	0.6	3	1.6	0.6	0.8	0.6	—	—	—	—	—
6—10	—	—	—	—	—	12	1.7	0.6	0.7	0.6	12	1.5	0.6	0.5	0.6	7	1.8	0.6	0.6	0.5	11	2.0	0.6	0.5	0.5	—	—	—	—	—
10—14	1	1.3	0.6	0.9	0.7	4	1.8	0.5	0.7	0.6	4	2.0	0.6	0.4	0.4	4	2.1	0.6	0.4	0.4	2	2.3	0.6	0.7	0.6	—	—	—	—	—
14—18	—	—	—	—	—	1	1.8	0.6	0.5	0.5	—	—	—	—	—	1	2.3	0.6	0.5	0.5	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2%	1.4	0.6	0.9	0.7	22%	1.8	0.6	0.6	0.6	34%	1.7	0.6	0.5	0.5	26%	2.0	0.6	0.6	0.5	16%	2.0	0.6	0.7	0.6	—%	—	—	—	—

Locality 6. Ikaalinen, Vatula.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	5	1.7	0.7	0.8	0.5	19	1.5	0.6	0.8	0.6	18	1.5	0.6	0.6	0.6	7	1.8	0.7	0.7	0.6	5	2.0	0.6	0.6	0.4	—	—	—	—	—
6—10	—	—	—	—	—	11	1.7	0.6	0.8	0.7	8	1.4	0.6	0.6	0.6	4	1.9	0.7	0.7	0.6	2	2.2	0.7	0.8	0.5	—	—	—	—	—
10—14	—	—	—	—	—	10	1.8	0.6	0.8	0.6	3	1.6	0.6	0.9	0.9	3	2.0	0.6	0.6	0.6	1	1.3	0.7	0.9	0.7	—	—	—	—	—
14—18	—	—	—	—	—	3	2.1	0.6	0.8	0.6	1	1.4	0.6	0.9	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5%	1.7	0.7	0.8	0.5	43%	1.8	0.6	0.8	0.6	30%	1.5	0.6	0.8	0.7	14%	1.9	0.7	0.7	0.6	8%	1.8	0.7	0.8	0.5	—%	—	—	—	—

Locality 7. Hämeenkyrö, Hirvola.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	14	1.6	0.7	0.7	0.6	10	1.4	0.7	0.5	0.5	6	1.8	0.6	0.8	0.4	—	—	—	—	—	—	—	—	—	—
6—10	—	—	—	—	—	26	1.6	0.6	0.7	0.6	22	1.7	0.7	0.7	0.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10—14	4	1.5	0.7	0.8	0.7	6	2.1	0.6	0.8	0.6	6	2.8	0.6	0.6	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14—18	—	—	—	—	—	4	1.8	0.7	0.7	0.7	2	1.5	0.5	0.9	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4%	1.5	0.7	0.8	0.7	50%	1.8	0.7	0.7	0.6	40%	1.9	0.6	0.7	0.6	6%	1.8	0.6	0.8	0.4	—%	—	—	—	—	—%	—	—	—	—

Locality 8. Viljakkala, W-end of Lintuharju.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	2	1.2	0.6	0.9	0.8	15	1.7	0.6	0.6	0.5	8	1.5	0.5	0.6	0.5	4	2.0	0.7	0.7	0.4	7	2.3	0.7	0.7	0.5	1	1.3	0.6	0.7	0.5
6—10	—	—	—	—	—	18	2.0	0.6	0.7	0.5	19	1.8	0.6	0.5	0.6	7	2.2	0.6	0.7	0.5	13	2.8	0.6	0.6	0.3	—	—	—	—	—
10—14	—	—	—	—	—	1	3.0	0.6	0.7	0.5	1	1.6	0.6	0.7	0.7	—	—	—	—	—	3	2.1	0.6	0.8	0.6	1	2.1	0.6	0.9	0.5
14—18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2%	1.2	0.6	0.9	0.8	34%	2.2	0.6	0.7	0.5	28%	1.6	0.6	0.6	0.6	11%	2.1	0.7	0.7	0.5	23%	2.4	0.6	0.7	0.5	2%	1.7	0.6	0.8	0.5

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Locality 9. Viljakkala, E-end of Lintuharju.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	19	1.6	0.6	0.6	0.6	24	1.6	0.6	0.5	0.5	12	2.0	0.6	0.5	0.4	3	2.5	0.6	0.7	0.4	2	1.7	0.6	0.5	0.6
6—10	—	—	—	—	—	8	1.5	0.5	0.7	0.6	16	1.7	0.6	0.4	0.5	4	2.3	0.7	0.7	0.4	1	2.0	0.5	0.5	0.3	1	2.0	0.7	0.3	0.5
10—14	—	—	—	—	—	1	2.0	0.5	0.5	0.5	1	1.8	0.5	0.3	0.5	4	1.4	0.6	0.5	0.5	2	2.0	0.5	0.4	0.6	—	—	—	—	—
14—18	—	—	—	—	—	1	1.8	0.5	0.7	0.7	—	—	—	—	—	1	1.6	0.7	0.7	0.7	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	29%	1.7	0.5	0.6	0.6	41%	1.7	0.6	0.4	0.5	21%	1.8	0.7	0.6	0.5	6%	2.2	0.5	0.5	0.4	3%	1.8	0.7	0.4	0.6

Locality 10. Hämeenkyrö, Laitila.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	1	2.0	0.4	0.5	0.5	14	1.5	0.6	0.8	0.7	6	1.5	0.6	0.6	0.7	1	1.5	0.6	0.5	0.5	1	1.3	0.7	0.3	0.7	1	1.5	0.6	0.9	0.7
6—10	2	1.6	0.6	0.8	0.7	23	1.5	0.6	0.7	0.7	22	1.6	0.6	0.7	0.7	6	1.7	0.6	0.8	0.6	3	1.5	0.6	0.6	0.6	—	—	—	—	—
10—14	2	1.5	0.6	0.8	0.8	10	1.6	0.6	0.7	0.7	5	1.7	0.6	0.7	0.7	—	—	—	—	—	2	1.6	0.6	0.7	0.7	—	—	—	—	—
14—18	—	—	—	—	—	1	1.5	0.6	0.9	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5%	1.7	0.5	0.7	0.7	48%	1.5	0.6	0.7	0.7	33%	1.6	0.6	0.7	0.7	7%	1.6	0.6	0.7	0.6	6%	1.5	0.6	0.5	0.7	1%	1.5	0.6	0.9	0.7

Locality 11. Hämeenkyrö, Ketunkivenkangas.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	20	1.5	0.6	0.6	0.6	8	1.5	0.6	0.5	0.6	8	1.7	0.5	0.7	0.6	6	1.4	0.5	0.7	0.6	—	—	—	—	—
6—10	—	—	—	—	—	30	1.6	0.6	0.6	0.6	6	2.1	0.6	0.3	0.4	2	1.3	0.6	0.5	0.7	4	1.7	0.5	0.9	0.6	2	1.2	0.6	0.5	0.7
10—14	—	—	—	—	—	10	1.8	0.6	0.5	0.6	—	—	—	—	—	—	—	—	—	—	4	2.0	0.6	0.5	0.5	—	—	—	—	—
14—18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	60%	1.6	0.6	0.6	0.6	14%	1.8	0.6	0.4	0.5	10%	1.5	0.6	0.6	0.7	14%	1.7	0.5	0.7	0.6	2%	1.2	0.6	0.5	0.7

Locality 12. Ylöjärvi, Pinsiönkangas.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	3	1.6	0.6	0.4	0.4	15	1.7	0.6	0.5	0.6	2	1.7	0.6	0.7	0.6	4	1.8	0.6	0.9	0.5	12	2.0	0.6	0.8	0.5	—	—	—	—	—
6—10	—	—	—	—	—	23	1.8	0.6	0.5	0.6	7	1.5	0.7	0.5	0.6	10	1.7	0.5	0.8	0.6	7	2.1	0.6	0.7	0.5	—	—	—	—	—
10—14	—	—	—	—	—	8	2.0	0.6	0.5	0.6	1	2.0	0.6	0.5	0.5	—	—	—	—	—	2	1.9	0.5	0.6	0.6	—	—	—	—	—
14—18	—	—	—	—	—	2	2.2	0.6	0.5	0.5	1	2.1	0.4	0.5	0.5	1	1.4	0.5	0.5	0.7	2	3.3	0.5	0.3	0.4	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3%	1.6	0.6	0.4	0.4	48%	1.9	0.6	0.5	0.6	11%	1.8	0.6	0.6	0.6	15%	1.6	0.5	0.7	0.6	23%	2.3	0.6	0.6	0.5	—%	—	—	—	—

Locality 13. Ylöjärvi, Siironmaa.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	12	1.6	0.6	0.5	0.5	8	1.8	0.6	0.3	0.5	29	2.1	0.6	0.5	0.4	6	2.5	0.6	0.5	0.4	—	—	—	—	—
6—10	—	—	—	—	—	9	2.0	0.6	0.4	0.5	5	1.9	0.6	0.3	0.4	13	1.7	0.6	0.6	0.6	11	2.0	0.6	0.5	0.5	—	—	—	—	—
10—14	—	—	—	—	—	1	1.8	0.6	0.3	0.5	1	2.6	0.7	0.6	0.3	1	2.8	0.5	0.5	0.3	3	2.9	0.5	0.3	0.4	—	—	—	—	—
14—18	—	—	—	—	—	1	2.7	0.6	0.3	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	23%	2.0	0.6	0.4	0.5	14%	2.1	0.6	0.4	0.4	43%	2.2	0.6	0.5	0.4	20%	2.5	0.6	0.4	0.4	—%	—	—	—	—

Locality 14. Tampere, Lamminpää.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	28	1.6	0.6	0.4	0.5	8	1.6	0.6	0.4	0.6	15	2.1	0.7	0.5	0.4	6	2.3	0.6	0.5	0.4	—	—	—	—	—
6—10	—	—	—	—	—	17	1.7	0.6	0.4	0.5	9	1.5	0.6	0.5	0.6	9	2.3	0.6	0.4	0.4	5	2.6	0.6	0.6	0.4	—	—	—	—	—
10—14	—	—	—	—	—	2	1.9	0.6	0.3	0.6	—	—	—	—	—	1	1.7	0.5	0.7	0.7	—	—	—	—	—	—	—	—	—	—
14—18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	47%	1.7	0.6	0.4	0.5	17%	1.6	0.6	0.5	0.6	25%	2.0	0.6	0.5	0.5	11%	2.5	0.6	0.6	0.4	—%	—	—	—	—

Locality 15. Tampere, Lielahti.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	16	1.3	0.6	0.6	0.6	9	1.5	0.6	0.7	0.6	23	1.7	0.6	0.7	0.6	19	1.7	0.6	0.7	0.5	—	—	—	—	—
6—10	—	—	—	—	—	6	1.6	0.6	0.7	0.5	2	1.4	0.6	0.9	0.9	15	1.8	0.6	0.7	0.5	6	2.3	0.6	0.8	0.4	—	—	—	—	—
10—14	—	—	—	—	—	1	1.8	0.8	0.5	0.7	1	2.4	0.5	0.5	0.5	1	2.1	0.5	0.5	0.5	1	2.3	0.5	0.9	0.5	—	—	—	—	—
14—18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	23%	1.6	0.7	0.6	0.6	12%	1.8	0.6	0.7	0.7	39%	1.9	0.6	0.6	0.5	26%	2.1	0.6	0.8	0.5	—%	—	—	—	—

Locality 16. Tampere, Kaarela.

ø	Gb	F	A	R	S	Gd	F	A	R	S	Gr	F	A	R	S	Bs	F	A	R	S	As	F	A	R	S	Ss	F	A	R	S
2—6	—	—	—	—	—	15	1.8	0.6	0.6	0.6	—	—	—	—	—	20	1.7	0.6	0.6	0.5	20	2.2	0.6	0.6	0.4	—	—	—	—	—
6—10	—	—	—	—	—	20	1.7	0.6	0.7	0.6	—	—	—	—	—	10	1.7	0.6	0.5	0.6	12	2.4	0.6	0.5	0.4	—	—	—	—	—
10—14	—	—	—	—	—	1	1.6	0.5	0.9	0.7	—	—	—	—	—	2	2.1	0.6	0.5	0.5	—	—	—	—	—	—	—	—	—	—
14—18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18—22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22<	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—%	—	—	—	—	36%	1.7	0.6	0.7	0.6	—%	—	—	—	—	32%	1.8	0.6	0.5	0.5	32%	2.3	0.6	0.6	0.4	—%	—	—	—	—

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