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Learning to know a Rune Carver and his cutting technique. A method study and some results

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A method study on the use of surface structure analysis with laserscanner according to Freij 1990 has been performed in cooperation with a modern rune carver. Results of the statistical data analyses show that it is possible to distinguish between individual rune carvers with at least 70% accuracy. The method is continually modified. Statistical methods used are *Cluster Analysis, Discriminant Analysis and* ANOVA. The conclusions of the method study is the starting point for the analysis of rune stones of the Viking Age situated in the counties Uppland and Östergötland in Sweden. Some carvers, who have been extremely productive, like Öpir, have given rise to the question if the rune stones were subject to schools. This in connection to the carver's role and position in society is the aim of my study. Data are also tested against Herschend's view that two carvers named Öpir have been active during overlapping time periods (Herschend 1997). Results indicate that the division of Öpir into at least two carvers is justified, ubiR can clearly be distinguished from ybiR/ybir.

Introduction

This article presents method-studies for surface structure analysis of Rune stones conducted together with the modern rune carver Kalle Dahlberg and the results are applied to Viking Age rune stones. Firstly, I introduce some general aspects of the craft of rune carving in stone. Secondly, the method studies are presented and finally the results are applied to a selection of signed rune carvings found in Uppland and Östergötland in Sweden (table 1) and the data is tested against Herschend's suggestion of dividing Opir into ubiR and ybiR/ybir. The method of surface structure analysis of rune stones using a laser scanner, and how to extract the variables, was first developed by Henry Freij. Parts of Freij's pioneer work have been published in Laborativ Arkeologi, Journal of Nordic Scientific Archaeology (1986, 1990). However, with Freij's kind permission, the following investigations are founded on material not yet published. A summary of field work, measuring accuracy and sources of error is to be found in Kitzler 1995a. The stylistic datings according to Ann-Sofi Gräslund's criteria as described in Gräslund 1992 have been found in the database MÄLSTEN compiled by the Archaeological Department at Uppsala University. For explanations of the statistical methods, I refer to Aldenderfer & Blashfield 1987, Arabie et al. 1996 and Hair et al. 1992.

So far, the surface structure analysis has concentrated on finding significant differences in variables to establish systematic tendencies and groupings. In doing this, Freij has made several interesting and usable observations, such as the fact that there is a strong correlation between v and D (fig. 2b) which means that the carver aimed at the same width of cut mark, rather than the same depth (Freij, pers. comm.1996). But since all studies have been made on ancient rune stones, we have had no possibility to check the validity of the results. For this reason I have spent some time on method studies on modern rune stones. This work began in 1995 (Kitzler 1995), but has recently been extended. The modern rune carver has had several helpers, and he has himself developed from a beginner to a fairly experienced carver. The aim of the method study on the newly cut rune stones is to estimate the reliability of the results. The results of the analyses are compared to the "key".

A modern Rune Carver about cutting cechnique

One of the starting points of my work is that traditional handicraft is limited by the physical properties of the material and the human body. A craftsman who has found out a way to work functionally is conservative in choice of tools and technique. Motor performance is integrated with the individual and is not easily changed. Similar theoretical assumptions are found in the investigations of the late James Hill and his colleagues into individual variation in the production and

Table 1. The rune stones in the analysis.

Stone	Carver	Parish	Place	Style	Samples	
					Orn.	Runes
Modern						
K1 (Viking Line)	unskilled Kalle, unskilled Helper	Stockholm	Stadsgården	–	4	7
K2 (Pegasus)	skilled Kalle, unskilled Markus	Adelsö	Adelsö	–	8	12
Viking age, Signed rune stones						
	1)			2)		
U29	Torbjörn	Hilleshög	Hillersjö	P4	3	3
U37	Torbjörn	Sånga	Säby (Gallows hill)	P2	–	6
U167	Fot	Östra Ryd	Church	P3	6	8
U181	Öpir (ubiR)	Ösby Garn	Church	P5	5	10
U210	Öpir (ybiR)	Angarn	Åsta	P4	5	11
U226	Gunnar	Vallentuna	Bällsta	P1	4	12
U229	Öpir (ybir)	Vallentuna	Grana	P5	4	13
U268	Fot	Fresta	Harby	?	4	5
U485	Ofeg Öpir (ybiR)	Lagga	Marma	P5	5	10
U678	Fot	Skokloster	Church	?	6	9
U687	Öpir (ubiR)	Skokloster	Sjusta	P4	4	8
U1034	Öpir (ybir)	Tensta	Church	P5	5	9
Ög81	Torkel	Högby	Church (abandoned)	–	2	4
Ög82	Torkel	Högby	Vicarage	–	2	4

1) Axelson 1993
2) MÄLSTEN (Gräslund & Herschend 1993)

decoration of artifacts in various material (Hill et al. 1977).

A rune cut is made in several stages (fig. 1). When Dahlberg starts up a new composition, he first cuts a small narrow groove following the sketch he has drawn on the stone (Dahlberg will be referred to by his Christian name, Kalle, when acting as a rune carver, just as were his predecessors). The tool will easily follow this first groove when he passes on to cut more heavily and roughly. This first line must meticulously follow the sketch-drawing as inaccuracies in it will be difficult to correct later. The chisel is held with its edge along the cutting direction. In stage 2, the tool runs in the first groove. The chisel edge is held perpendicular to the cutting direction and the groove becomes wider. During stage 3 and 4 the groove is made alternately deeper and wider. At each stage Kalle either changes to another tool or he uses the same tool but changes the angle of the chisel edge. This is to increase the effectiveness of the cutting process. If he does not make any of these changes the tool begins to run in a groove of the same form as the chisel itself and very little material is removed at each blow. The tool is held perpendicularly to the stone's surface, not sloping. To cut one rune takes about 0.5–1 hour. The first rune is cut comparatively quickly in Kalle's case, but he works more slowly during the first day as muscle fatigue grows; as the days pass, and his muscle strength grows he establishes a steady rate: 5–7 runes take a full working day. The rune stone is cut lying down on the ground. To cut on an erect surface doubles the work. Kalle stresses that the time needed to cut a composition is dependent to a very high degree on how long it is, i.e. on the number of metres length of the grooves in the composition. A simple composition might be cut within a month, whereas a complicated composition including two or more runic animals might take up to five months. It is understood that the rune carver has plenty of time to find his own cutting rhythm.

Lines running closely parallel to earlier lines have to be cut carefully so as to avoid damaging the material left between them. This can be seen with the naked eye e.g. at the eye and eyebrow of the runic animal, where one trace is often deeper than the other. If the eye is deeper than the eyebrow, it has probably been cut before the eyebrow. If the distance between the lines is less than about 20 mm this care is necessary, even if a narrow cutting tool can be used. There is also a risk of the stone splitting where lines meet or cross each other, e.g. where a by-stave meets the upright. It is often seen on rune stones that to avoid narrow angles the rune carver has not connected the by-stave to the upright. The hit frequency is considerably more uneven for an unskilled carver than for one who is skilled. Kalle, too, takes

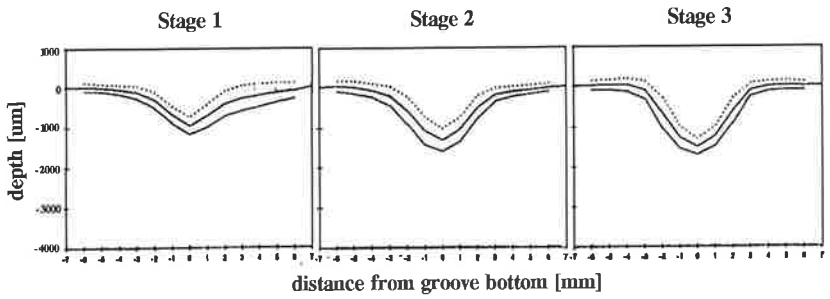

Figure 1. Cross-section of the groove in the first three stages of cutting.

time to find his form when he begins cutting a new stone. Although he would like to begin with the head of a runic animal, he chooses a more simple part until he has got to know this particular stone, its surface and properties. During cutting, stone powder is produced in the grooves, but when cutting outdoors it blows away.

Change over time

The rune carver's cutting technique is expected to change over the years. This is confirmed by Kalle. On the other hand, criminology has shown that the change in motor performance over years in e.g. handwriting is not so great as the difference between individuals (Hill 1977:101). Evenness in the rune traces indicates skill (Dahlberg, pers. comm. Oct. 96). In comparing several rune stones by the same carver, the ones with more regular stroke intervals should represent a later period in the rune carver's career. Kalle mentions also that he has changed tools since he first began carving. A craftsman is unlikely to make such changes haphazardly, but in order to improve his effectiveness either in time or quality. In such circumstances an optimal state can be reached which requires little development in terms of tool type.

Basic differences between modern and ancient rune stone carving: material quality

Kalle uses material prepared as gravestones for his rune carving. The material is rough-backed and the surface burnt with a gas-flame, and therefore more flat and even than a natural stone surface which has been trimmed manually. The temperature of the gas-flame is 3100°C (personal comm. Vätö Stone Masonry). I have been told that an LPG-flame (liquefied petroleum gas) might suffice, but I do not know the lower limit of temperature needed to level off the stone surface. I cannot say whether it could be done by fire. The irregularities in a natural stone make the carving appear skewed even when symmetrically planned. Kalle uses standard tools with edges about 3 mm wide. These produce a narrow groove with sharp edges and are at variance with the tools used by ancient masons. A handsmithed tool has been produced according to a probable prehistoric model, its edge being about 6–8 mm. This tool is used with the edge perpendicularly to the cutting direction only. A complete rune stone has not yet been made with this handsmithed tool. These differences are a drawback for the method-study.

Material and sampling

The present study compared modern and ancient rune stones in order to assess if equivalent variations in the quality of the carving could clarify the production process of the prehistoric stones. Each stone has been sampled – i.e. its surface characteristics recorded – at a number of locations on across its surface. The numberof samples for each carving varies. The early studies used 6 locations (Kitzler 1995a, Kitzler 1995b); the majority of the results presented here use between 12 and 14; the maximum number is 18. The sampling strategy is to find undamaged cut marks, evenly distributed on the left/right and up/down part of the composition. The samples are also designed to record the variation between wide/narrow lines, the narrow being the ones running closely parallel to another line. Sections of ornament lines not crossed by other lines or connected to rune staves are preferred.

The modern material includes two carvings, one carving made for the shipping company Viking Line and one made for the EC-project Pegasus. The Viking Line-stone (K1) was made by Kalle when he was a beginner together with a carver (even less experienced) who cut a small number of runes in the commission. The Pegasus-stone (K2) was cut three years later by a considerably more experienced Kalle (he had produced other carvings in between) together with an unskilled 15-year old boy, Markus. In this case another set of tools was used. The situation could be compared to when the master works with a new apprentice. Kalle noted that Markus's cut marks were wider than his own and, due to his not having strength enough to hold the tool properly and not having learnt the technique, also uneven. When Markus is cutting, the tool jumps. Kalle and Markus used one set each of similar tools, 3 chisels of varying size. The narrowest had an edge like a car-

penter's pen and was only used to cut small joints, the edge of the eye and the like. The largest was used in the first stages of cutting, but the trace of this tool was cut away in the last cutting stage when the middle-width tool was used. Samples have been taken during the gradual creation of the composition and have been used to produce a comparison between Kalle's and Markus's traces at different stages of the process, e.g. Markus's day 1 and day 2 ornaments and Markus's first runes to be compared to Kalle's traces made at the same time on the same stone with the same kind of tools.

The ancient material includes 14 signed rune stones (Appendix). The known carvers are Öpir, Fot, Torbjörn Skald and Torkel. Torkel is from the county Östergötland, the others are from Uppland. All the stones are made of crystalline rock, sandstones are excluded. Torkel's could be regarded as a group of control samples since geographical distance should set him apart from the Upplandic carvers. It should be noted that U678 in Skokloster has drawn attention due to its unusual ornamentation. The horseman stylistically resembles Vendel Period mounts. The possibility that an older carving might have been recut and "improved" by Fot has been discussed (U678, Almgren 1940:161–162; Nerman 1947:122–126). Due to the fact that rune stones are carved in several stages this would obviously be hard to detect. The older cut marks would be destroyed. Examination of the carving revealed that the cutting technique of the horseman cannot be told apart from that of the cross. For this reason I regard U678 as an example of Fot's cutting technique. However, it must be accepted that the similarity of the marks does not necessarily imply single authorship. The potential confusion is extended by the possibility that the carvers might have imitated each other.

Variables

The 9 variables in use have been found to represent the most distinguishing features of a cut mark (Freij, pers. comm.). The variables can be divided into three categories, referring to *Mean Profile* (fig. 2a), *Groove Angle* (fig. 2b) and *Longitudinal Information* (fig. 2c). *Longitudinal Information* refers to the stroke interval and the cutting rhythm. To obtain acceptable longitudinal information a minimum of 3 cyclical lapses (n_Q) in the sample is demanded. If $n_Q < 3$, the values of the longitudinal variables are substituted by the means of

Figures 2 a-c.
The figures illustrate the variables used in the investigation.

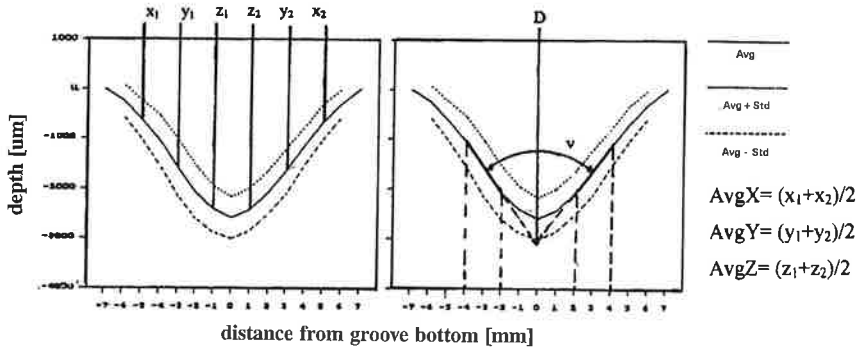

Figure 2a. *Figure 2b.*

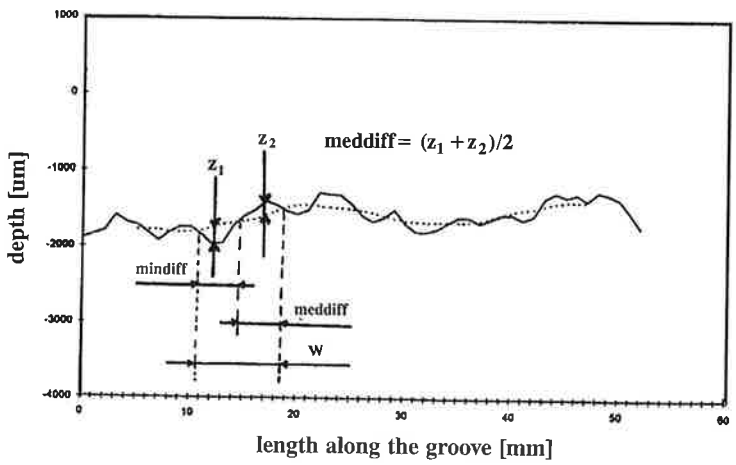

Figure 2c.

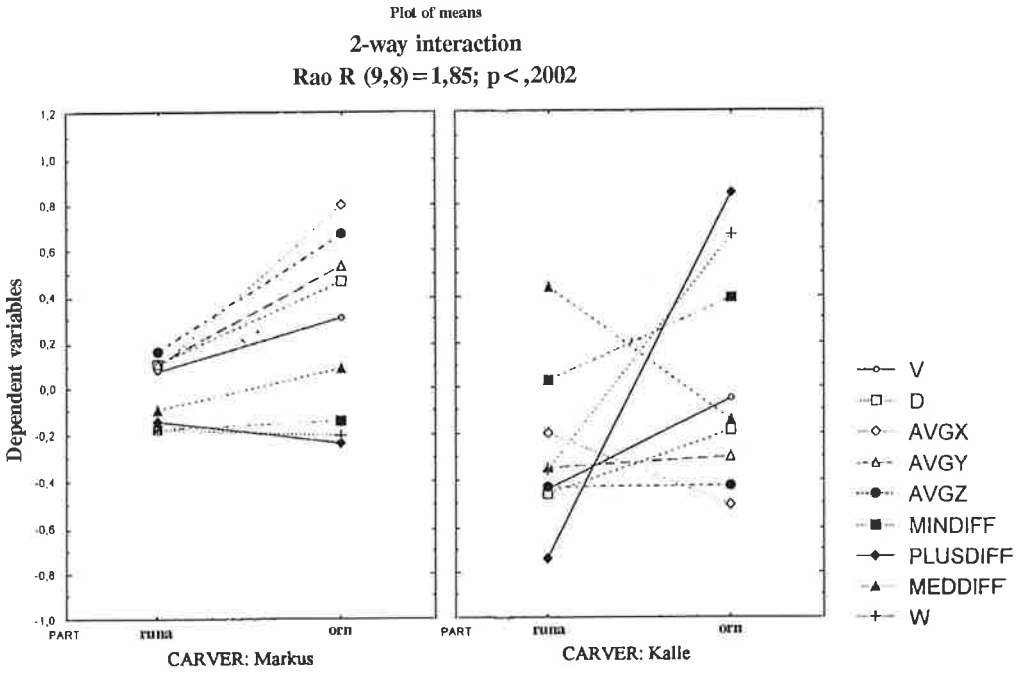

Figure 3.
Interaction of Means. Note the differences between runes and ornaments for the more experienced Kalle as compared to the beginner Markus.

the other samples in the group. This only occurs in samples of runes, due to the limited length of the upright.

Method-study

Interaction of Means

As a first step towards an understanding of how variables interact, the Interaction of Means (a feature of the statistical concept ANOVA), was studied for the standardized variables of the runes and ornaments for Markus and Kalle respectively on the Pegasus-stone K2 (fig. 3). Standardization means that the variables are recalculated to compensate for varying magnitude and different units. For advantages and drawbacks of standardization, see Aldenderfer & Blashfield 1987:20, Milligan 1996:352ff. For the unskilled carver the cutting technique (or lack of technique) is similar for runes and ornaments. The skilled carver has reached a higher degree of specialization and the differences between runes and ornaments for some variables are pronounced. This is especially the case with the longitude variables (fig. 2c). The skilled carver has a larger interval between the strokes when he cuts the ornaments than in cutting the runes. The unskilled carver is just as bad in both actions. The actual intervals in variables vary, but the systematic difference is easy to distinguish (fig. 4). Apart from a shorter stroke interval in the runes, the cut marks of the specialised carver have a different longitudinal symmetry at the base of the cut, the reason for which is another cutting rhythm. This symmetry is expressed by the variables mindiff and plusdiff (fig. 2c). For the specialised carver, the difference between these two variables (Freij pers. comm. 1996) is up to 0.5–0.7 mm for the runes. If the stroke interval is longer in the runes than in the ornaments, distribution of the labour should be taken into account; a specialised carver might have made the runes while an unskilled carver has been put to cut the ornaments. Of course, there remains the possibility that one or more carvers have cooperated with the runes and/or the ornaments.

The question "Is the carver who is subject of analysis skilled or unskilled?" could be reformulated into "Does this carver have a specialised technique for runes and ornaments respectively?"

Specialised = the longitude variables differs between runes and ornaments

Not specialised = the longitude variables are alike for runes and ornaments

The conclusion is that runes and ornaments have to be analysed separately. A preliminary classification of six rune stones signed Öpir has been done from the conclu-

Table 2. Interpretation of the results displayed in fig. 5 sorted in the three spellings of Öpir as suggested by Herschend (1997) and with stylistic affiliation according to information in MÄLSTEN (Gräslund & Herschend 1993).

ubiR	U687	not spec.	P4
	U181	specialised	P5
ybiR	U210	not spec.	P4
	U485	spec. runes?	P5
ybir	U229	not spec.	P5
	U1034	specialised	P5

Table 3. Analyses performed no. 1-4.

Analysis no.	Variables
1. Interpretation of Mean Profiles in Euclidical Diagrams. c.f. Kitzler 1995	AvgX, AvgY, AvgZ
2. Interpretation of Groove Angle Diagrams*.	v, D
3. K-Means Clustering, clusters=2, 7 variables. (Mean Profile+Longitude)	AvgX, AvgY, AvgZ, mindiff, plusdiff, meddiff, w
4. K-Means Clustering, clusters=2, 9 variables. (Groove Angle+Mean Profile+Longitude)	v, D, AvgX, AvgY, AvgZ, mindiff, plusdiff, meddiff, w

**Interpretation of Groove Angle Diagrams was presented at a seminar at the Archaeological Research Laboratory in the spring 1997.*

sions above (fig. 5). The systematic difference in stroke interval *(w)* which indicates a specialized carver seems to appear on the stones U181 and U1034. In the runes of U485 the shifted symmetry in the runes can be seen, but the stroke interval is longer for the runes than for the ornaments. Also on U210 we find the inverted pattern that the stroke interval is longer in the runes than in the ornaments. There are several possible explanations to this. For example, different carvers may have made the runes and the ornaments. If this is the case, probably the more skilled one of the carvers has made the runes since these represent a more flowing cutting technique. Another possibility is that the carver is still a beginner and systematic tendencies are eliminated due to his clumsiness. On U229 the stroke interval is of the same magnitude for runes and ornaments. This trait is also seen in the cutting of the unskilled Markus. U229 is admittedly a problematic stone, whose style diverges considerably from all other Öpir-stones (pers. comm. O'Meadhra 1997). What patterns appear if we add information about 1) stylistic affiliation according to Gräslund's criteria (Gräslund 1992) and 2) the spelling of the name Öpir (Herschend 1997) (table 2)?

Whether Öpir is considered as one person or several, the stones that appear to have been cut with a higher level of skill (i.e. those where a differentiation in technique is observable between the carving of ornaments and runes) all belong to the P5 stylistic period,

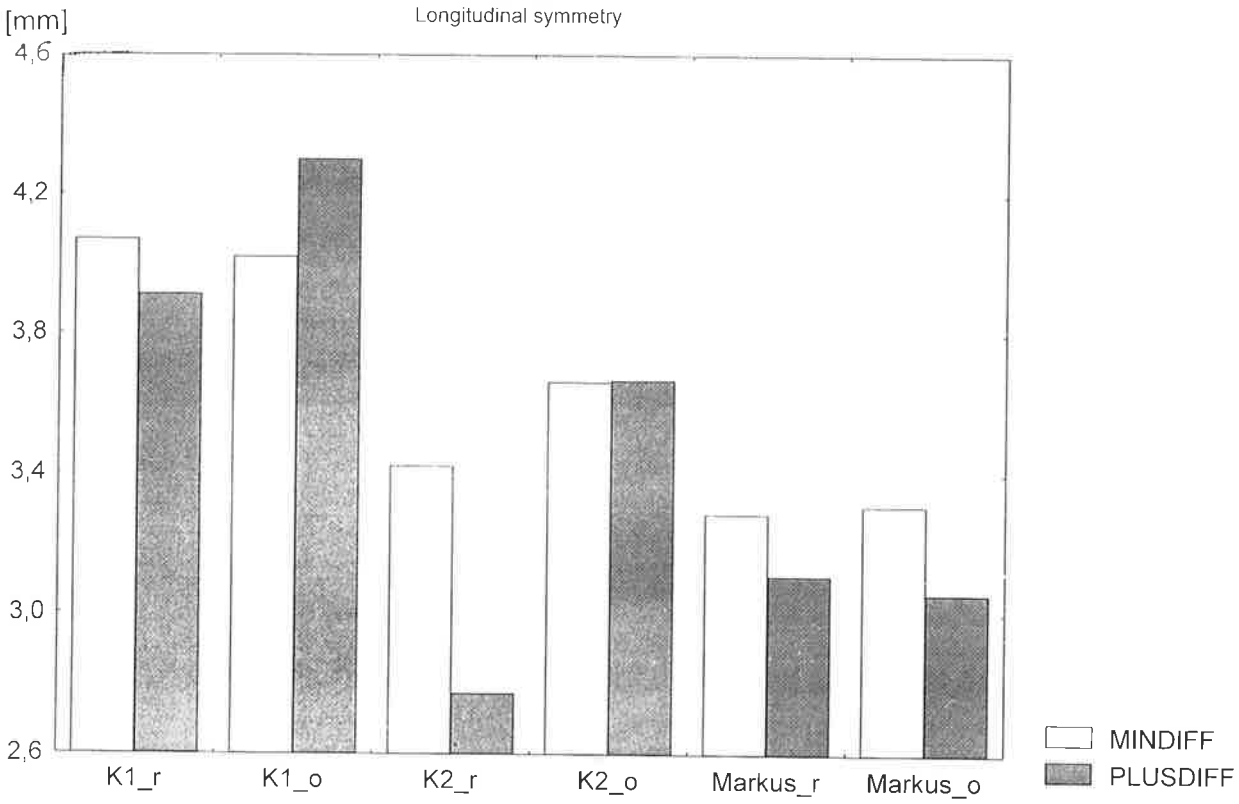

Figure 4. Markus=apprentice, K1= Kalle as a beginner, K2= Kalle as master. _r=runes, _o=ornament.

Table 4. Share of samples assigned to the right group (hit ratio).

Analysis no.	Total %	Runes %	Ornaments %
1	70	67	75
2	55	50	63
3	65	50	88
4	75	75	75

the later period in Öpir's career if Gräslund's relative chronology is relevant.

The accuracy of the methods of analysis: The Pegasus-stone

When grouping samples to different carvers, the results vary according to which variables are taken into account. An attempt has been made to statistically define which analysis gives the best accuracy. The investigation was carried out on the *Pegasus-stone*. For each analysis the judgement was noted on an overhead picture of the carving. This picture was compared to "the key" and it was calculated in percent how many of the samples were assigned to the right group (table 3).

For analyses 1 and 2, visual interpretations in the diagrams were made. Analyses 3 and 4 were made in the STATISTICA for Windows software. The clustering method used is K-Means clustering (Iterative Partitioning) and the analyses were made with standardized variables. In K-Means Clustering, the number of groups is decided in advance, in this case 2 groups since it is known that the material includes two carvers. The results are presented in table 4.

In table 4 it can be noticed that Analysis 2, where only two variables have been entered (v and D) gives the poorest result, for runes as well as the ornaments. The accuracy is about fifty-fifty and therefore appears as haphazard. Overall, analysis 4, where variables representing *Mean Profile*, *Groove Angle* and *Longitudinal Information* have been combined, yields the best result with an accuracy in distinguishing the two carvers of about 75%. However, for ornaments the result is better in Analysis 3. Generally, runes are more difficult to classify than ornaments. It is my conviction that the accuracy may be improved by further sophistication of the statistical method.

In all analyses except Analysis 3, the parts requiring great care cut by Kalle, like the head of the runic animal and the narrow snake with their closely running parallel lines, are the parts most easily confused with those parts cut by the unskilled Markus. "Caution" is a

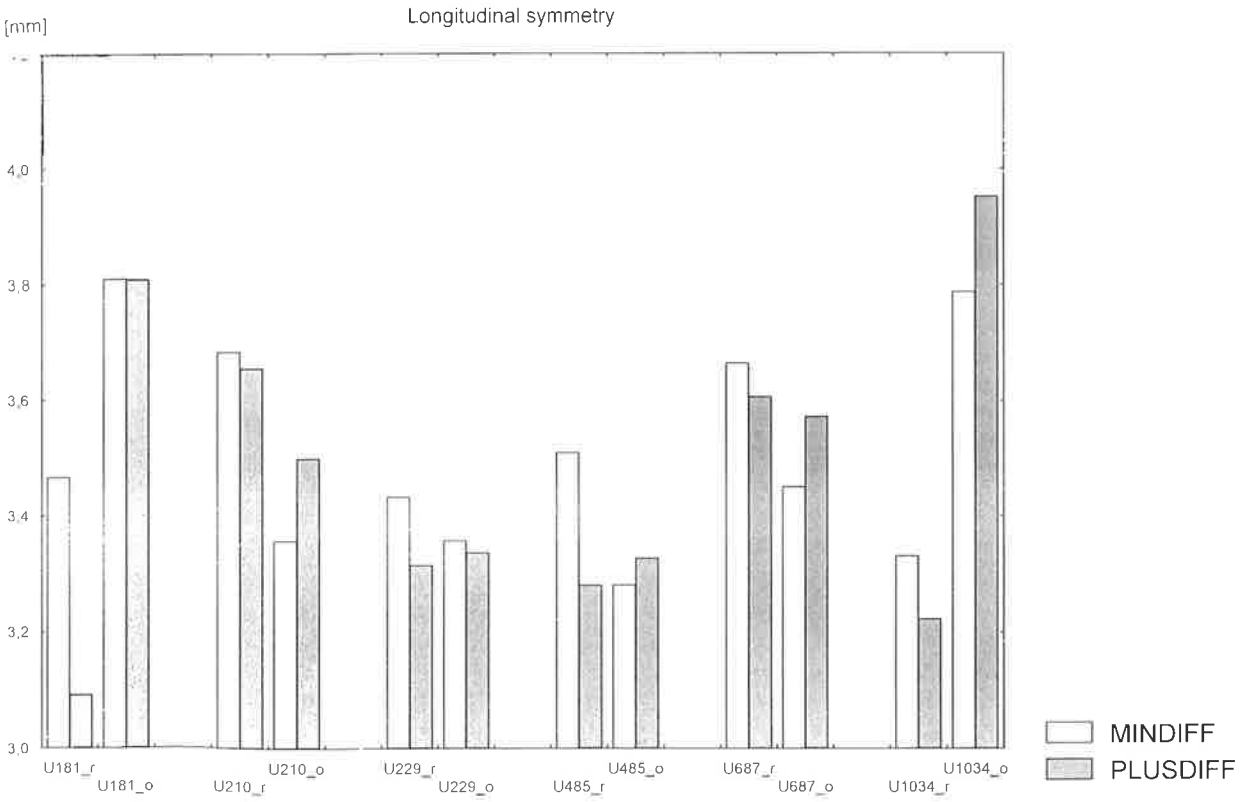

Figure 5. Mindiff and plusdiff for runes respective ornaments for some rune stones signed Öpir.

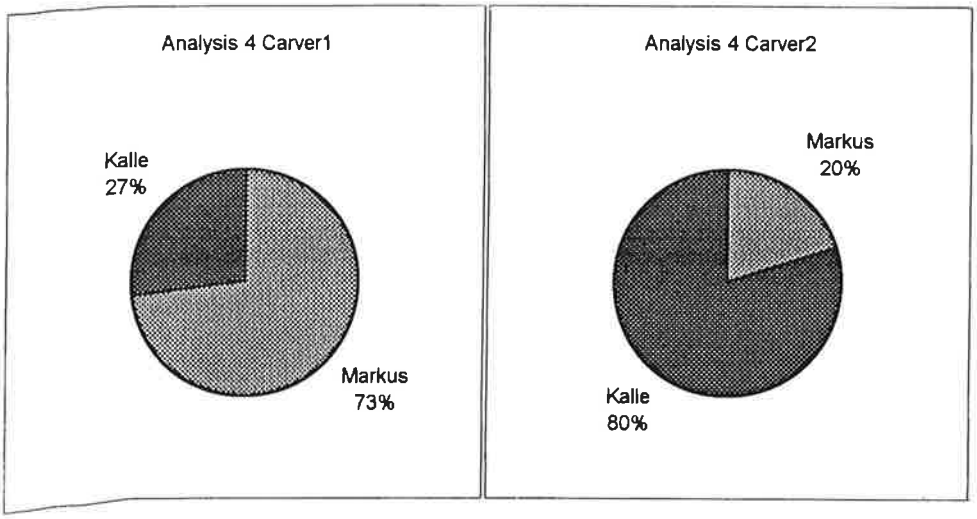

Figure 6.
The pie diagram illustrates the structure of the clusters after Analysis 4; K-Means Clustering combining 9 variables.

factor which the beginner has in common with the concentrated master. Analysis 4 sorts the "complicated" ornaments to the correct carver, but on the other hand a sample of Markus Day 2 wrongly goes into the Kalle-group. The conclusion is that for classifying ornaments variables *v* and *D* should not be included since these variables impair the grouping of the more demanding parts of the ornaments. Moreover, the analyses have shown that even if variables *v* and *D* used alone give the wrong impression about the division of labour, they contribute to a correct separation in a cluster analysis – at least for the runes.

Fig. 6 shows the reliability of the clusters after Analysis 4, and should be interpreted as follows: For Analysis 4 the cluster which is attributed to Carver 1 is composed of 73% of Markus's cut marks and 27% of Kalle's cut marks. In other words, about 20–30% of the samples in a group have been cut by "the other" carver. A source of error in these estimations of accuracy is that Markus is represented by a larger share of the samples than Kalle (Markus 58%, Kalle 42%). This is not compensated for since similar quantitative bias will inevitably occur in analyses of ancient rune stones. K-Means Clustering including 9 variables (Analysis 4) was also conducted with 12 samples, 8 taken from runes and 4 from ornaments, since this is a number of samples much of the available ancient material amounts to. The share of correctly classified samples still amounts to 75%.

The K-Means Cluster Analyses mentioned so far have one outstanding deficiency – the analyst, rather than the analysis itself, defines the number of carvers that have been at work. Even if the samples are taken from the work of a lone carver they will be forced into as many groups as the analyst chooses. To determine the number of clusters there are several validating procedures, all of which include a degree of subjectivity (Milligan 1996, Hair et al. 1992, Aldenderfer & Blashfield 1987). In this case it is no problem because it is known that the material includes exactly two carvers.

Anyhow, the analyses above disclose that to approach any kind of accuracy in classification we have to set out on an expedition into the multidimensional statistical inferno, the STATISTICA Commedia.

Discriminant Analysis

By now it is realised that all the variables in use to characterize a rune carver's cutting technique interact in a

Table 5a. Classification Matrix: Modern rune stones, ornaments.

Stat.	Classification Matrix (metod.sta)
Discrim.	Rows: Observed Classifications
Analysis	Columns: Predicted classifications

Group	Percent Correct	Markus p = .50000	Kalle p = .50000
MARKUS	100.0000	3	0
KALLE	92.3077	1	12
TOTAL	93.7500	4	12

Table 5b. Classification Matrix: Modern rune stones, runes.

Stat.	Classification Matrix (metod.sta)
Discrim.	Rows: Observed Classifications
Analysis	Columns: Predicted classifications

Group	Percent Correct	Markus p = .33333	Kalle p = .33333	Helper p = .33333
MARKUS	88.8889	8	1	0
KALLE	68.7500	4	11	1
HELPER	100.0000	0	0	2
TOTAL	77.7778	12	12	3

complicated and by no means simple way. There is no way to distinguish individual carvers by visual inspection of their cut marks. The intervals of the variables overlap and the specific carver can only be located as a kind of "centre of gravity" in these diffusions. To make comparisons between carvers who have been working on different rune stones we will now pass on to Discriminant Analysis. One of the advantages is that the variables do not have to be standardized, which is a benefit when you wish to compare actual values.

Discriminant Analysis has partly been performed on modern material with known distribution of work, partly on a Viking Age material consisting of signed rune stones of granite. The principle of Discriminant Analysis is that a known case (reference material) is used to calculate to what extent each variable contributes to the distinguishing between the groups. Functions are created defining what makes one group different from the others. These functions can be used to classify unknown material. The variables v, AvgX, Avgy, AvgZ, mindiff, plusdiff and meddiff were entered into the analysis, but since the forward stepwise method was employed and redundant variables are excluded (tolerance value 0.01, F to enter=1.00, F to remove=0.00), the actual variables used may vary. The accuracy of the classification is obtained when the classification is being done on a known case which is not included in the reference material. Strictly seen, to evaluate the accuracy on the same material as has been used as reference material is not quite accurate since it gives an upward bias in the hit ratio (Hair et al. 1992:97ff). In this study, the samples were too few to be divided into an analysis sample (reference) and a holdout sample (test). More precise evaluations will be done when more material is available. The results in this study are not interpreted for single samples as if one carver has made one specific rune and another carver some others. All the runes in one carving are treated as a unit, as well as the samples of the ornaments. Of this reason, outliers have to be found and evaluated. Outliers of extreme values could originate from a "poorly sampled subgroup" (Aldenderfer & Blashfield 1987:61). For study of details, the singular elements have to be studied in relation to each other. This is important and interesting, but not within the scope of this paper. Runes and ornaments are analysed separately since, as seen above, the cutting technique differs between them for skilled carvers. Note that for the modern samples (table 5a, b) of ornaments only two carvers are represented, while there are three carvers for the runes.

Looking at the percent-levels for correctly classified samples, the hit ratio, the result may seem a little weak and deficient, but in a frequency distribution there appear significant peaks for respective carvers (fig. 7a,b–8a,b). Samples drop over to other carvers partly due to the fact that the variables describing the cutting technique overlap for the different carvers. In the matrix it appears which of the carvers who are easily confused by their cutting techniques. It should be stressed that samples can only be classified to carvers represented in the analysis and that the alternative "none of these carvers" is not available. The hit ratio for runes is less than for the ornaments, partly due to the fact that the limited length of the upright does not allow the carver to fully fall into his cutting rhythm, but mostly because the short samples of runes also make the calculation of the stroke length less representative.

The enigma of Öpir

The carvers Fot, Torkel and Torbjörn all have characteristic and relatively well distinguishable cutting techniques, while the cut marks of the runes on the stones signed by Öpir have a very large diffusion and variation. It could be argued that the size of the groups are too unequal to fit the discriminant analysis, but this is not enough to explain away the poor hit ratio for Öpir. One reason for the diffusion could be that Öpir had several helpers working on the stones he signed. The consequence of this is that what is being used as a definition of Öpir is actually a conglomerate of himself and his assistants. How can we decide what samples really belong to Öpir? Öpir himself must have developed from an unskilled beginner to an experienced master. To bring all these stones together into one single reference group is to demand much of the method. Each carving has to be investigated to see whether the carver used specialised techniques in cutting his ornaments and runes, or whether differences emerge from more than one carver having worked on the stones. This reasoning is still assuming that Åhlén's view is right, that Öpir is responsible for all the carvings signed with that name, with a few exceptions (Åhlén 1997:27ff, 60f). Traditionally 65 stones of various reasons have been attributed to Öpir. On linguistic grounds, Åhlén has in her dissertation (Åhlén 1997) reduced the number of attributed stones to 27. This is motivated by conformative formulas and orthographic habits. Herschend opposes this view since the name Öpir is found with three spellings which moreover represent two groups with diverging linguistic features. Herschend believes there are at least two carvers working, one of whom did not want to be mixed up with the other one (Herschend 1997).

In the following I am trying to test Herschend's hypothesis against the surface structure data, to see whether this grouping could be confirmed. If Öpir is divided in ubiR and ybiR/ybir, the discriminant functions (fig. 8a, b) yields a very good hit ratio for the ornaments of ubiR, which means that he is well distinguishable from the other carvers. For the runes, however, the result is depressing both for ubiR and ybiR/ybir. The reason might be that these (hypothetical) two carvers worked more frequently with helpers than did the other carvers. This would suit well with Herschend's

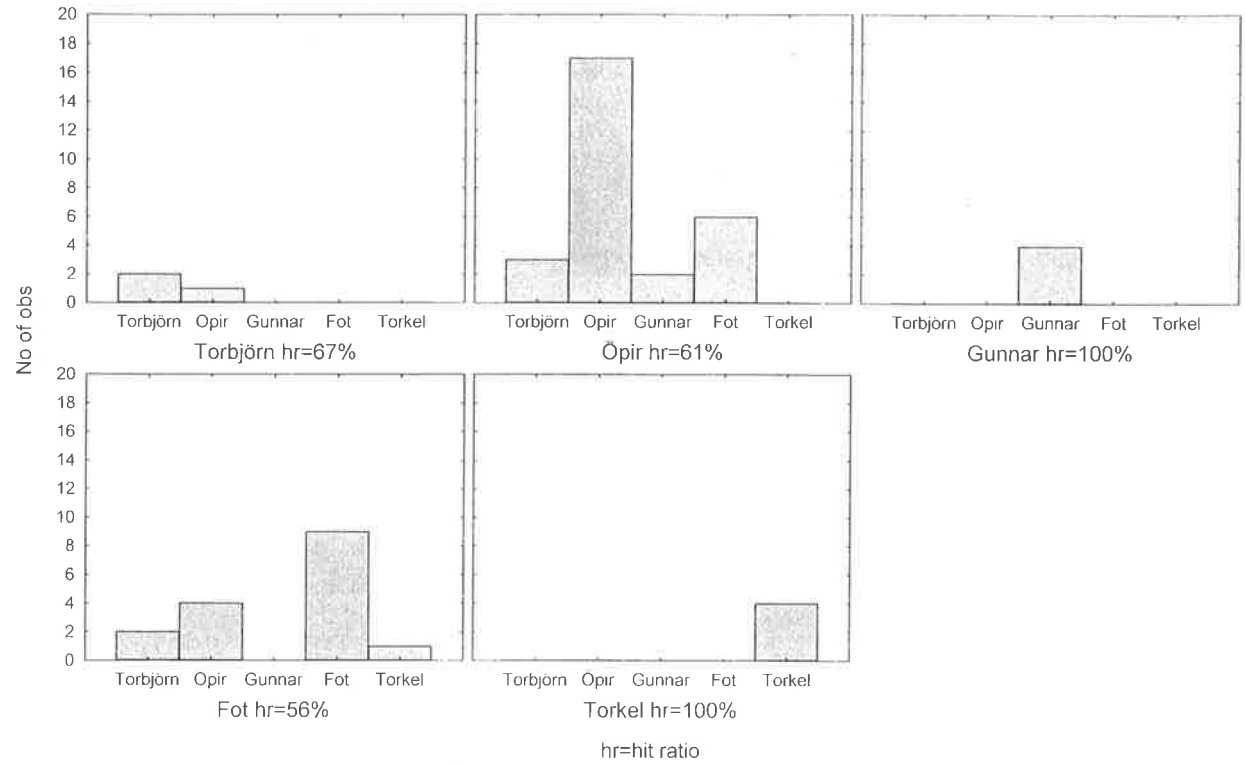

Figure.7a. Frequency distribution: Signed granite rune stones, ornaments.

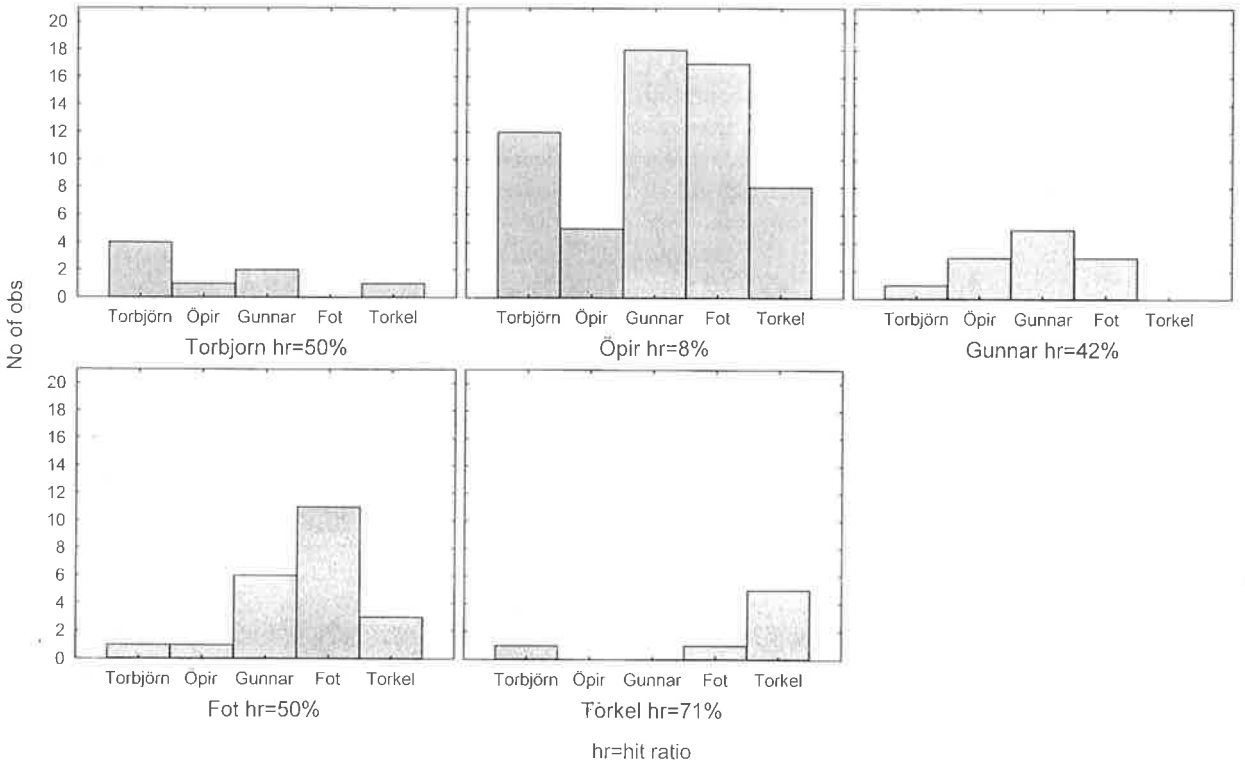

Figure 7b. Frequency distribution: Signed granite rune stones, runes.

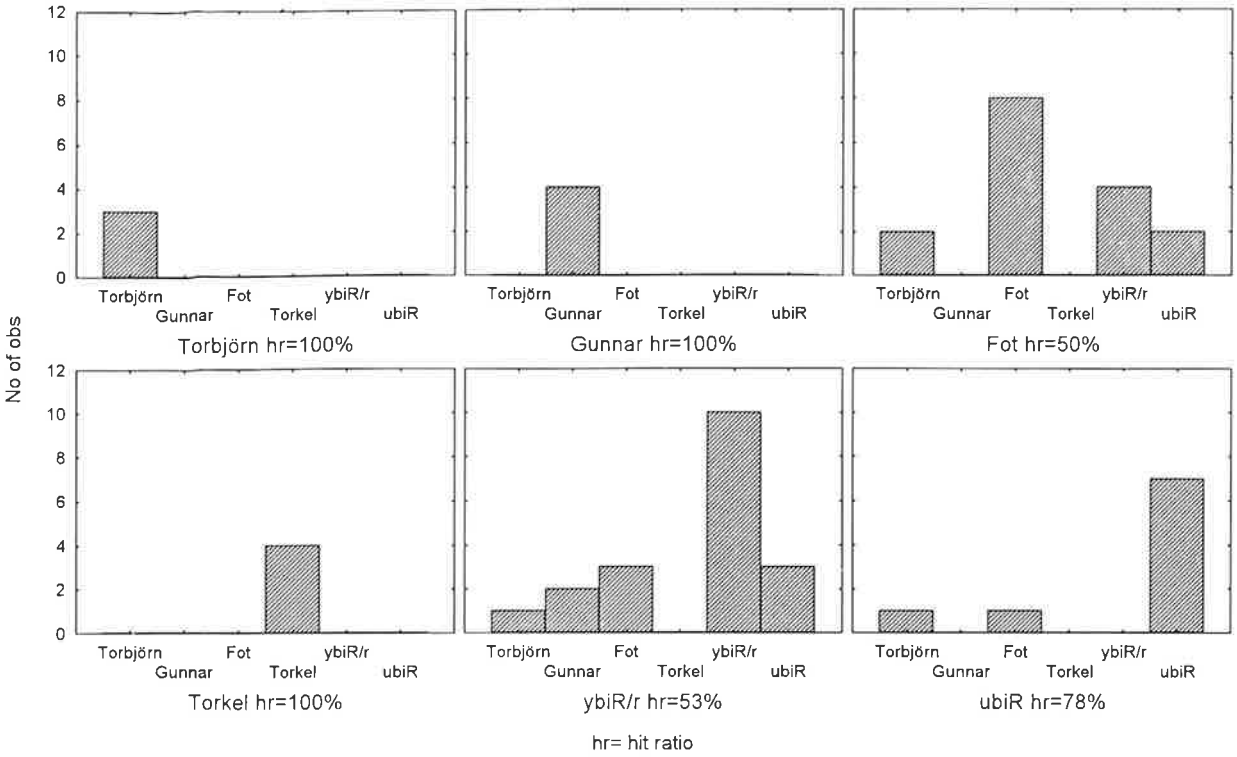

Figure 8a. Frequency distribution: Öpir divided into the two groups ubiR and ybiR/ybir, ornaments.

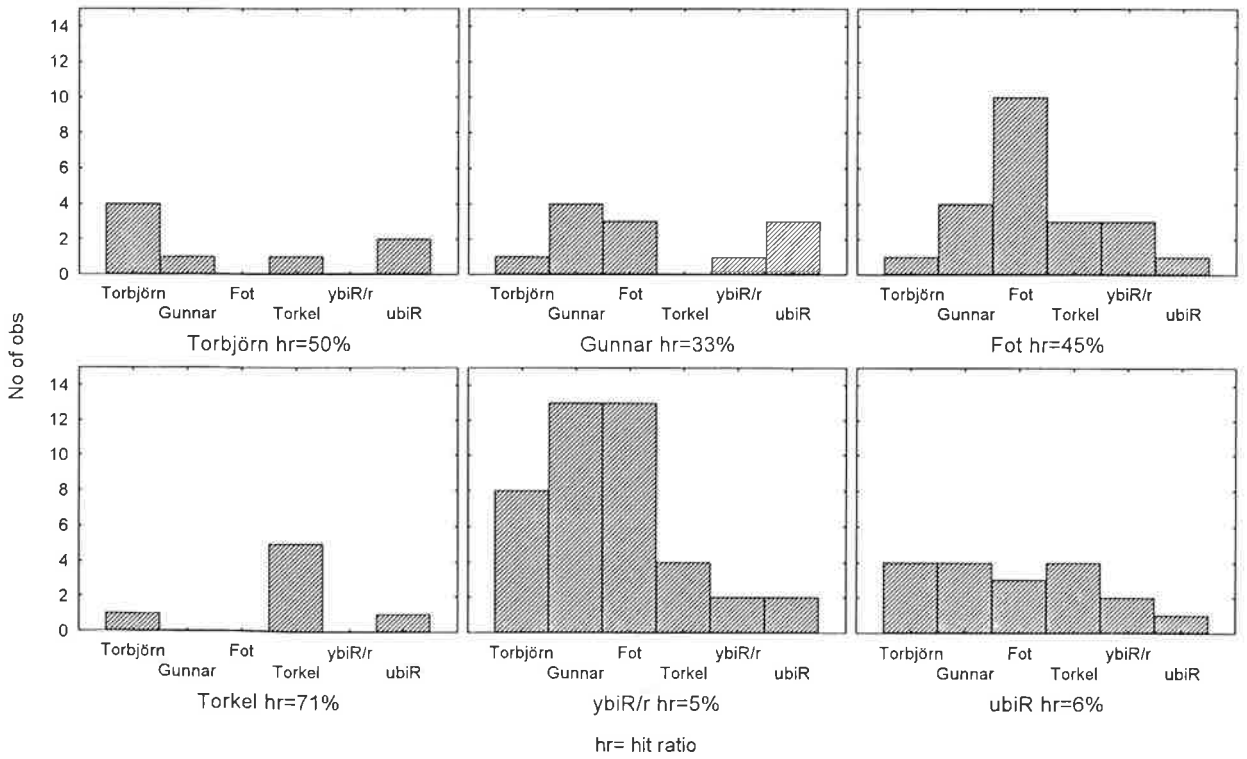

Figure 8b. Frequency distribution: Öpir divided into the two groups ubiR and ybiR/ybir, runes.

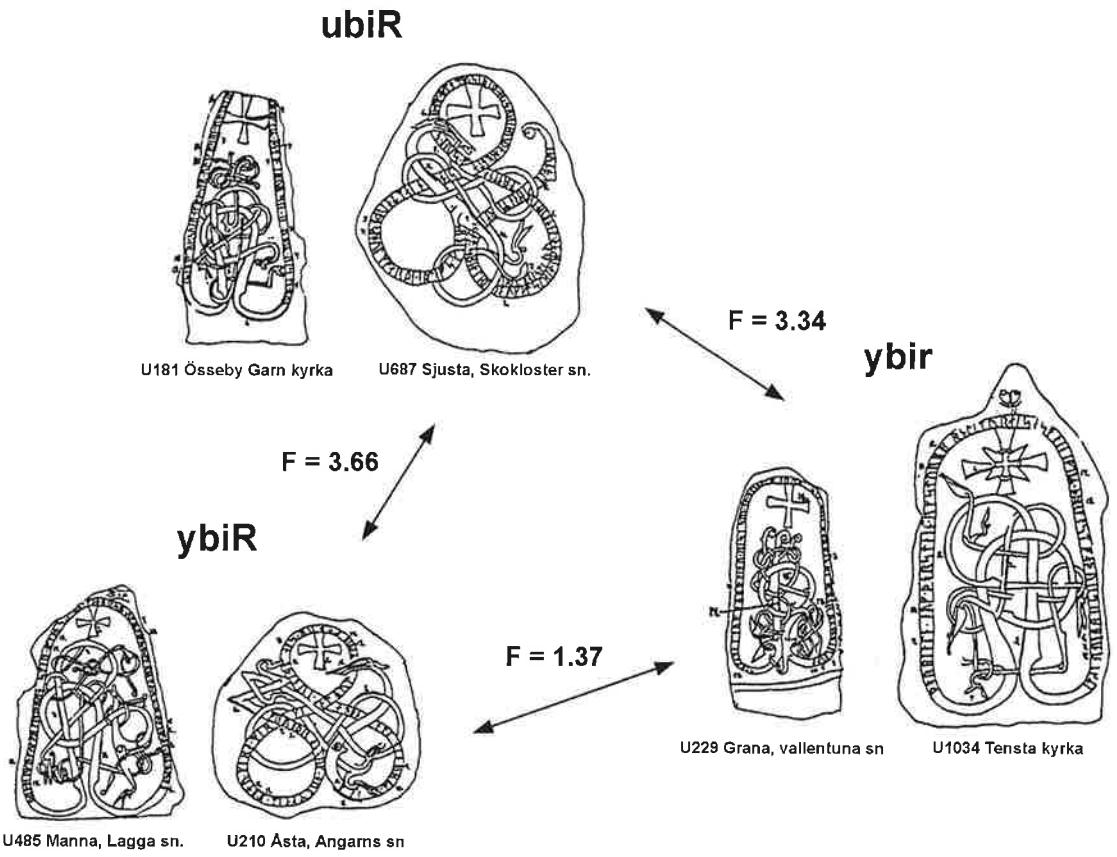

Figure 9. Distances between groups expressed in F-values. Larger F-value = further distance between the groups. Variables: AvgX, AvgY, AvgZ, Plusdiff, Meddiff, W.
Degrees of freedom=6.20. Critical value for F at p=0.05: F=2.60.
If the F-value exceeds the critical value for F at a p-level of 0.05, there is a less than 5% risque of rejecting the null hypothesis when it in fact is true. The null hypothesis in this case is that there is no difference between the groups.

thoughts about increasing professionalism in rune carving when the relatives of the deceased decrease their direct participation in the act of producing the memorial carving (Herschend 1993, 1997:6; cf. Zachrisson 1997:158ff). In her dissertation on *Motif-pieces*, Uaininn O'Meadhra (1987) has studied the organization of craftsmen. Motif-pieces might have been introduced in Scandinavia by Irish craftsmen, possibly in connection with missionaries, and may have inspired the ornamentation of the rune stones. In addition, they have been regarded as proof of the existence of schools. O'Meadhra mentions the special social category *aes dána,* including skilled craftsmen, poets, jurists and clerks (O'Meadhra 1987:21). Perhaps the late rune-carvers are comparable with these versatile artisans?

To further investigate the matter, a discriminant analysis with Öpir-material only was conducted. The samples were divided into the three spellings, each group represented by two carvings. A useful feature of Discriminant Analysis while testing how the data fit into different hypotheses is *Distances between groups* expressed in F-values and p-levels. In the analysis it appears very clearly that ubiR is well distinguished from both ybiR and ybir. However, since a hypothesis never positively can be proven to be right (Hempel 1966:40), it cannot be said the other way round that ybiR and ybir belongs to the same group. The relationships between the groups are expressed in fig. 9 (F-values, 6 variables) and in fig. 10 (mean profiles, 3 variables). My conclusion is that the surface structure analysis lends support to Herschend's hypothesis of two carvers who name themselves Öpir.

In this paper I have discussed the ancient rune stones as if they were made by lone carvers. Recently, by normality distributions and t-tests, I have discovered that some of them indeed are products of cooperation. In forthcoming studies the implications of this discovery will be explored.

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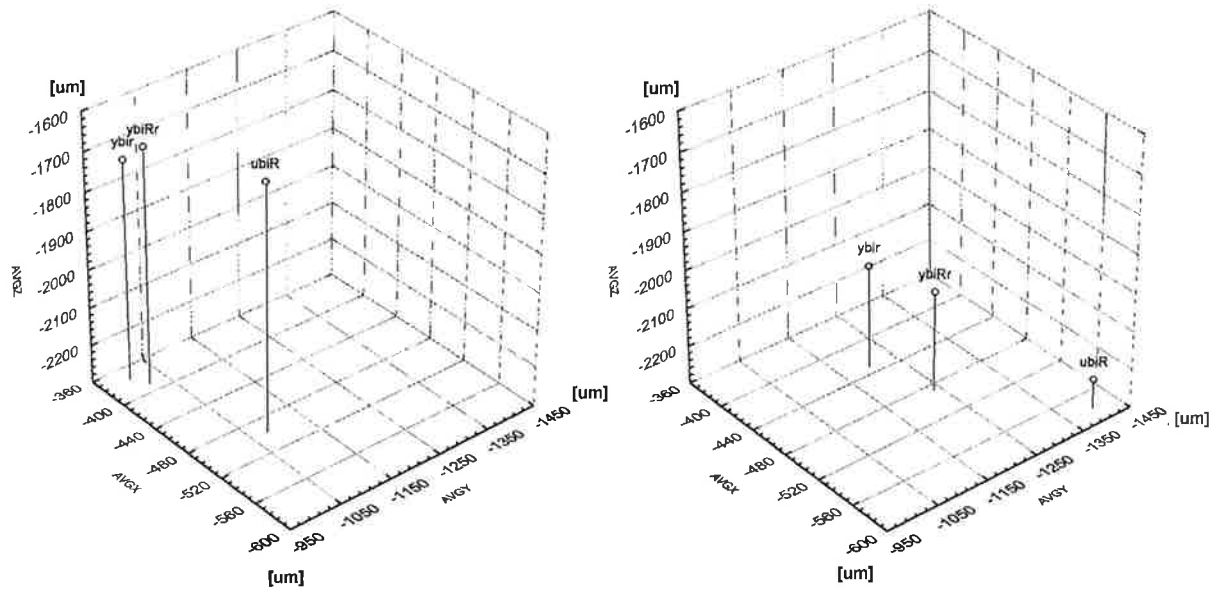

Figure 10. Mean Profiles representing the three spellings of the name Öpir. Each spelling is represented by the mean value of two rune stones.

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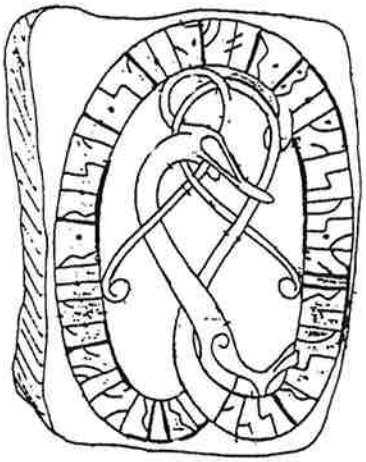
Vätö Stenhuggeri (Vätö Stone Masonry).

Appendix: Rune Stones

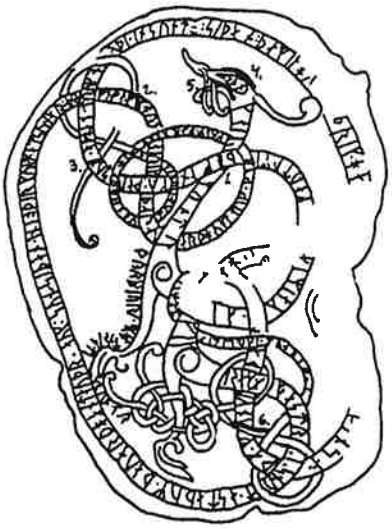
MODERN REFERENCE MATERIAL

K1. Viking Line. Stadsgården, Stockholm
Unskilled kalle, unskilled Helper

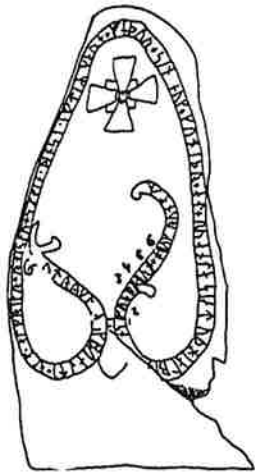


K2. Pegasus. Adelsö
Skilled kalle, unskilled Markus

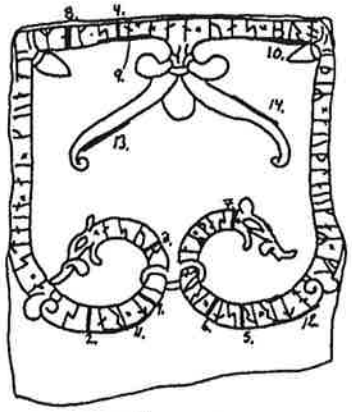
SIGNED GRANITE STONES



U29 Hillersjö, Hilleshög p.
Torbjörn

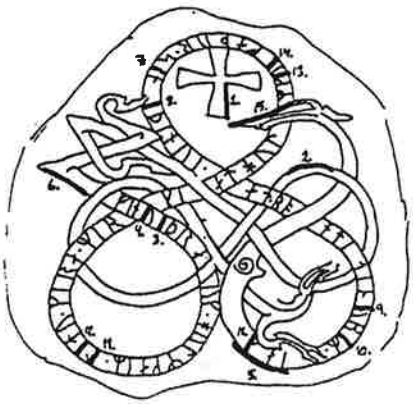


U37. Säby, Sånga p.
Torbjörn

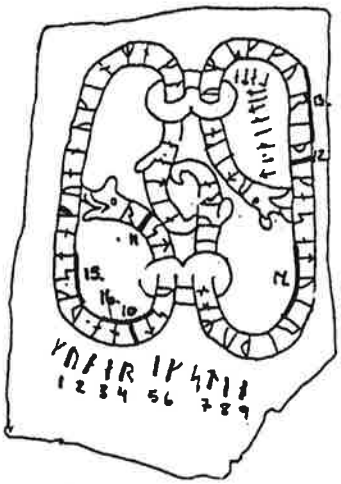


U167. Östra Ryd Church
Fot

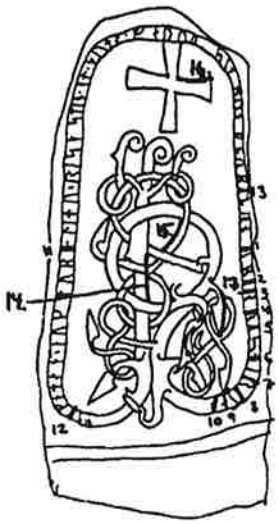
U181. Ösbeby Garn Church
Öpir (ubiR)



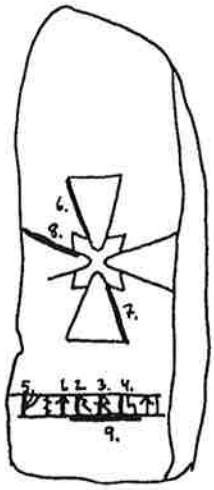
U210. Åsta, Angarn p.
Öpir (ybiR)



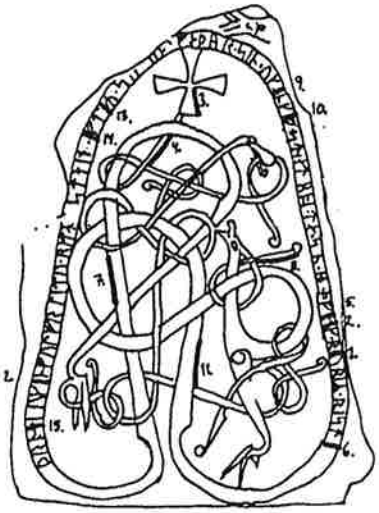
U226. Bällsta, Vallentuna p.
Gunnar



U229. Grana, Vallentuna p.
Öpir (ybir)

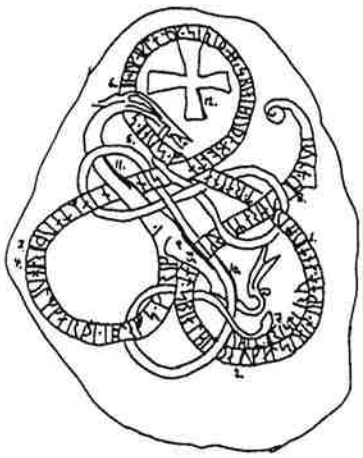


U268. Harby, Fresta p.
Fot

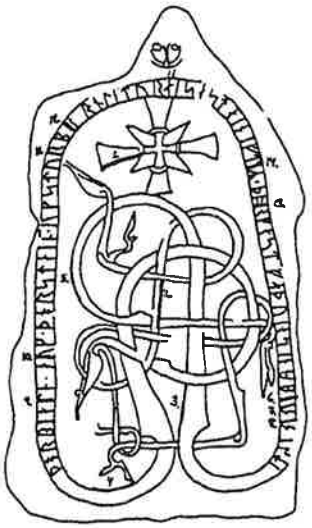


U485. Marma, Lagga p.
Ofeg Öpir (ybiR)

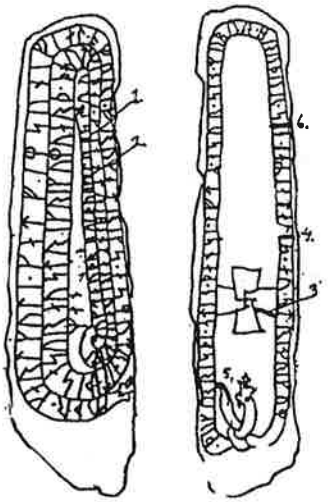
U678. Skokloster Church
Fot



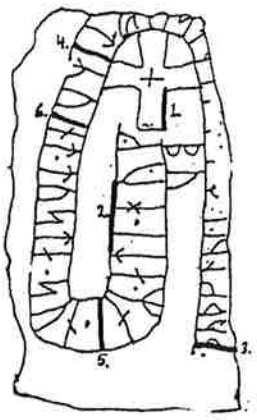
U687. Sjusta, Skokloster p.
Öpir (ubiR)



U1034. Tensta Church
Öpir (ybir)



Ög81. Högby Church
Torkel



Ög82. Högby Vicarage
Torkel