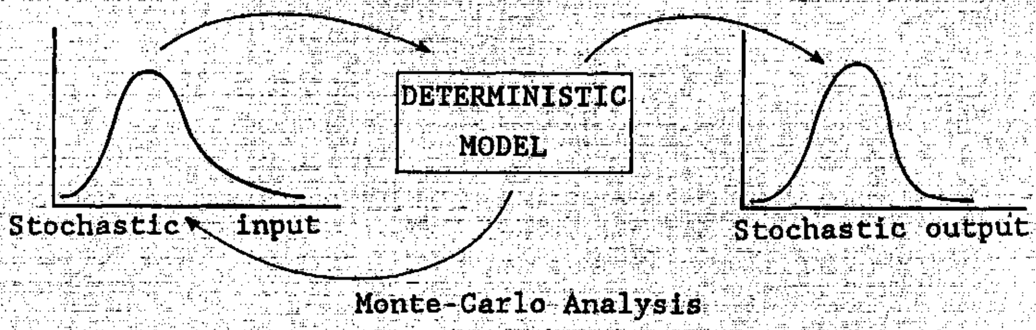
SOIL HYDRAULIC PROPERTIES IN THE STUDY AREA HUPSELSE BEEK AS OBTAINED FROM THREE DIFFERENT SCALES OF OBSERVATION: AN OVERVIEW



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SOIL HYDRAULIC PROPERTIES IN THE STUDY-AREA HUPSELSE BEEK AS OBTAINED FROM THREE DIFFERENT SCALES OF OBSERVATION: AN OVERVIEW

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SOIL HYDRAULIC PROPERTIES IN THE STUDY AREA HUPSELSE BEEK AS OBTAINED FROM THREE DIFFERENT SCALES OF OBSERVATION: AN OVERVIEW

J.W. Hopmans and J.N.M. Stricker

Introduction

Soil properties vary in space. Especially when the area of interest classifies into various soil map units. However, also soils that are seemingly uniform or soils within a soil map unit can vary such that no representative value for a soil property can be found from one or a few samples (Warrick and Nielsen, 1980).

Water balance models and saturated/unsaturated water flow models most often require knowledge of the soil hydraulic properties of the system considered. In the past, one would determine one or a few representative water characteristic curves and hydraulic conductivity functions and use those for the model calculations. More intensive sampling has shown that soil properties can vary much more than we anticipated them to vary. The fact that in many cases water flow models are very sensitive to variation in soil hydraulic properties, therefore, poses a problem. An intensive measurement campaign has been set up in the study-area Hupselse Beek with 2 of the following objectives: (i) to determine the variation of the soil hydraulic properties in the study-area and (ii) to find techniques to describe this variation, so that it can be used as stochastic input in a numerical model to simulate soil-water flow.

The data, pertaining to all the measurements of soil hydraulic properties in the study-area form the basis of this report. Results of statistical analysis of the available soil hydraulic data will be presented in the second part.

Description of Measurement Sites

Soil hydraulic properties were determined for various horizons at three different scales of observation. In the first sampling scheme, seven profiles across the 650 ha study area were examined. These seven sites were chosen in such a way that they included most characteristic profiles and horizons that were classified in the study area. This classification was based on a densily spaced soil survey (1200 points). The seven sites will be referred as sampling scheme 1. Figure 1 shows a 1:25000 map of the Hupselse Beek area with the location of the seven measurement sites. The names of the sites and their respective sampled horizons are listed in Table 1. The results of the soil physical measurements were reported by Wösten et al. (1983).

For the second sampling scheme, an area of 0.5 ha was chosen such that the seven sites within this area were all from the same and most important soil map unit (Hn52-STIBOKA soil map). Each of the seven sites was sampled in duplo at the 10 and 50 cm soil depth. A detailed map of the sub-area with the sampled locations is shown in Figure 2. To the northeast within this sub-area lies site 1 of sampling scheme 1. Brom (1983) reported the soil physical data for this sampling scheme.

Finally, the highest sampling density was achieved in the third sampling scheme, where at six locations triplicate samples were taken within 2 m^2. This sampling area was located between sites 1 and 7 of sampling scheme 2 (Fig. 2). At each of the six locations, samples were taken at depths of 30, 60 and 90 cm. Figure 2 shows the location of the sampling area, while a schematic view of the sampling strategy of sampling scheme 3 is presented in Figure 3. Booltink (1985) gives a detailed presentation of the measurement techniques and the soil physical data pertaining to the last sampling scheme.

		Sampled horizons	
Site	Name	Soil Water Characteristic Curve	Hydraulic Conductivity Function
1	Brom pv	A1 B2 C11 C12	B2 C11 C12
2	Assink pv	A1 B2 C11 C12	B2 C11 C12
3	Lensink	Aan B2 C11 C12	B2 C11 C12
4	Assink bl	A1 B2 C11 C12	B2 C11 C12
5	Ten Barge	A1 B2 C11g D1 D2	B2 C11g D1 D2
6	Schuurmans	A1 D1	D1
7	Faaks	Ap C11g D1	C11g D1

Table 1. Measurement sites and sampled horizons for sampling scheme 1.

Figure 1. Sample locations of sampling scheme 1.

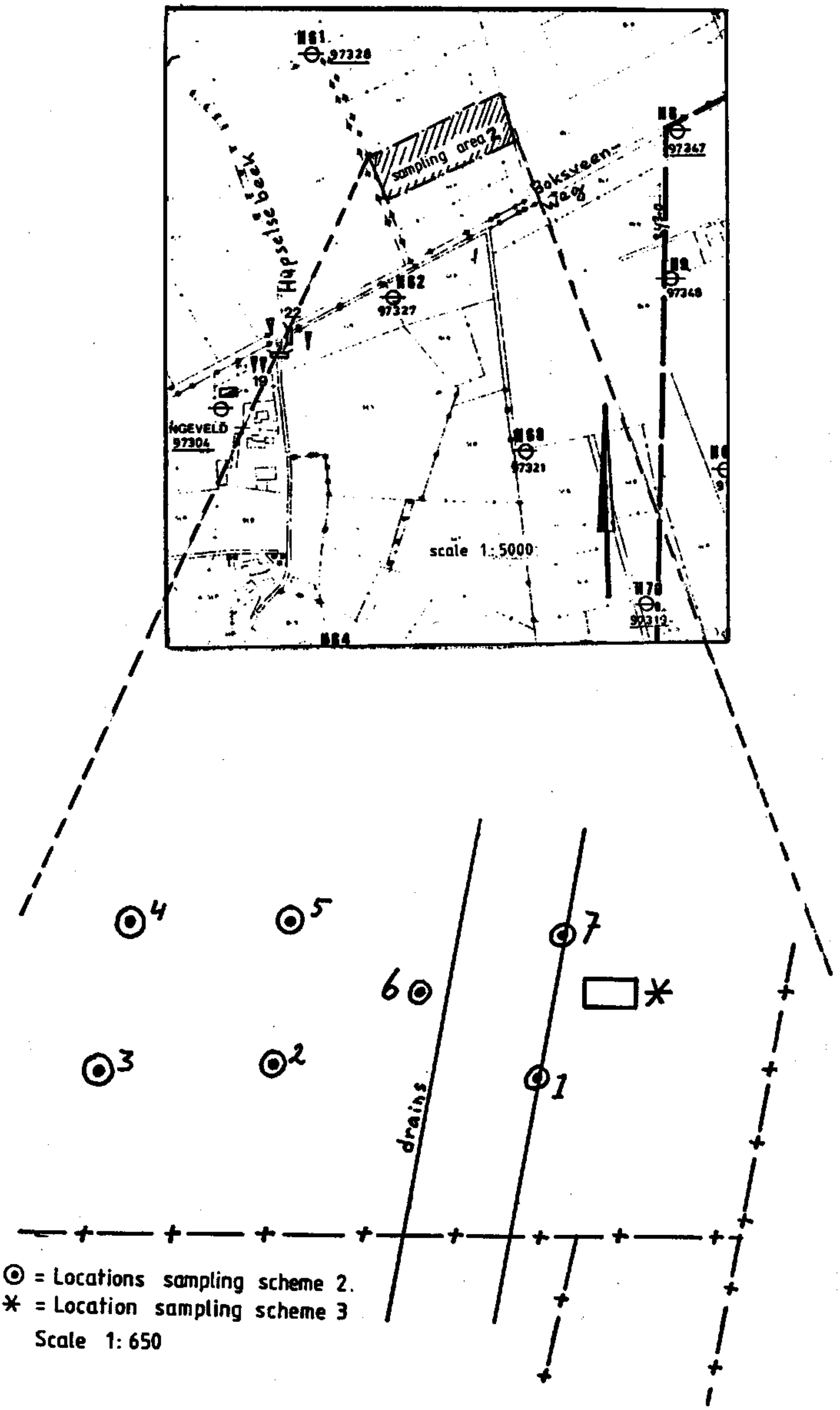


Figure 2. Location of sampling schemes 2 and 3 and the measurement sites of scheme 2.

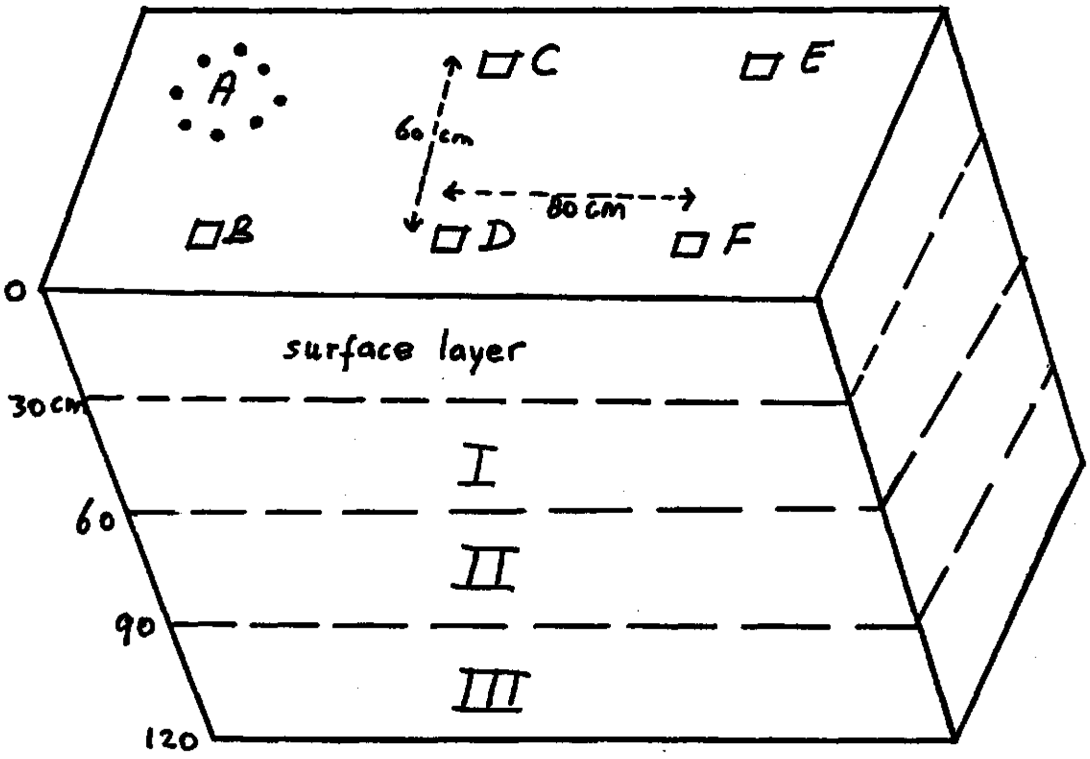


Figure 3. Sampled locations of sampling scheme 3.

Materials and Methods

Soil water characteristic curves as well as hydraulic conductivity functions were obtained by various techniques.

Stiboka (Wösten et al., 1983; sampling scheme 1) determined soil water characteristic curves by slow evaporation of wet undisturbed samples in the laboratory, in combination with in-situ measurements. In both cases, soil water pressure heads (h) were determined from tensiometer readings, while water contents (θ) were obtained from gravimetric sampling and neutron probe readings, respectively. Hydraulic conductivity (K) values of soil above the water table were measured with the crust-test down to approximately $h=-50$cm (Bouma et al., 1977) and by the sorptivity method (Dirksen, 1979) and the hot-air method (Arya et al., 1975) for lower K-values. The samples contained in PVC-cylinders to be used for the crust-test were also used for the laboratory part of the soil water characteristic curves. Wösten et al (1983) reported very good agreement between the hydraulic conductivity values calculated with the sorptivity and hot-air method.

Brom (1983; sampling scheme 2) used the sandbox apparatus (Stakman et al., 1969) to determine soil water characteristic curves down to a soil water pressure head of approximately -500 cm. Undisturbed soil cores were thereby put on a box filled with sand or kaolien clay, while the desired suction was applied to the sandbox by a hanging water column or a suction pump. A continuous water phase will be established, unless the air-entry value of the soil in the sandbox is smaller than the desired suction in the soil sample. Hydraulic conductivity values as a function of soil water pressure head were again measured by the crust-test, while lower K-values as a function of Θ were determined by both the sorptivity and hot-air method. However, results obtained by the sorptivity method deviated substantially from the K-data as determined with the hot-air method. In addition, there was a poor match between the K-values determined with the crust method at high water content values and the data obtained from the sorptivity method in the lower content range.

Booltink (1985; sampling scheme 3) used the same techniques as Brom (1983). However, after desorption of the soil sample, Booltink also determined the sorption part of the soil water characteristics.

Analysis of so many soil physical data would be easier if the data can be fitted by analytical expressions. Van Genuchten (1978) introduced closed-form analytical expressions for both hydraulic functions. These are:

$$\Theta = \left[\frac{1}{1 + |\alpha h|^n}\right]^m \quad , \qquad [1]$$

and

$$K_{rel}(\theta) = K/K_s = \Theta^{1/2} \left[1 - (1-\Theta^{1/m})^m\right]^2, \qquad [2]$$

where

$$\Theta = \frac{\theta - \theta_r}{\theta_s - \theta_r}, \text{ and } m = 1 - (1/n).$$

θ_r refers to the residual water content for which the slope $d\theta/dh$ becomes zero, excluding the region near θ_s, the saturated water content. K_s denotes the saturated hydraulic conductivity. Equations [1] and [2] therefore constitute a 5-parameter model (α, n, θ_s, θ_r and K_s).

Van Genuchten (1978) developed a curve fitting procedure to estimate the parameters θ_r, α and n from available water retention data. It is thus assumed that θ_s is known. These parameters together with a measured K_s-value can then be used in Equation [2] to describe the hydraulic conductivity function. The described Van Genuchten fitting procedure was used, except that θ_r was not estimated but set equal to zero in all cases. No satisfactory θ_r-value could be estimated as in almost all cases no water retention data were available for the dryer part of the soil water characteristic curves (beyond the inflection point of the curves). Since θ_r is known, van Genuchten's curve fitting program was modified such that instead of θ_r, an optimum value for θ_s could be estimated (θ_s^*).

However, rather than using a measured K_s-value in Eq. [2], a conductivity value at some intermediate water content was used to obtain an optimum K_s^*-

value such that Eq. [2] would match the experimental data points best. In an iterative way successive K(θ)-combinations were fitted to Van Genuchten's model. The combination that yielded the minimum least squares was assumed to be the optimum hydraulic conductivity function. To reduce the weight of the points at high K-values, the logarithm of K instead of K was used in the optimalization procedure.

Description Datafile

The soil hydraulic data pertaining to all three sampling schemes were combined in one datafile. Each sampled site was given a soil identification number, consisting of four digits. The fourth digit indicates whether the soil physical data for that particular site and horizon are combined (1), or that each replicate is considered separately (digit refers to sample number). Table 2 explains the meaning of each digit. The structure of the data file is shown in Table 3, which lists the data for soil number 3331. The soil identification number is followed by the x, y and z coordinates of the site. X and y are given in meters, while the z-coördinate is expressed in cm depth below the soil surface.

The first two numbers on the next data line refer to the available number of experimentally determined water retention and hydraulic conductivity data. These are followed by a value for α, n, θ_s^* and K_s^*, to be used when one prefers Van Genuchten's analytical expressions (Equation [1] and [2]). The superscript star refers to fitted, rather than measured θ_s and K_s-values. The fitting procedure assumes θ_r to be zero. A K_s^*-value of 99.9999 denotes a missing value. It also indicates that no unsaturated conductivity data are available.

Finally the last two values on the second data line denote α and n for the sorption part of the soil water characteristic. Sorption data were only determined in sampling scheme 3.

The following set of lines contain the experimentally determined (θ-h)-combinations (θ in $cm^3\ cm^{-3}$ and h in cm). The number of data points is defined in the second data line. All the remaining lines refer to hydraulic conductivity data. In general, these data can be divided into three groups. K-data obtained with the crust-test, the sorptivity method and the hot-air method. Each line lists the hydraulic conductivity (cm day^{-1}), the corresponding h (cm) and θ-value, and for K-data determined with the last two methods also the diffusivity value ($cm^2\ s^{-1}$). Only for sampling scheme 3, the K-data obtained by the sorptivity method were calculated using the sorption part of the water retention curve. No sorption data were collected for the other 2 schemes.

For sampling schemes 2 and 3, the data file contains also the soil water retention data for the individual samples (3332 and 3338 in Table 3). Since each sample was either used for water retention or conductivity measurements, no K-data are here included. That is, water retention and conductivity data were never determined from the same sample.

The data file can be read by the format descriptions listed in Table 4. The data file is included in the Appendix.

Digit	Description	Possible values
1	sampling scheme	1, 2, 3
2	site number	1, 2, 3, 4, 5, 6, 7
3	depth indication	1, 2, 3, 4, 5
4	sample number	1*, 2, 3, 5, 8

* All replicates combined

Table 2. Description of soil identification number.

```
    3331  242508.6  453081.9      90.0
      13        30    0.0151    2.1261    0.2930   53.5        0.0621    1.6279
   0.278         3
   0.262        32
   0.202        63
   0.112       100
   0.066       148
   0.036       331
   0.311         3
   0.292        10
   0.279        32
   0.230        63
   0.172       100
   0.144       148
   0.081       331
272.2200         0     0.293              CRUST
192.8700        10     0.290
175.3400        14     0.287
 51.6000        24     0.277
 22.4500        18     0.284
122.4000        19     0.283
104.3600         2     0.293
250.6300         0     0.293
  0.0170       204     0.059   0.00110  SORP
  2.5332        72     0.110   0.03300
 19.6759        41     0.150   0.12000
  8.8477        54     0.130   0.07700
 45.0111        28     0.180   0.18000
  0.0007       258     0.051   0.00007
  0.0016       210     0.058   0.00011
  0.1272       100     0.091   0.00270
  0.5415        85     0.100   0.00900
 62.0486        54     0.130   0.54000
  0.0014       340     0.043   0.00021
  0.0312       162     0.068   0.00140
  1.0747        72     0.110   0.01400
 27.7928        25     0.190   0.10000
  0.9719        73     0.190   0.00690  HAM
  0.9400        87     0.170   0.00770
  0.6579       102     0.150   0.00640
  0.3040       121     0.130   0.00370
  0.0543       145     0.110   0.00087
  0.0188       179     0.090   0.00043
  0.0070       228     0.070   0.00025
  0.0022       313     0.050   0.00015

    3332  242508.8  453082.0      90.0
       6         0    0.0146    2.7256    0.2806   53.5
   0.278         3
   0.262        32
   0.202        63
   0.112       100
   0.066       148
   0.036       331
    3338  242508.6  453081.7      90.0
       7         0    0.0157    1.8078    0.3062   53.5
   0.311         3
   0.292        10
   0.279        32
    0.23        63
   0.172       100
   0.144       148
   0.081       331
```

Table 3. Soil physical data for site 333.

Line/data	Format
1	5x, A5, 3(F10.1)
2	2I10, 6F10.4
retention	F10.3, I10
conductivity	F10.4, I10, F10.3, F10.5

Table 4. Format description data file.

Discussion

Diffusivity values D, obtained by the sorptivity and hot-air method, are used to compute hydraulic conductivity values. The two properties are related by:

$$K(\theta) = D(\theta) * C(\theta), \qquad [3]$$

where $C(\theta)$ denotes the water capacity function or the slope of the water characteristic curve. Using the same characteristic curve one can subsequently determine K(h)-combinations. Therefore, only those conductivity data are presented that correspond to soil water pressure head values equal or larger than for which soil water characteristic curves were determined.

Since the soil water characteristic function is hysteretic, so is the diffusivity function $D(\theta)$. There is, therefore, a marked difference between the sorptivity and hot-air method. In the first method, water is absorbed by the soil, while in the latter hot-air method the soil is dried. In principle, $K(\theta)$ and K(h)-data obtained by the two methods can only be combined if both the wetting and drying part of the soil water characteristic are measured ($C_w(\theta)$ and $C_d(\theta)$, where subscripts w and d denote wetting and drying, respectively). No sorption data, however, were measured by either Wösten et al. (1983, sampling scheme 1) or Brom (1983, sampling scheme 2). Wösten et al. (1983) found still good agreement between the two methods, when K was plotted versus h. However, $K(\theta)$ and K(h) data obtained with the sorptivity method by Brom (1983) did in most cases not agree with those determined with the hot-air and crust-method. These K-data were therefore eliminated and are not presented in this report.

Booltink (1985, sampling scheme 3) did measure hysteresis. Examples for two soils are shown in Figure 4 and 5. The same figures also show K(h)-data as obtained with the sorptivity method when the desorption (circles) or sorption part (+) of the soil water characteristic curve is used to convert from diffusivity to conductivity values (Equation [3]). These figures show that there is a significant hysteresis effect, which should be considered when soils are either wetted or dried to determine conductivity values. It can be seen that the sorptivity method will tend to overestimate K when using the desorption or drying curve. Booltink's diffusivity data to calculate K were indeed treated as being partly obtained during drying (hot-air method) and partly during wetting (sorptivity method).

The resulting $K(\theta)$ and K(h) relationships for the same samples are shown in Figure 6 and 7. The $K(\theta)$-data are divided into three groups, each group being determined by another method. The data obtained with the crust-test (circles) and hot-air method (+) seem to overlap well.

There is, however, no agreement with the sorptivity method (triangles) at higher water content values. A similar inconsistancy between the sorptivity method and the other two methods was reported by Brom (1983). The sorption data indicate a 1000-fold increase in K with a water content increase of ca. 0.05 (Figure 6b and 7b) in the high conductivity range. This seems very unlikely. A continuous slip on the cam may have resulted in a decreased infiltration rate and therefore in too low water content values. Therefore, the $K(\Theta)$-data from the sorptivity method were not included in the fitting of Van Genuchten's expression (Equation [2]).

Since the K(h)-function is hysteresis dependent, there exists no unique relation between K and h. The fitted curves (van Genuchten) through the K(h)-data in Figure 6c and 7c are desorption curves. The sorption curves would lie below the fitted lines.

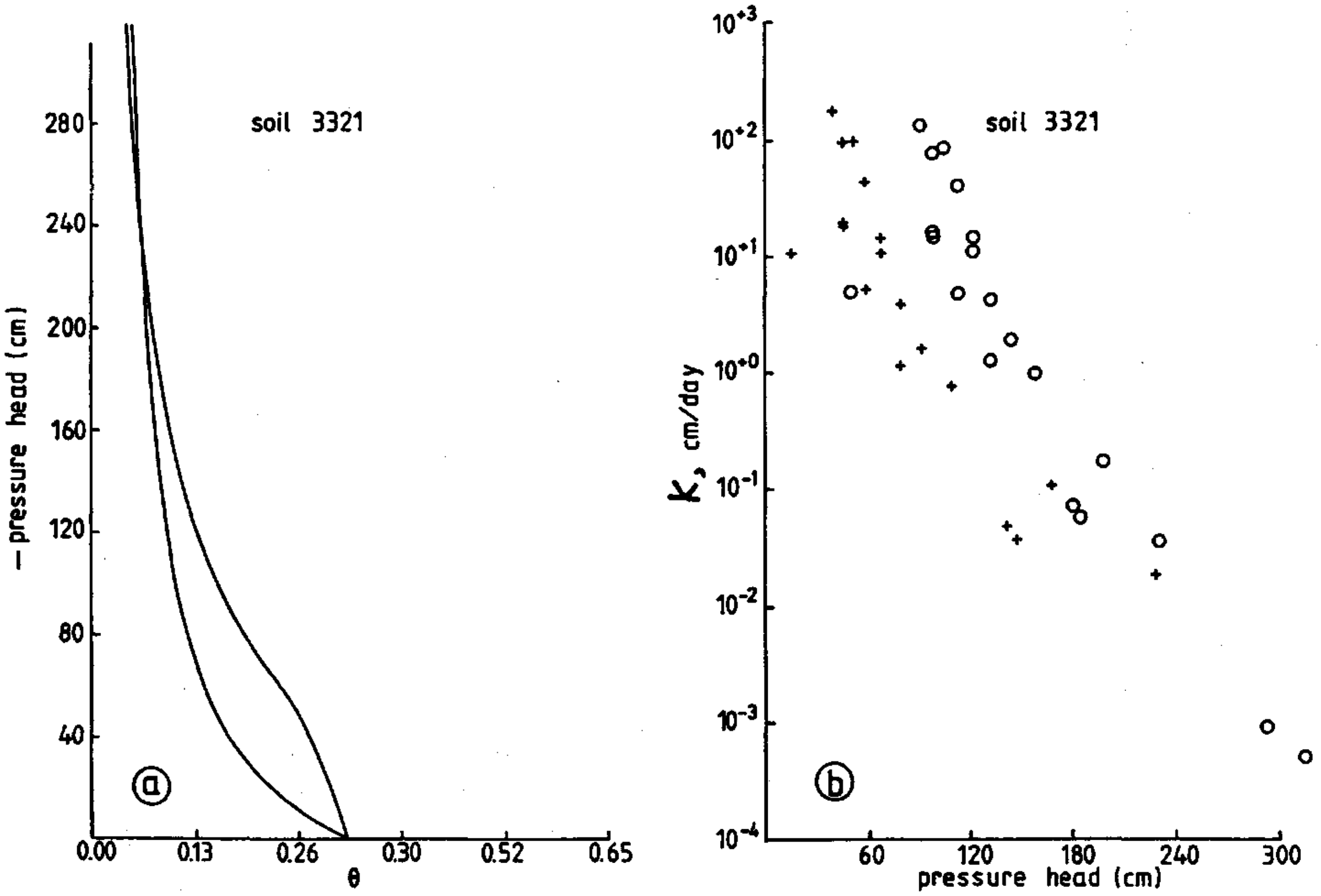


Figure 4. Drying and wetting curves (a) and K(h)-data from sorptivity method (b), when drying (circles) or wetting curve (+) is used for soil 3321.

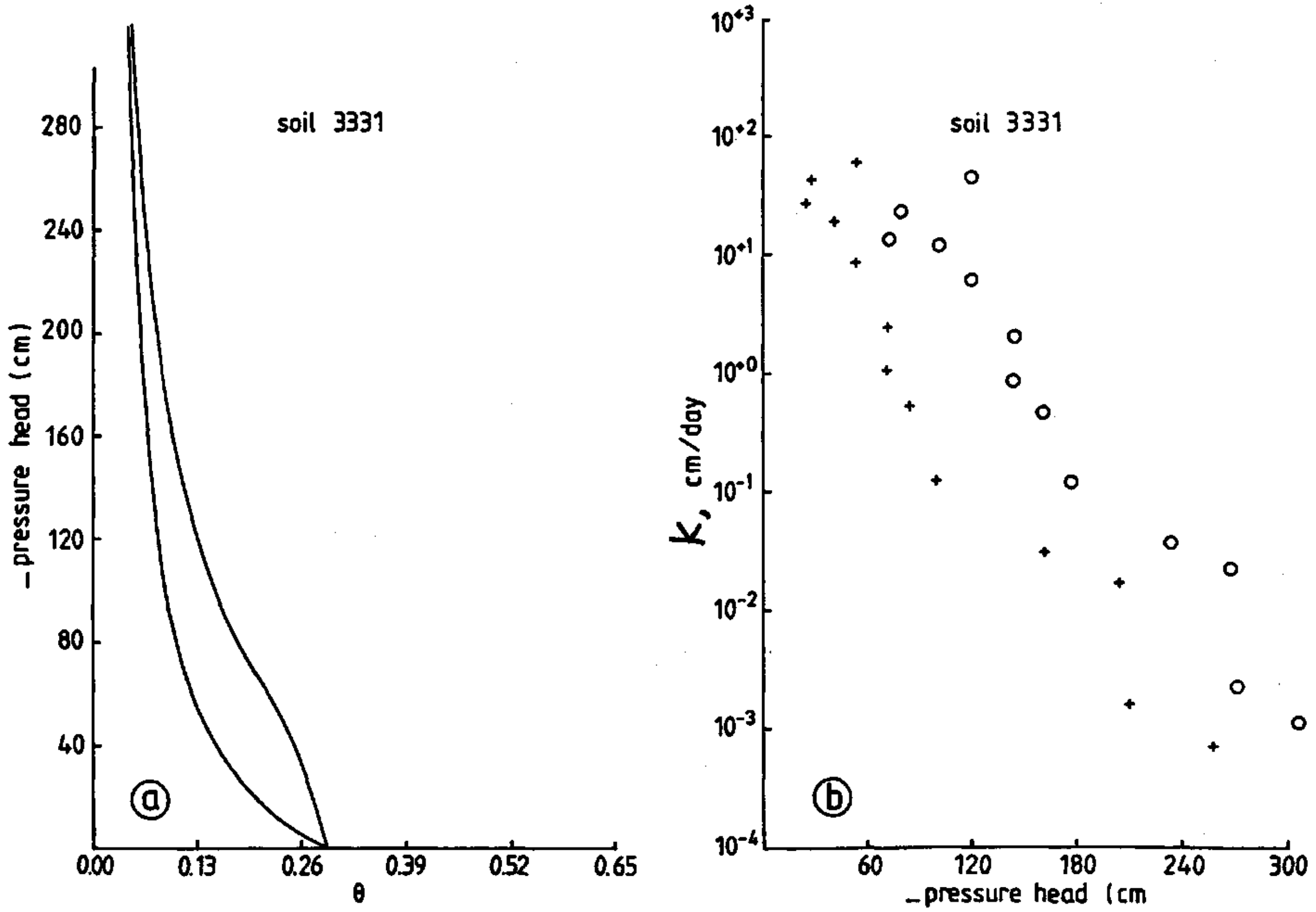


Figure 5. Drying and wetting curves (a) and K(h)-data from sorptivity method (b), when drying (circles) or wetting curve (+) is used for soil 3331.

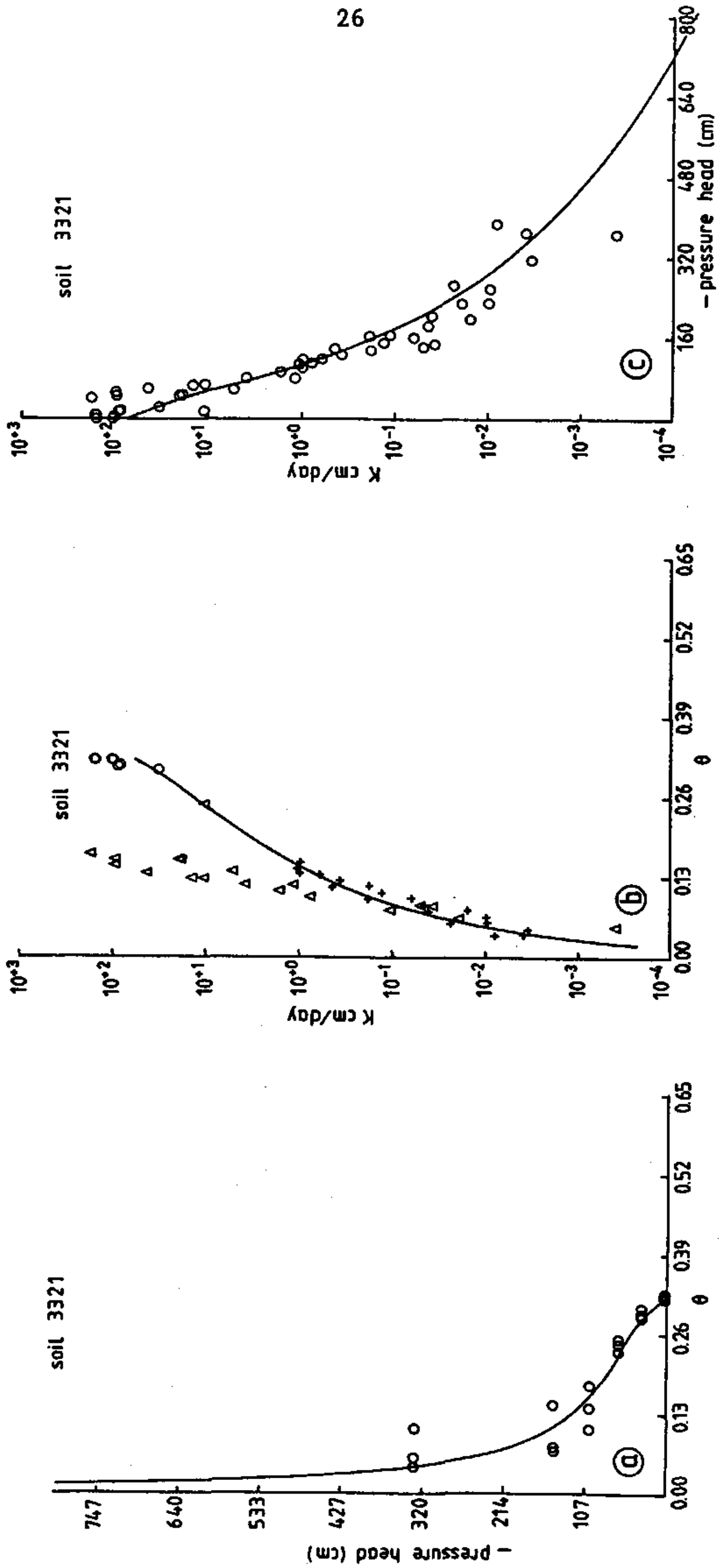


Figure 6. Drying curve (a), K(θ)-data (b) as determined with crust test (circles), sorptivity method (triangles) and hot-air method (+) and combined K(h)-data (c), where lines are only fitted through data obtained with crust and hot-air method. Soil 3321.

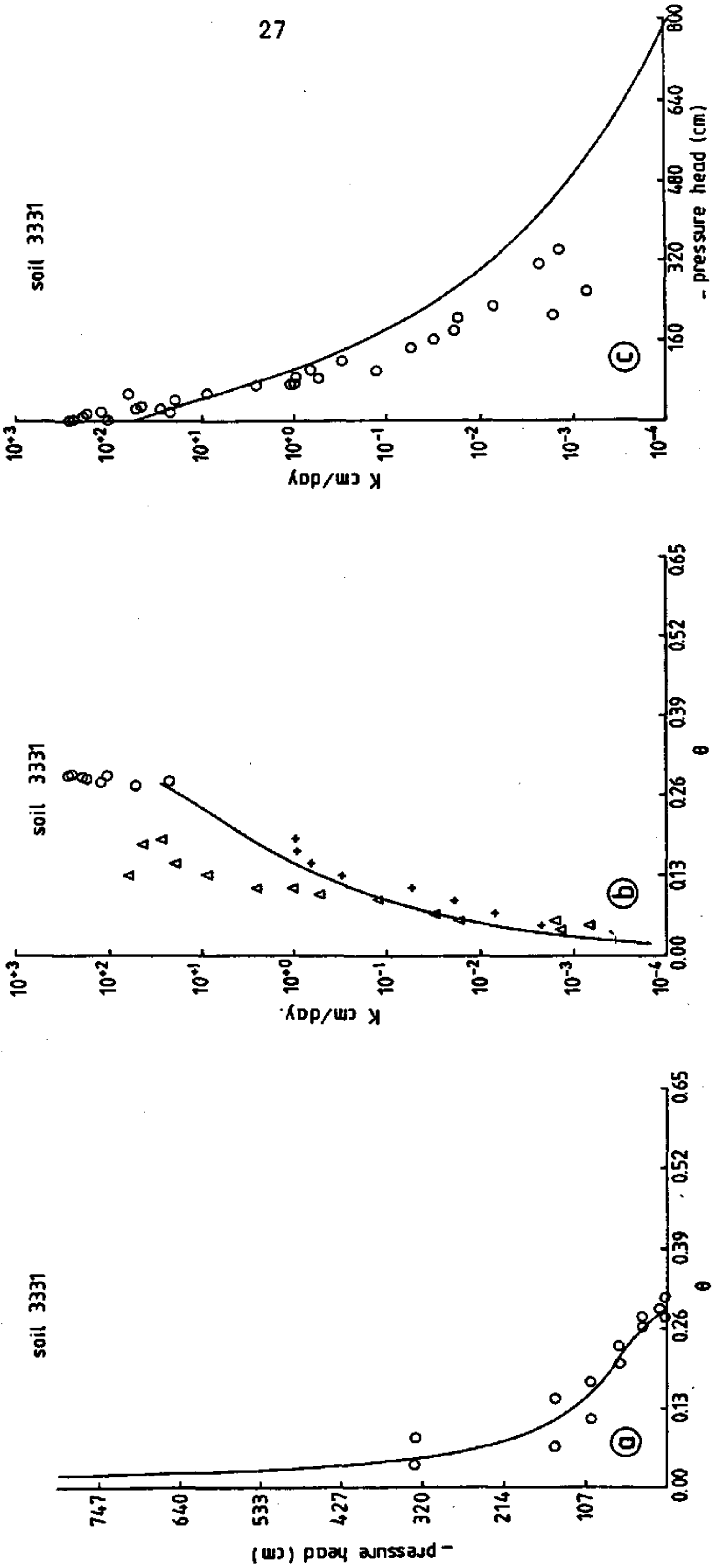


Figure 7. Drying curve (a), K(θ)-data (b) as determined with crust test (circles), sorptivity method (triangles) and hot-air method (+) and combined K(h)-data (c), where lines are only fitted through data obtained with crust and hot-air method. Soil 3331.

Some Statistical Analysis

The following section gives some preliminary results from statistical analysis of the available soil physical data. The analysis is by no means complete, but is an indication of what can be done.

1. Multiple regression analysis

Multiple regression analysis was carried out to check if there exists significant correlation amoung α, n (Van Genuchten functions), K_s^* and θ_s^*. High correlation coefficients were obtained when α was regressed against n, n^2, K_s^* and K_s^{*2}. The results are listed in Table 5. The coefficients of determination (R^2) for sampling scheme 2, 3 and the combination of the two schemes are significantly larger than the other regressed populations. The first sampling scheme pertains to different soil map units, while the other two schemes comprised only one soil map unit.

A similar regression analysis was done for K_s^* being the dependent variable, while including θ_s^* as one of the independent variables. This is more interesting than the previous analysis, since prediction instead of measurement of K_s would reduce the total number of measurements required to quantify the soil physical characteristics. The results are shown in Table 6 and 7. Table 6 lists R^2 values for a stepwise increase in the number of independent variables, while Table 7 lists the regression coefficients when all independent variables are included. Table 6 clearly shows a significant increase of the R^2 values when θ_s^* is included in the regression analysis. The increase in the coefficient of determination with the inclusion of $(\theta_s^*)^2$ may be the result of the quadratic relation between saturated hydraulic conductivity and pore size radius. Figure 8 illustrates how such predicted K_s-values compare with the fitted K_s-values for sampling scheme 1.

Sampling scheme	Regression Coefficients					R^2-Value
	a	b	c	d*10^3	e*10^6	
1 (19)¶	.0978	-0.588	.00825	.150	-0.100	.749
2 (14)	-.00301	.00690	-.00036	.291	-0.300	.897
3 (17)	.0696	-.0522	.0114	.162	-0.300	.863
1+2 (33)	.0511	-.0291	.00422	.132	-0.100	.639
2+3 (31)	.0301	-.0221	.00566	.199	-0.200	.819
1+3 (36)	.0662	-.0372	.00528	.135	-0.100	.709
1+2+3 (50)	.0422	-.0214	.00307	.125	-0.000	.643

¶ number of observations

Table 5. Regression coefficients and coefficient of determination for prediction of α from n and K_s^*-values ($\alpha = a + b\cdot n + c\cdot n^2 + d\cdot K_s^* + e\cdot K_s^{*2}$).

independent parameters	R²-Values For Sampling Scheme						
	1	2	3	1+2	1+3	2+3	1+2+3
α, n	.464	.520	.802	.483	.495	.579	.500
α, n, θ_s^*	.819	.665	.803	.701	.724	.596	.658
α, n, α^2, n^2	.773	.557	.827	.652	.711	.586	.631
α, n, θ_s^*, α^2, n^2, θ_s^{*2}	.974	.792	.878	.870	.929	.624	.847

Table 6. Coefficients of determination for prediction of K_s^* from α, n and θ_s^*.

	Regression coefficients							R^2
Sampling scheme	$a*10^{-3}$	$b*10^{-4}$	$c*10^{-1}$	$d*10^{-4}$	$e*10^{-4}$	f	$g*10^{-4}$	
1	.2586	2.503	40.56	-.8344	-10.40	-49.43	1.297	.974
2	8.715	.1089	-1299	1.577	4.011	3823	-2.732	.792
3	-1.522	-1.798	-18.49	1.084	42.39	43.51	-1.467	.878
1+2	2.031	1.714	-7.653	-1.326	-7.587	-10.42	1.833	.870
1+3	1.337	2.097	28.19	-1.204	-8.905	-36.15	1.699	.929
2+3	.1459	.9896	-53.93	.2575	-3.481	111.0	-.4536	.624
1+2+3	2.019	1.583	1.348	-1.279	-6.796	-.5399	1.774	.847

Table 7. Regression coefficients and coefficients of determination for prediction of K_s^* from α, n and θ_s^*
($K_s^* = a + b\cdot\alpha + c\cdot n + d\cdot\theta_s^* + e\cdot\alpha^2 + f\cdot n^2 + g\cdot\theta_s^{*2}$)

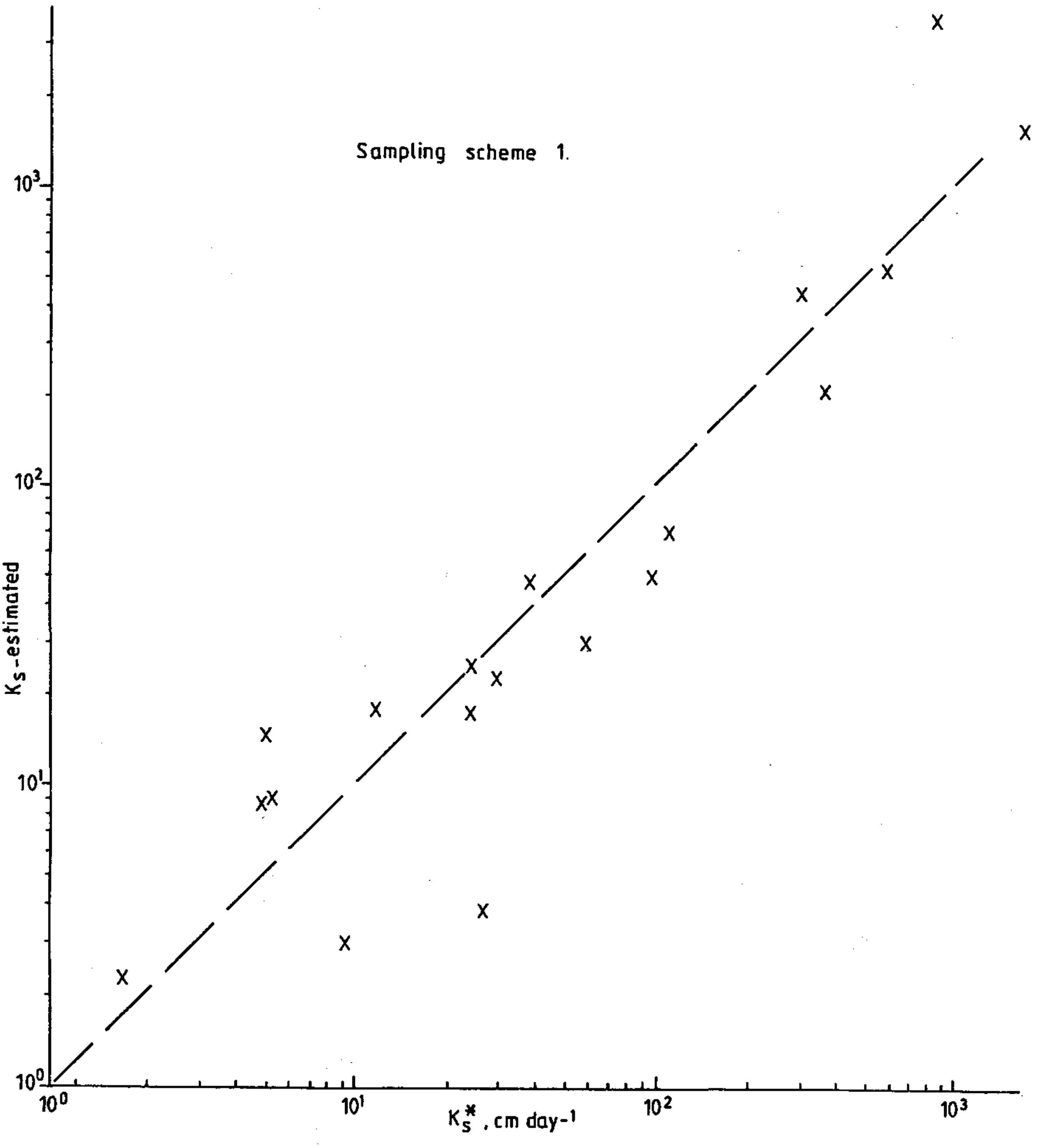


Figure 8. Saturated hydraulic conductivity values of sampling scheme 1 predicted from α, n, and θ_s, plotted versus K_s^*.

2. *Test for distribution type*

The study of soil water flow with spatial variable soil hydraulic properties requires that the distributions of the values of the properties or of the parameters that functionally describe these properties are known. This is true since the soil hydraulic properties will then serve as stochastic input for a computer model to simulate unsaturated water flow. It is, therefore, of interest to find the distribution function of α, n, θ_s^* and K_s^*. In Table 8 a normal and lognormal distribution are compared for these four variables and for the various sampling schemes. In this table, KS denotes the modified distribution-free Kolmogorov-Smirnov Statistic (Stephens, 1974), which is used to determine the goodness-of-fit of a hypothetized theoretical distribution with an estimated mean and variance to the empirical distribution function. The KS-statistic is a quantitive measure of the maximum difference between the empirical and hypothetical distribution function, and its value therefore decreases if the 2 distributions are closer together. In the case treated in Table 8, a value below .895 indicates an acceptable fit at the 5% probability level (see Stephens, 1974).

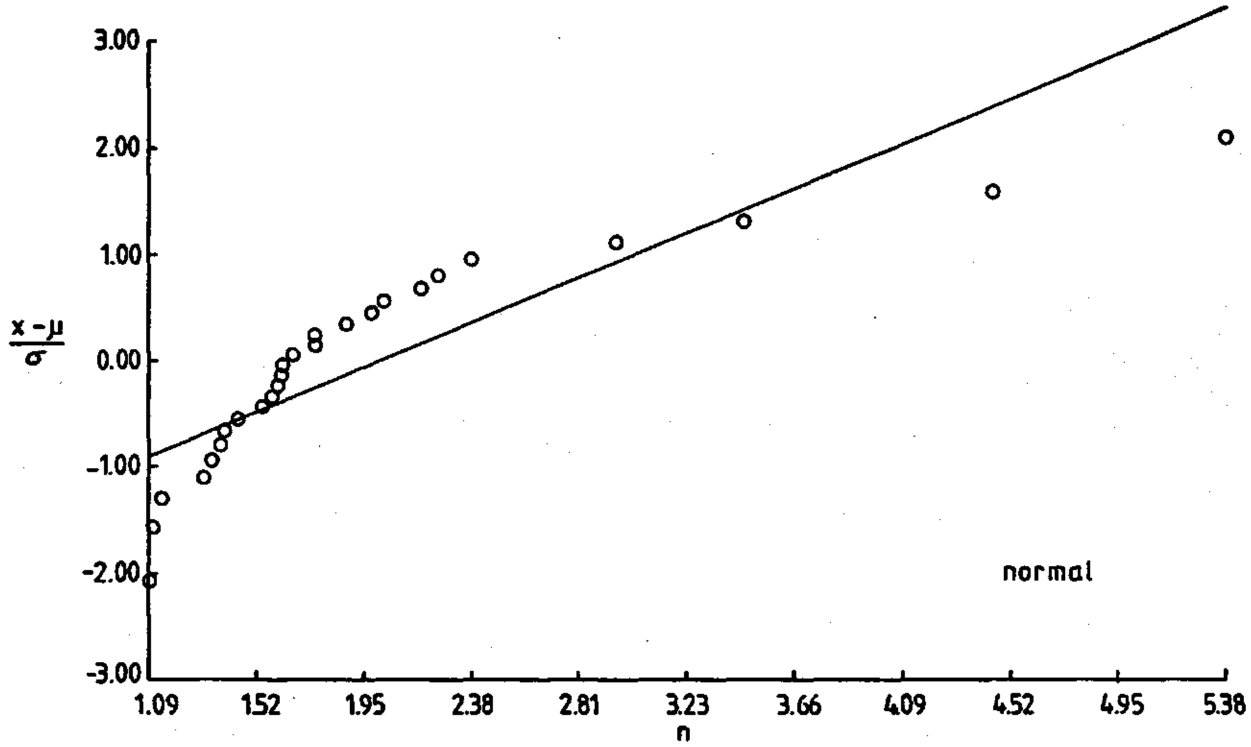
According to Stephens (1974) KS was calculated from $D^*[n^{0.5}-0.01+0.85/n^{0.5}]$, where D^* is the usual Kolmogorov-Smirnov statistic and n the number of observations. Those parameters that are labelled with a star were rejected as being normally or lognormally distributed at the 95% confidence level. In general, K_s^* follows a lognormal and θ_s^* a normal distribution function. One can also observe from the last two columns in Table 8 that the KS-statistic largely decreased in most cases when the data were transformed to a lognormal distribution. Visual inspection of the frequency distributions, (Fig. 9 to 12) would indicate that a lognormal distribution fits the empirical data better for all parameters, except possibly θ_s^*. A similar conclusion was reported by Greminger et al. (1985). Examples of such distributions are shown in Figure 9 through 12 for sampling scheme 1.

	μ		σ		KS	
parameter	normal	lognorm.	normal	lognorm.	normal	lognorm.
Sampling scheme 1						
α (26)	.03440	-3.686	.03405	.8023	1.382*	.652
n (26)	2.011	.6093	1.023	.4008	1.183*	.867
θ_s^* (26)	.3778	-.9899	.07322	.1829	.741	.594
K_s^* (19)	236.2	3.614	455.5	2.502	1.554*	.709
Sampling scheme 2						
α (14)	.02264	-4.015	.01756	.6729	.859	.546
n (14)	1.440^+	$-.3593^+$	.1615	.1057	.970*	.898
θ_s^* (14)	.3689	-1.005	.04731	.1327	.451	.538
K_s^* (14)	116.3	3.709	198.3	1.485	1.291*	.408
Sampling scheme 3						
α (17)	.02382	-3.822	.01076	.4119	1.136*	1.097*
n (17)	1.947	.6423	.4606	.2227	1.062*	.963*
θ_s^* (17)	$.3383^+$	-1.096^+	.05631	.1589	1.097*	1.002*
K_s^* (17)	94.01	4.066	96.35	1.038	1.473*	.721
Sampling scheme 2 + 3						
α (31)	.0233	-3.909	.01399	.5443	1.250*	.930*
n (31)	1.718	.5145	.4363	.2276	1.165*	.874
θ_s^* (31)	.3522	-1.055	.05386	.1523	.748	.634
K_s^* (31)	104.1	3.905	148.7	1.250	1.742*	.531
Sampling scheme 1 + 2 + 3						
α (57)	.02835	-3.807	.02557	.6772	1.576*	.643
n (57)	1.852	.5578	.7685	.3189	1.768*	1.331*
θ_s^* (57)	.3639	-1.025	.06414	.1686	.727	.627
K_s^* (50)	154.3	3.794	306.5	1.809	2.233*	.546

+ mean is significantly different from sampling scheme 1 at 95% confidence level.

* hypothesis that distribution is normal or lognormal is rejected at 95% confidence level (critical region: KS<0.895).

Table 8. Comparison of normal and lognormal distribution functions for α, n, θ_s^* and K_s^* (all sampling depths combined).



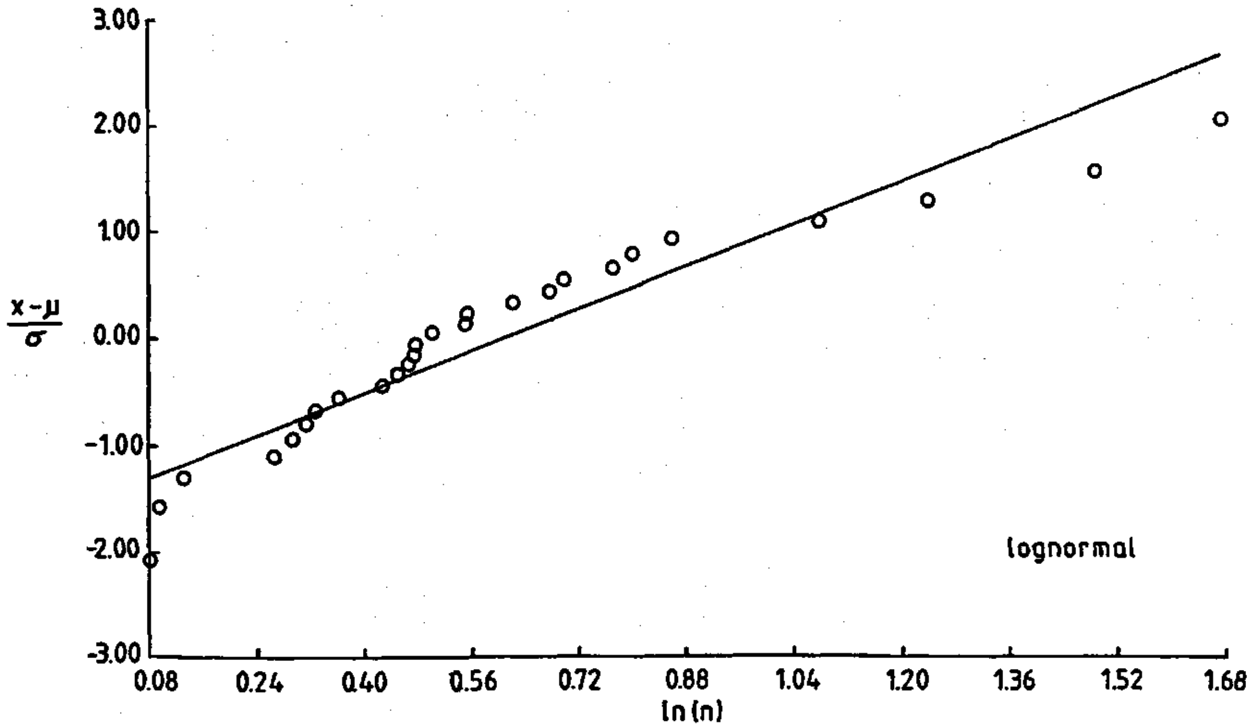
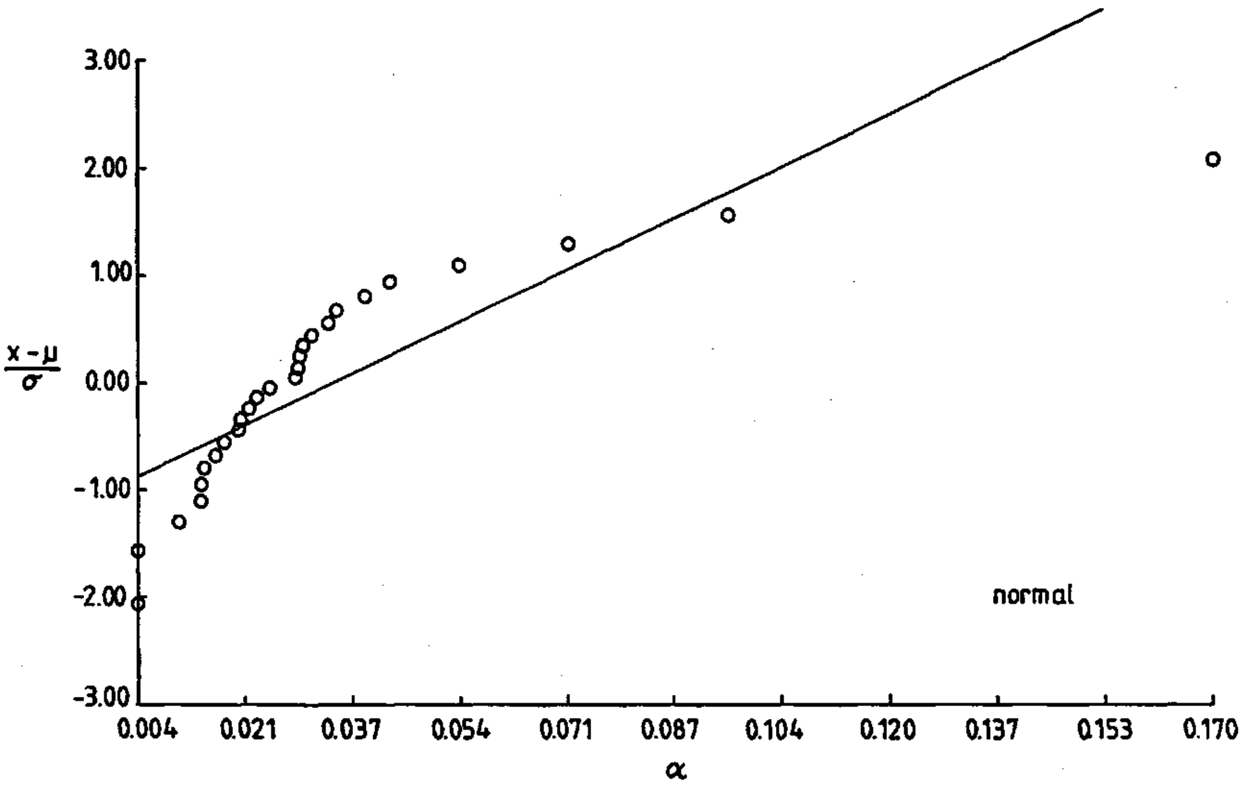


Figure 9. Fractile diagrams for normal and lognormal distribution of n (scheme 1).



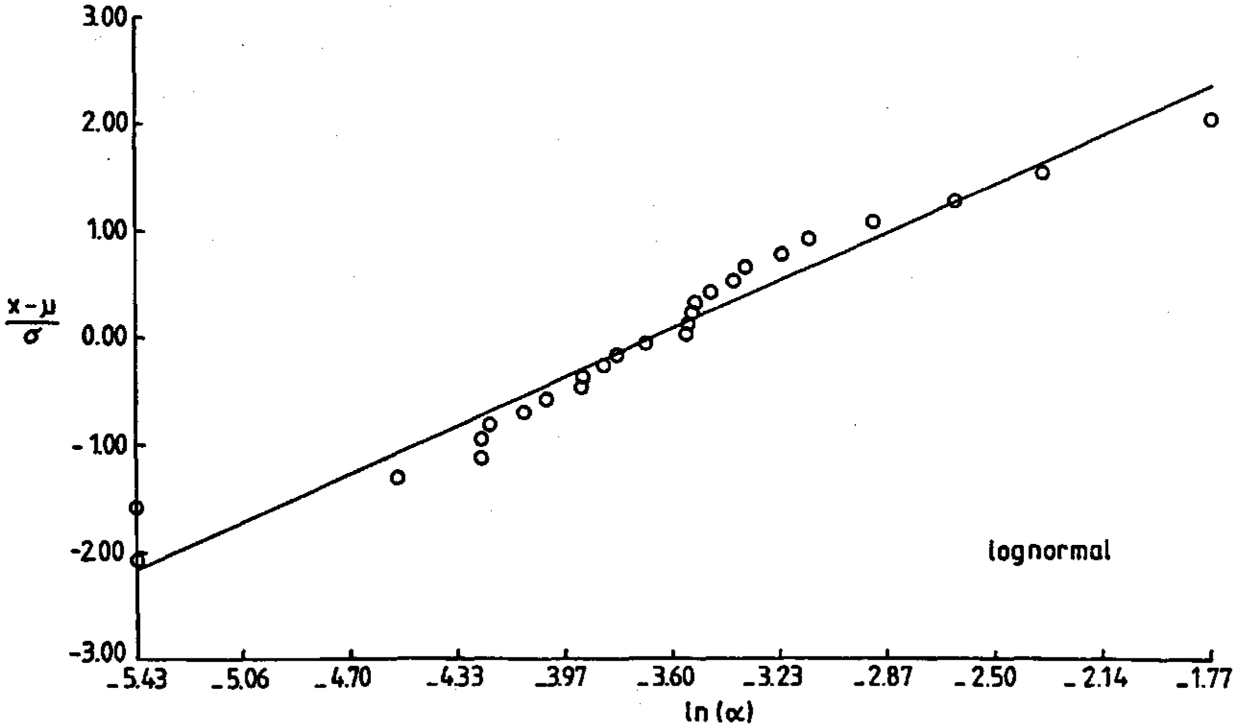


Figure 10. Fractile diagrams for normal and lognormal distribution of α (scheme 1).

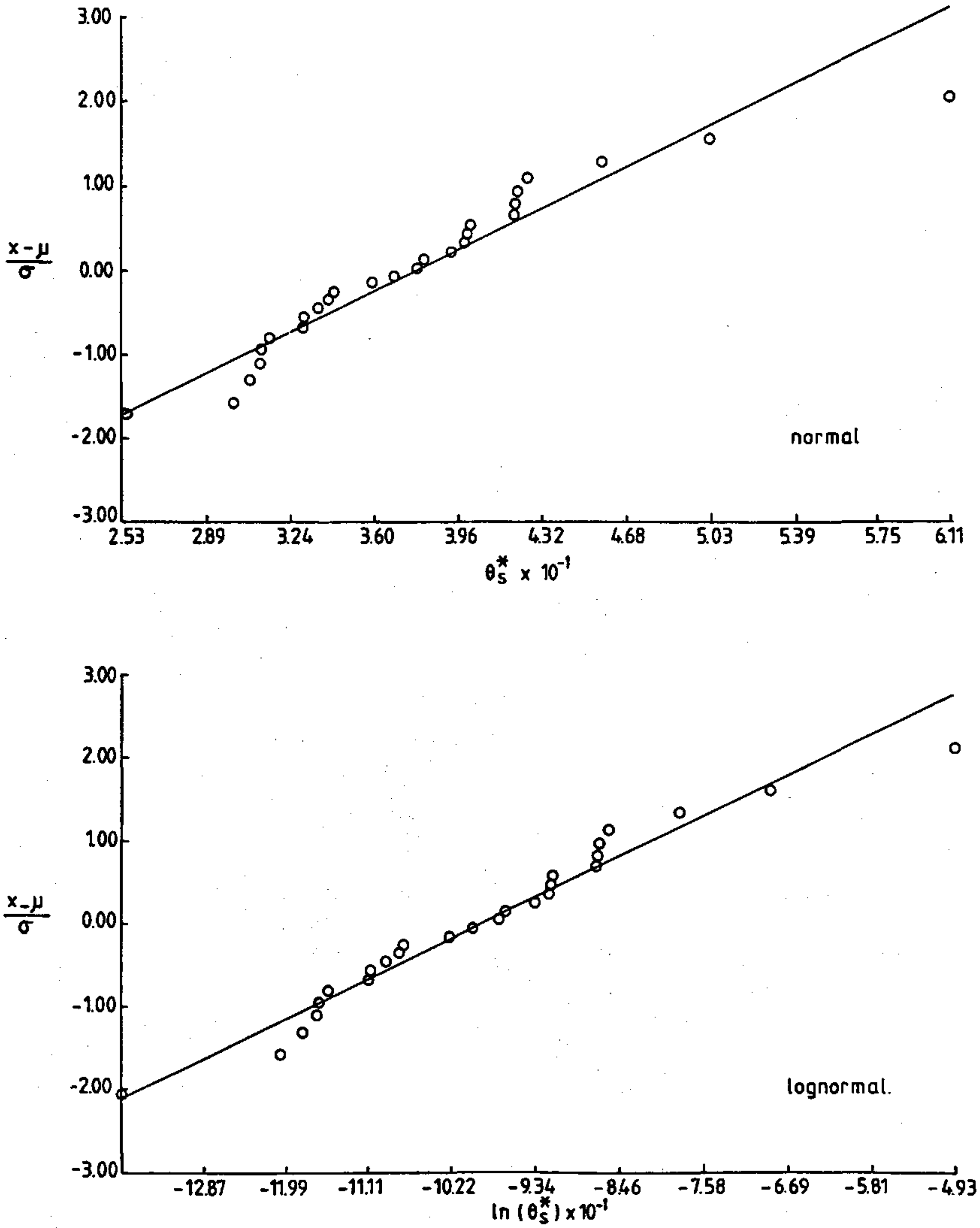


Figure 11. Fractile diagrams for normal and lognormal distribution of θ_s (scheme 1).

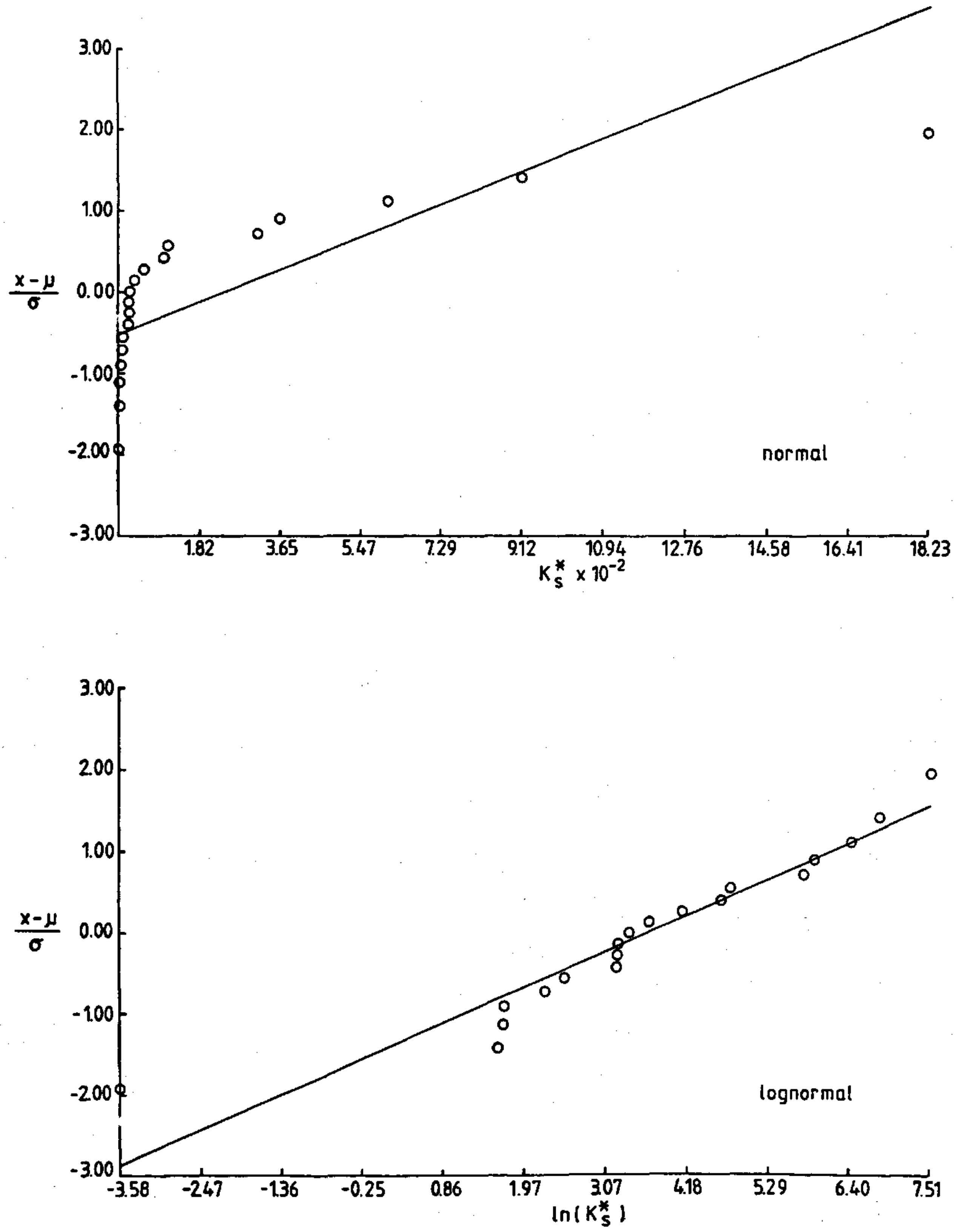


Figure 12. Fractile diagrams for normal and lognormal distribution of K_s (scheme 1).

Also the gamma distribution function was considered as a possible distribution function. A comparison of the normal, lognormal and gamma distribution is shown in Table 9, which lists the sum of squares of the difference between the empirical and hypothetical distribution function for all four parameters when all 3 schemes are combined. It is clear from this table that the lognormal distribution is the best possible choice of the three considered (minimum sum of squares).

It is further of interest to know whether the parameters of sampling schemes 1, 2 and 3 are populations of the same normal or lognormal distribution function. The T-test can be used to test for equality of means. It should be noted that the T-test assumes that the samples under consideration are approximately normal distributed and independent. If necessary, log-transformed values of the parameters were used in the T-test. The independence assumption may not be fulfilled for parameters of the third sampling scheme, since soil samples were taken within an area of only 2 m^2. At the 95% confidence level, only the mean of log (n) of sampling scheme 2 and the mean θ_s^* of sampling scheme 3 were significantly different from the respective means of sampling scheme 1 (Table 8).

3. *Analysis of variance*

Equality of variances between sampling schemes can be tested with the F-test. Comparison of the F-statistic values indicated that there is a significant difference in variance for most parameters. Therefore, the parameters of sampling schemes 1, 2 and 3 have different distribution functions. The F-test also indicated that the variances of all parameters of sampling scheme 2 were significantly smaller than of sampling scheme 1.

	Sum of Squares-Values			
Distribution	α	n	θ_s^*	K_s^*
Gamma	.4511	.5452	.0669	.9097
Normal	.8367	.8199	.0917	1.628
Lognormal	.0645	.3081	.0699	.0634

Table 9. Sum of squares for comparison of three distribution functions.

Since different soil map units were part of the first sampling schemes this comes as no surprise. However, no such clear difference was found in the variances of sampling schemes 2 and 3, where only the variance of log α was significantly smaller for the latter sampling scheme. It can furthermore be seen from Table 8 that the variances of n and θ_s^* of sample scheme 3 are larger than of scheme 2. This seems contradictory, since the sampled area of scheme 2 is much larger than of sample scheme 3 (5000 and 2 m^2, respectively), while both schemes 2 and 3 were part of the same soil map unit.

Sofar, all sampled depths were combined in the analysis. It seems, however, likely that significant differences in soil hydraulic properties will be found between horizons. Further analysis will focus on saturated water content and hydraulic conductivity. Values of these two variables for the various horizons and sampling schemes are listed in Table 10 and 11. Replicates θ_s^*-values were available for scheme 2 and 3, and no experimental K_s-data were determined for the A-horizon of scheme 1. No D-horizons were included in the analysis, since these occurred only in 3 sites of scheme 1. The difference of number and type of horizons between scheme 1 and the schemes 2 and 3 is the reason that only the A and B horizon of sampling scheme 1 are listed in Table 10 and 11. For sampling scheme 1 only 4 observations were available from C1- and C2-horizon, which each came from different depths.

Table 10. Available Replicate values of θ_s^*

scheme	location	horizon		
		A	B	C
1	1	.4003 (10)*	.4207 (35)	
	2	.4200 (10)	.3120 (60)	
	3	.5026 (40)	.3820 (95)	
	4	.3992 (15)	.3410 (50)	
	5	.4011 (15)	.3363 (65)	
	6	.4214 (20)	--	
	7	.3788 (15)	.3073 (40)	
2	1	.4151 .3901 (10)	.2915 .2676 (50)	
	2	.3776 .3803 (10)	.3595 .3039 (50)	
	3	.4826 .4107 (10)	.3452 .3633 (50)	
	4	.3986 .3841 (10)	.3972 .4107 (50)	
	5	.3888 .3173 (10)	.3305 .3285 (50)	
	6	.4194 .3727 (10)	.2973 .2963 (50)	
	7	.4389 .4120 (10)	.3827 .3676 (50)	
3	1	.4536 (32)	.3973 .3010 .3623 (64)	.3156 .3469 .2898 (90)
	2	--	.3081 .3195 (64)	.3142 .3198 (90)
	3	.4312 .4222 (35)	.3242 .3153 .3312 (60)	.2806 .3062 (90)
	4	.4075 .4304 (35)	.3529 .2735 .2907 (60)	.2957 .2989 .2939 (90)
	5	.3700 .4400 .3930 (28)	.2999 .3319 .2862 (59)	.2687 .2751 .2767 (90)
	6	.3700 .3639 .4090 (28)	.2998 .2819 (59)	.2880 .2538 .2847 (90)

* depth (cm)

Table 11. Available K_s^*-values.

scheme	location	horizon		
		A	B	C
1	1		25.04	
	2		25.3	
	3		911.0	
	4		24.8	
	5		60.7	
	6		--	
	7		318.0	
2	1	10.30	3.53	
	2	80.13	9.92	
	3	25.46	695.0	
	4	96.33	420.19	
	5	11.03	138.50	
	6	31.14	19.06	
	7	40.06	47.32	
3	1	280.5	323.4	31.6
	2	--	73.2	44.9
	3	72.0	70.9	53.5
	4	75.5	62.2	45.5
	5	212.3	18.8	8.1
	6	190.6	18.3	16.9

Since replicate values of θ_s^* were available, the first point of interest was to test whether the location means of θ_s^* for a given sampling scheme and horizon are identical. The method to be used is called analysis of variance (ANOVA). The resulting F-test will provide a means to test whether fixed or random effects of each location are present (Snedecor and Cochran, 1980). Also, ANOVA is based upon the assumptions concerning normality and independency. Values for F, P (critical level), and LSD (least significant difference at 5% critical level) are shown in Table 12. The difference between a specific pair of means is significant at the 5% level if it exceeds LSD (Snedecor and Cochran, 1980). In only 2 out of 5 cases (scheme 2, B-hor., and scheme 3, C-hor.) a significant difference between locations was found. In the other 3 cases the variation between locations was not significantly larger than the within location variation.

Analysis of variance was also used to test whether the mean values of θ_s^* were identical for the different horizons and sampling schemes. The test results are shown in Table 13. When each sampling scheme was treated separately, the mean values of θ_s^* were significantly different for each horizon (Table 13, part A). On the other hand, when each horizon was treated separately, the mean values of θ_s^* were identical for each sampling scheme (Table 13, part B). One can therefore treat the whole population of θ_s^*-values (Table 10) as 3 different sub-populations, one for each horizon. The mean θ_s^*-values for the A, B and C horizons are 0.406, 0.331, and 0.294, while the corresponding standard deviations are 0.0354, 0.0401 and 0.0227, respectively.

Table 12. F, P, and LSD values to test whether location means of θ_s^* are identical.

Scheme	Statistics	Horizon		
		A	B	C
2	F	1.85	11.88*	
	P	.219	.0023	
	LSD	.075	.042	
3	F	1.99	1.29	3.66*
	P	.216	.340	.0385
	LSD	.074	.064	.036

* F is significant at 5% level.

Table 13. F, P, and LSD values to test whether horizon and sampling scheme means of θ_s^* are identical.

A. Test for identical horizon mean:

Scheme	F	P	LSD
1 (A,B)	12.00*	0.0134	0.048
2 (A,B)	22.60*	<0.0001	0.0265
3 (A,B,C)	85.46*	<0.0001	0.0186
1+2+3	64.45*	<0.0001	0.0212

B. Test for identical sampling scheme mean:

Horizon	F	P	LSD
A	0.94	0.406	0.029
B	2.22	0.128	0.035

* F is significant at 5% level.

Similar tests as for θ_s^* were done for K_s^*. However, no replicate K_s^*-values were available. Since it has already been shown that K_s^* is lognormally distributed (Table 8), a log transformation was first performed to stabilize the variance. The test results are shown in Table 14. Only the means of the log for horizon A of sampling scheme 3 differed significantly from the means of the B and C-horizon. For all practical purposes we may therefore consider all available K_s^*-data as being one population of which the log transformed mean and standard deviation are 1.730 and 0.5608, respectively.

Once it has been decided that the variable in question follows a normal distribution, one can apply traditional Fisher statistics (Snedecor and Cochran, 1980) to determine the minimum sample size required at a chosen level of probability. In doing so, it can be shown that to estimate the mean θ_s^* of the A-horizon with a tolerated error of 0.01 cm^3 cm^{-3}, you will need 48 samples at the 95% confidence level. Similarly, if one tolerates a deviation of 10 or 50 cm day^{-1} in the estimated mean of K_s, one would need 1450 and 58 samples, respectively. However, such a method is unsuited when the distribution of the population being sampled is nonnormal or of a unknown form. An alternative may be to use bootstrapping (Dane et al. 1986), a computer intensive method which has been developed recently.

Table 14. F, P and LSD values to test whether horizon and sampling scheme means of log K_s^* are identical.

A. Test for identical horizon means:

scheme	F	P	LSD
2 (2 horizons)	0.45	0.5132	0.767
3 (3 horizons)	5.18*	0.0207	0.489
2+3 (2 horizons)	0.92	0.4067	0.539

B. Test for identical sampling scheme mean:

horizon	F	P	LSD
A (2 schemes)	11.16*	0.0075	0.443
B (3 schemes)	0.12	0.8896	0.866
A+B (2 schemes)	0.64	0.535	0.538

* F is significant at 5% level.

4. *Bootstrapping*

The following procedure explains such an application of the bootstrap technique. Bootstrap replicates of size B = 2, 3, ..., N (N is population size) were generated 800 times, and the mean for each replicate calculated. The B random samples are drawn with replacement from the N available observations.

For each value of B, the fraction of the 800 replicates having means within a given percentage of the mean for the N observations is calculated and plotted against the value of B. The intersection point of a curve through the generated points with the horizontal, of which the ordinate is determined by the confidence level, determines the minimum sample size required. Examples for θ_s^* of the A-horizon and K_s^* are shown in Fig. 13 for maximum errors of estimate of 2.5, 5 and 10%.

The results show that the fraction of sample means within the error limits increases with sample size and eventually reaches a plateau beyond little or no additional information is gained. Also a reduction in error limit requires a larger number of observations to estimate the population mean with the same confidence interval. With respect to Fig. 13a, a tolerated error in the mean θ_s^* of 0.01 $cm^3 cm^{-3}$ corresponds to a maximum error of estimate of 2.5% (open circles in Fig. 13a). Hence, one would need at least an additional 10-15 samples to achieve the required minimum sample size with a confidence level of 95%. A tolerated error in the mean K_s^* of ca. 10 cm day^{-1} corresponds to a maximum error of estimate of 10% ('+' in Fig. 13b). The 31 samples that were available (A + B horizon) are by far not enough to obtain a reasonable estimate of the population mean of K_s^*.

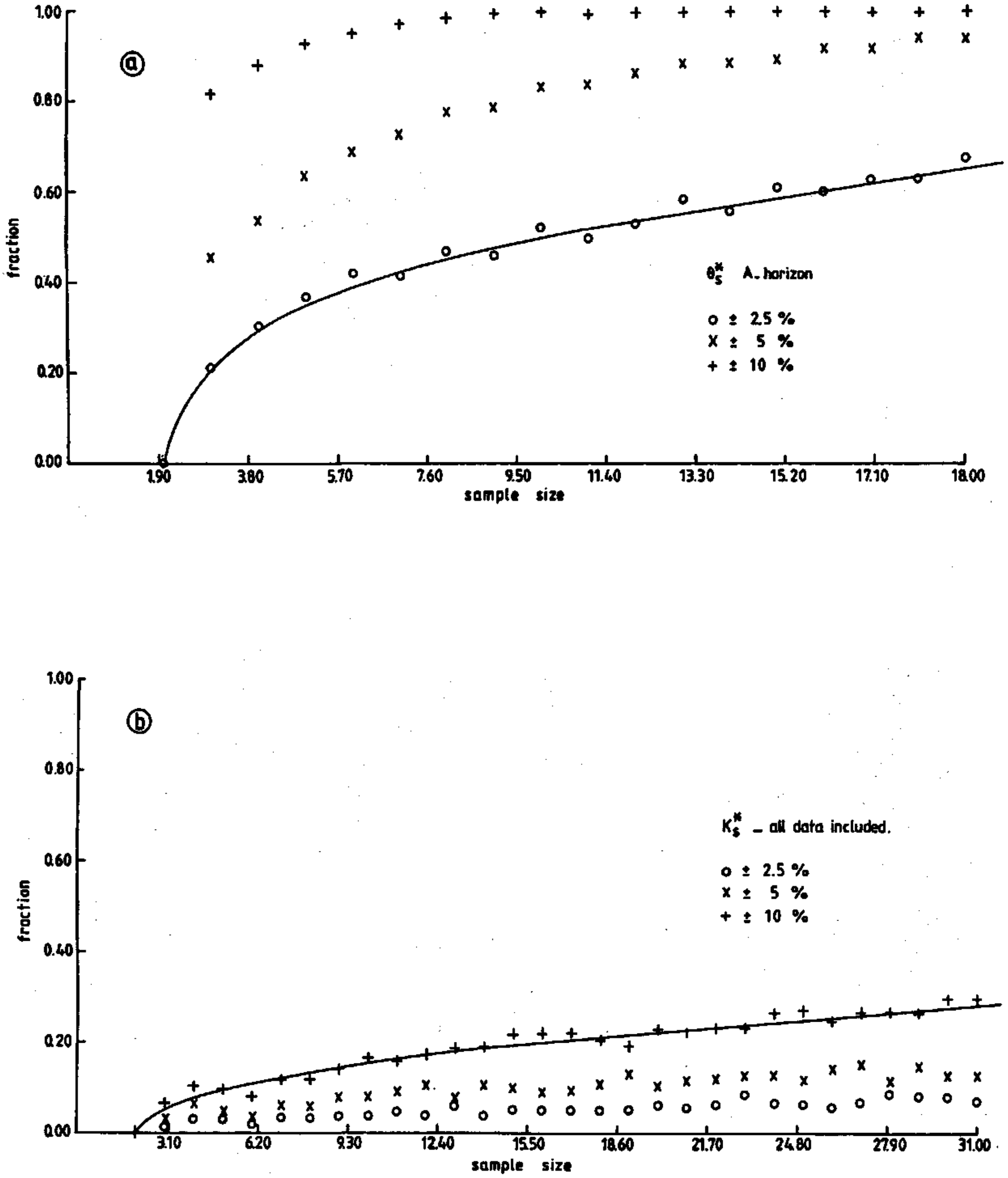


Figure 13. Fraction of samples within the indicated percentage of the maximum error of estimate as a function of bootstrap sample size for θ_s^* A-horizon (a) and K_s^* (b).

5. Spatial dependency

So far it was assumed in the statistical analysis that the soil properties measured make independent samples. However, it is intuitively felt that a soil at near places tends to be similar, whereas that between two distant places is not. An observation therefor carries some information from its neighborhood. Spatial dependence in a soil property can be expressed in terms of a semivariogram, defined as half the expected squared difference between values of places x and x + h. In the theory of regionalized variables (Journel and Huybregts, 1978) the semivariogram is used to predict values of the soil property at nonsampled places or over small areas within a region, by kriging. Fig. 14 shows the semivariograms for θ_s^* of the A and B horizon. Note that the lag distance between locations h is on a log scale. The lag distances for which the semivariance was calculated increases with a larger distance between the sampled points. The distance before the semivariance reaches a plateau value (sill), the range, is a measure for the distance between points where the soil property is spatially dependent. The range of θ_s^* for both horizons appears to be in the neighborhood of 10 m. There is a larger increase in semivariance for the B-horizon than for the A-horizon before the sill is reached, indicating that the saturated water content values in the B-horizon are more spatially dependent.

Semivariograms for log K_s^* are shown in Fig. 15. Again it appears that the B-horizon has a larger spatial dependence and that the range for both horizons is again ca. 10 m. McBratney and Webster (1983) showed that if spatial dependence is present, the required sampling effort to predict the value of a property at a specific location will be less, than would have been judged necessary using the classical approach.

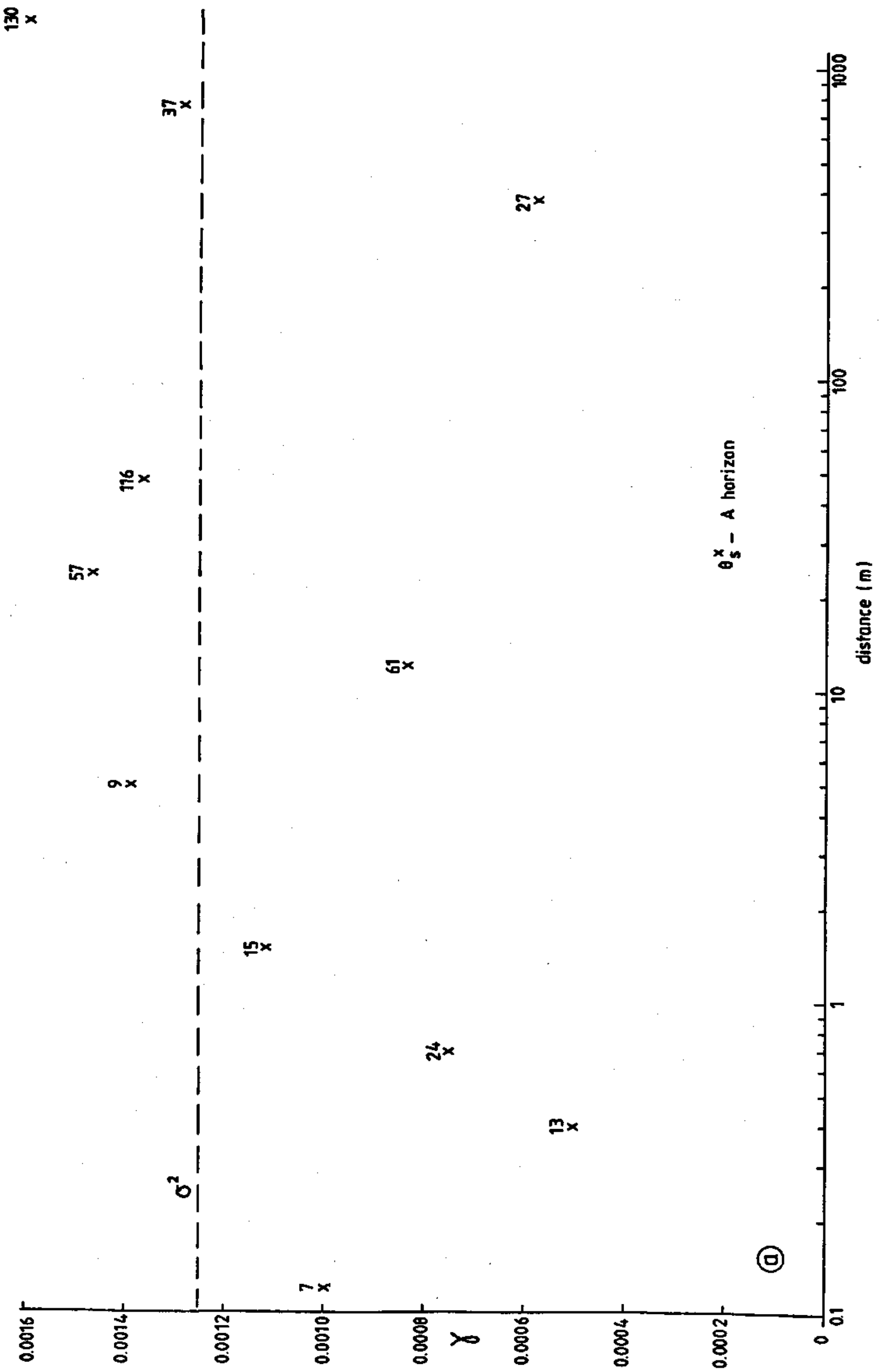


Figure 14a. Semi-variogram of θ_s^* for A horizon. Number near symbols indicate number of paired points to calculate semi-variance.

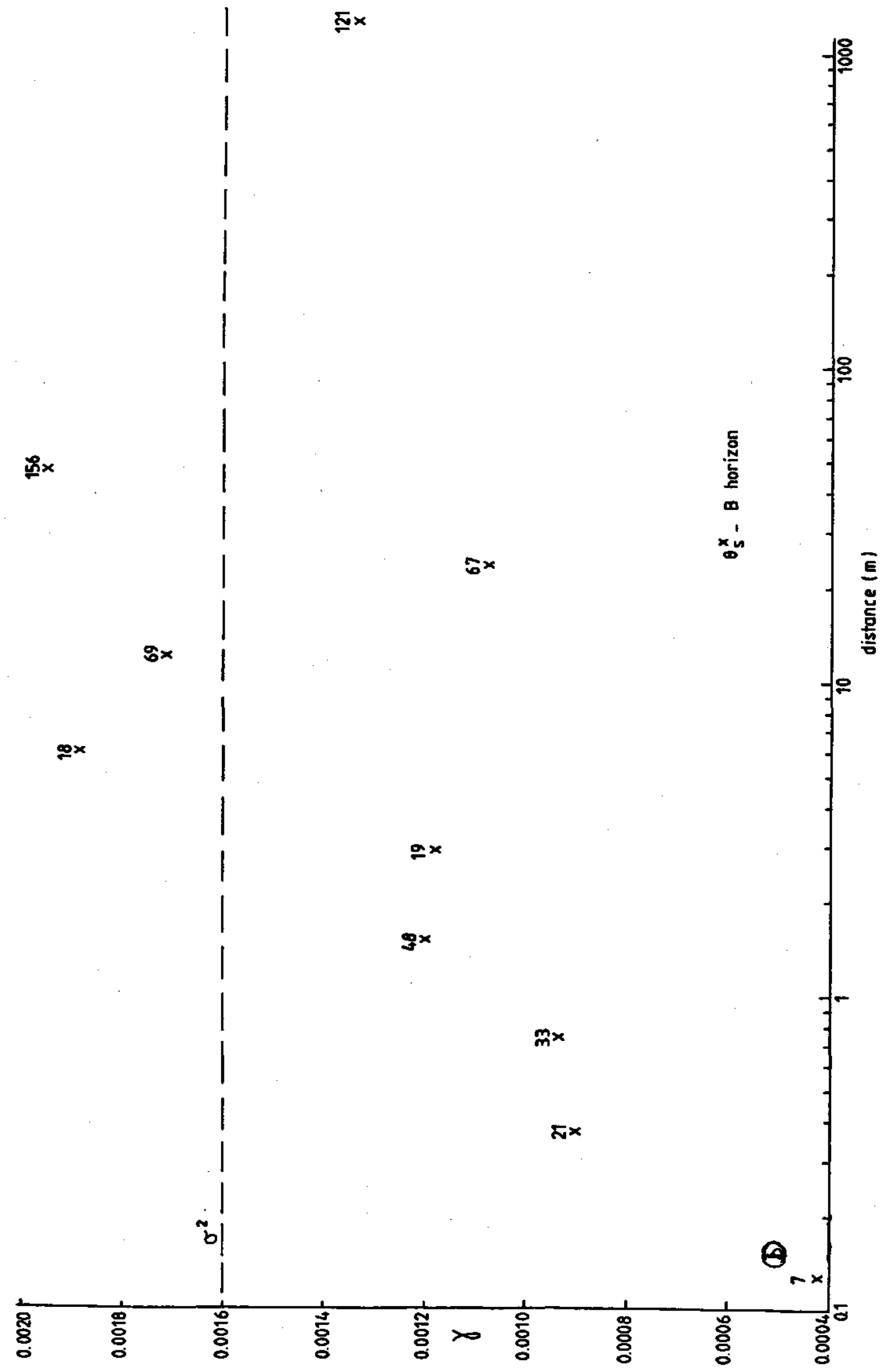


Figure 14b. Semi-variogram of θ_s^* for B-horizon.

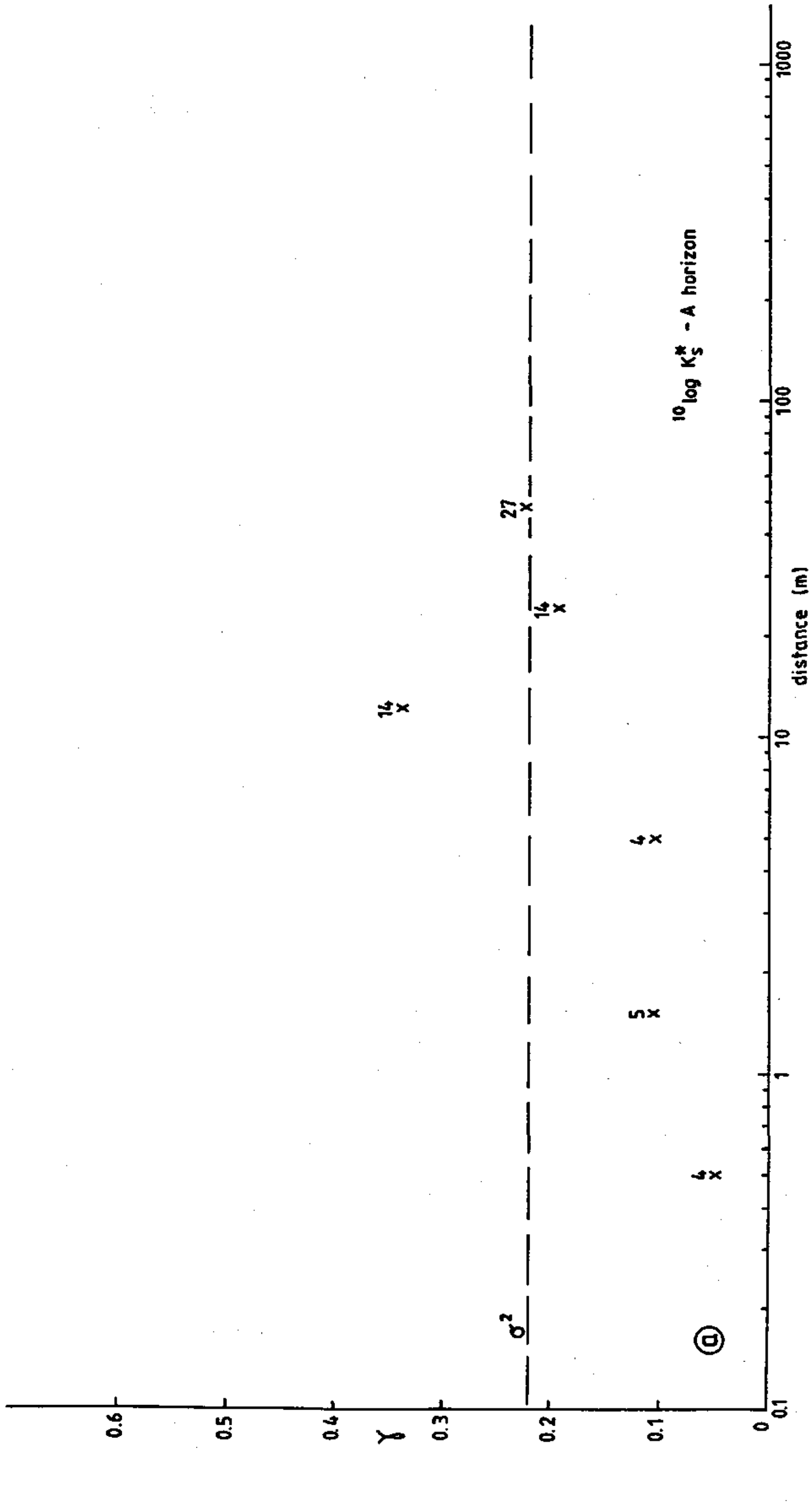


Figure 15a. Semi-variogram of log K_s^* for A-horizon.

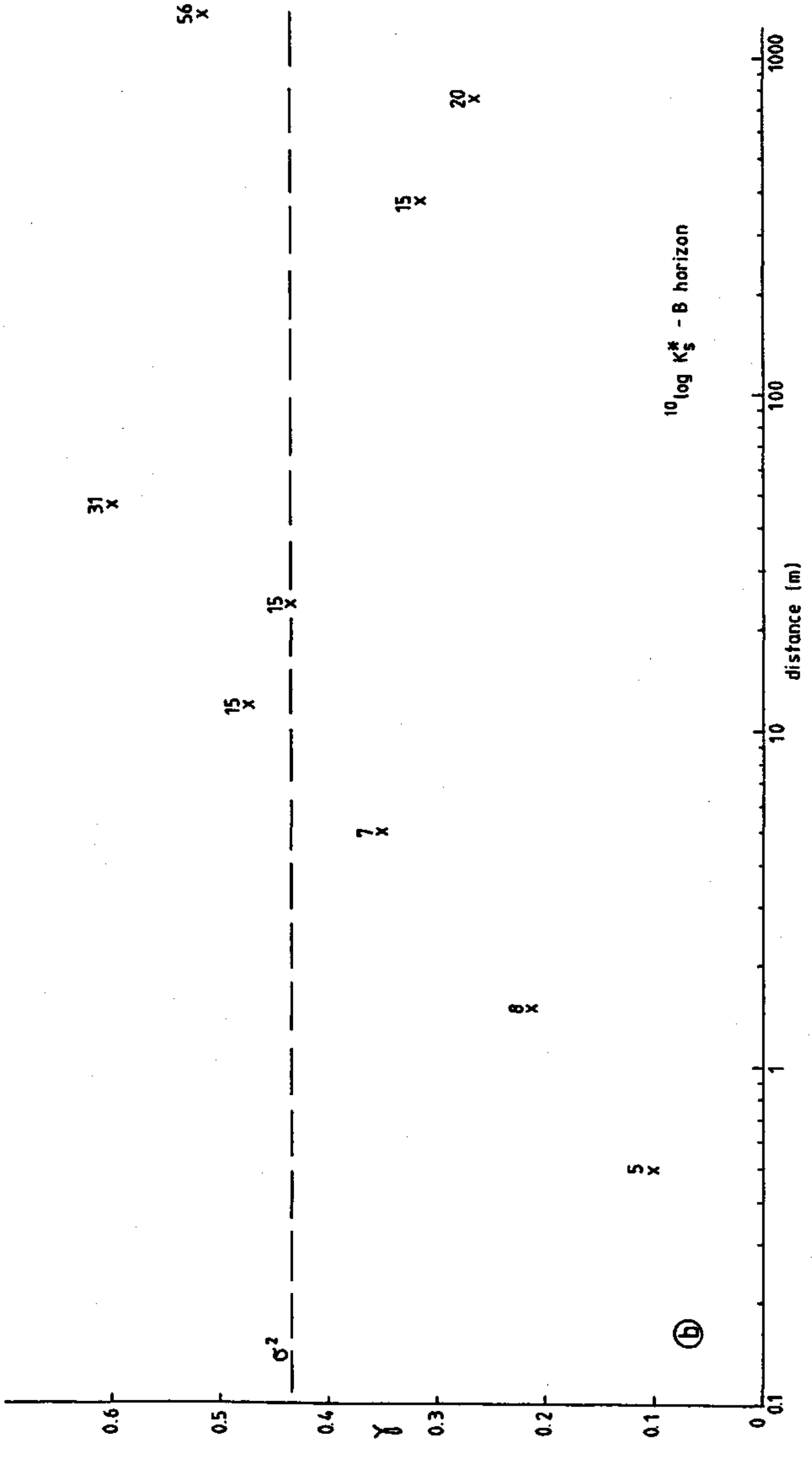


Figure 15b. Semi-variogram of log K_s^* for B-horizon.

6. Scaling

Prediction of water movement in spatial variable soils requires knowledge of the spatial variation of the soil hydraulic properties. A measure of such variation can be obtained by scaling, in particular, the scaling of soil water characteristic curves and hydraulic conductivity data. The theory of scaling is based on the similar media concept, introduced by Miller and Miller (1956). Similar media differ only in the scale of their internal microscopic geometries and have therefore equal porosities and equivalent particle and pore-size distributions. The purpose of scaling is to simplify the description of statistical variation of soil hydraulic properties. By this simplification, the pattern of spatial variability is described by a set of scale factors a, of which each a_l relates the soil hydraulic properties at each location, to a representative mean. Spatial variability is then characterized by the distribution of scale factors. Warrick et al. (1977) extended the application of scaling by estimating scale factors relative to the degree of saturation (s), with the result that the assumption of identical porosities can be eliminated. However, scaling should be restricted to soil locations having some reasonable morphological similarity.

Peck et al. (1977) defined a scaling parameter a_l as being the ratio of the microscopic characteristic length of a soil and the characteristic length of a reference soil, or

$$a_l = \lambda_l/\bar{\lambda},$$

where l=1, ..., L locations. As a result of scaling one can relate the soil water characteristic and hydraulic conductivity function at any location l to an average h_m and K_m, (a_l=1) such that

$$h_l = h_m/a_l \qquad [4]$$

$$K_l = a_l^2\, K_m, \qquad [5]$$

According to Eq. [4] and [5], the soil water characteristic and hydraulic conductivity curves of similar soils can be reduced to two single curves, (scaled mean curves) by means of scaling the soil water pressure head and hydraulic conductivity at each degree of saturation s. Validity of the similar media concept requires that the pressure head (a_l-h) and conductivity scale factors (a_l-K) are equal for each location l.

Hopmans (1987) investigated various scaling methods as used to obtain scaled mean hydraulic curves. Of these methods, the one introduced by Warrick et al. (1977) were found to be applicable to the Hupsel data. Before scaling, the measured water retention data were fitted by the van Genuchten model (Eq. [1] and [2]). When pressure head and conductivity data of all horizons and sampling schemes combined were each scaled independently, a correlation coefficient of 0.87 was found between a_l-h and a_l-K. In addition, both a_l-h and a_l-K were found to be lognormally distributed. Therefore, statistical analysis of the scale factors will only focus on a_l-h. It will be assumed that a_l-h can be used to describe the variability of the conductivity function, according to Eq. [5].

Since replicate water retention curves were determined for sampling schemes 2 and 3, it was first investigated whether the scale factor values between locations for a given sampling scheme and horizon were significantly different. Water retention curves for each scheme and horizon were scaled independently and analysis of variance was used to test the significance of log-transformed scale factor values between locations. The test results are shown in Table 15. In only one case (scheme 3, C-horizon) a significant difference between locations was found.

Analysis of variance was also used to test whether the mean of the log-transformed scale factor values were identical for the different horizons. All available water retention curves were used in the scaling, however, testing was done for each sampling scheme separately. Table 16 shows that no significant differences were found between the horizons of sampling scheme 3. Since the LSD-value was larger than the difference between the mean scale values of horizon B and C, these two horizons were combined and the analysis of variance repeated. There was now no significant difference between the A-horizon and underlying soil for all three sampling schemes.

Scheme	Statistics	Horizon		
		A	B	C
2	F	3.88	0.28	
	P	0.0501	0.929	
	LSD	0.4618	0.682	
3	F	2.92	1.05	7.38*
	P	0.117	0.440	0.0039
	LSD	0.245	0.391	0.264

* F is significant at 5% level

Table 15. F, P and LSD values to test whether location means of $^{10}\log$ (a) are identical

Scheme	F	P	LSD	log mean scale factor values of A	B	C
1	16.29*	0.0020	0.2467	0.1494	-0.3038	-
2	7.83*	0.0096	0.1327	-0.4567	-0.2761	-
3	3.09	0.0563	0.154	-0.0454	0.1469	0.09816
3@	5.79*	0.0207	0.141	-0.454	0.1225	-

* F is significant at 5% level

@ Combination of B and C horizon

Table 16. Statistics, to test for identical log-transformed means of scaling factor values between horizons.

To investigate differences between sampling schemes, the A and underlying horizont (B, and BC horizont for sampling scheme 3) were each scaled independently. Analysis of variance showed that the mean of the log-transformed scaling factors between all three schemes were significantly different for both horizons (Table 17). In general, the standard deviation in log(a) decreased with a smaller sampled area. Only the variance of scheme 3 for the the BC horizont did not follow this general behaviour. Since the samples of schemes 2 and 3 were part of the same soil type, one would expect statistically insignificant differences between schemes 2 and 3, and certainly a decrease in variance when comparing scheme 3 with 2.
Nevertheless, all three sampling schemes were combined and a mean and standard deviation of log(a) was calculated for each horizon. These statistics are listed in Table 18, which also shows that both distributions follow indeed a lognormal distribution (KS<0.895).

When the distribution of scale factor values is used to generate scale factor values (as in Monte Carlo analysis), it is important to notice that the scaled mean hydraulic functions are described with s (degree of saturation) as the independent variable. Also θ_S has a known distribution (page 46). So if there exists a correlation between θ_S and scale factor value, the two variables can not be generated independently of each other.
R^2-values between θ_S and log(a) were calculated to be 0.0017 and 0.0713, respectively, for the A and B horizon. I.e. θ_S can be drawn independently of log(a).

Since the unscaled water retention data were fitted by the van Genuchten model, it was further investigated if scale factor values could be predicted by the parameters α and n (Eq. [1]). As might be expected, regression resulted in high correlation coefficient values. Table 19 also shows the regression coefficient for each horizon separately, while calculated and predicted scale factor values are compared in Fig. 16. It would further be of interest if scale factors could be predicted from textural data, as was shown by Vauchaud et al. (1986). However, textural analysis was done for only a limited number of soils in Hupsel. In addition textural differences between soils where presumably too small to find any significant correlation.

A-horizon	F	P	LSD
	15.93*	<0.0001	0.239

scheme	$\mu_{\log a}$	$\sigma_{\log a}$
1 (7)	-0.1434	0.2993
2 (14)	-0.3730	0.2364
3 (11)	-0.2302	0.1148

B(C)-horizon	F	P	LSD
	17.43*	<0.0001	0.179

scheme	$\mu_{\log a}$	$\sigma_{\log a}$
1 (6)	0.0472	0.1971
2 (14)	-0.3404	0.1530
3 (32)	0.0253	0.2174

* F is significant at 5% level

Table 17. Statistics to test for identical log-tranformed means of scaling factor values between sampling schemes.

horizon	$\mu_{\log a}$	$\sigma_{\log a}$	KS
A (32)	-0.1154	0.3430	0.844*
B(C) (52)	-0.0706	0.2567	0.853*

* lognormal distribution accepted (critical region KS>0.895)

Table 18. Mean and standard deviation of $^{10}\log a$ of A and B(C)-horizon, when all 3 sampling schemes were combined.

	Regression coefficient					Coefficient of
	b_o	b_1	b_2	b_3	b_4	determination R^2
A-horizon						
(32)	-5.2638	3.6872	30.3091			0.844
	-0.9265	-2.6866	61.0696	2.1472	-523.091	0.900
BC-horizon	-1.1874	0.9817	8.8800			0.8826
(52)	-2.5713	1.8565	35.7843	-0.1780	-271.346	0.945

Table 19. Regression and correlation coefficients for prediction of scale factor values from α and n; $a=b_0+b_1n+b_2\alpha(+b_3n^2+b_4\alpha^2)$.

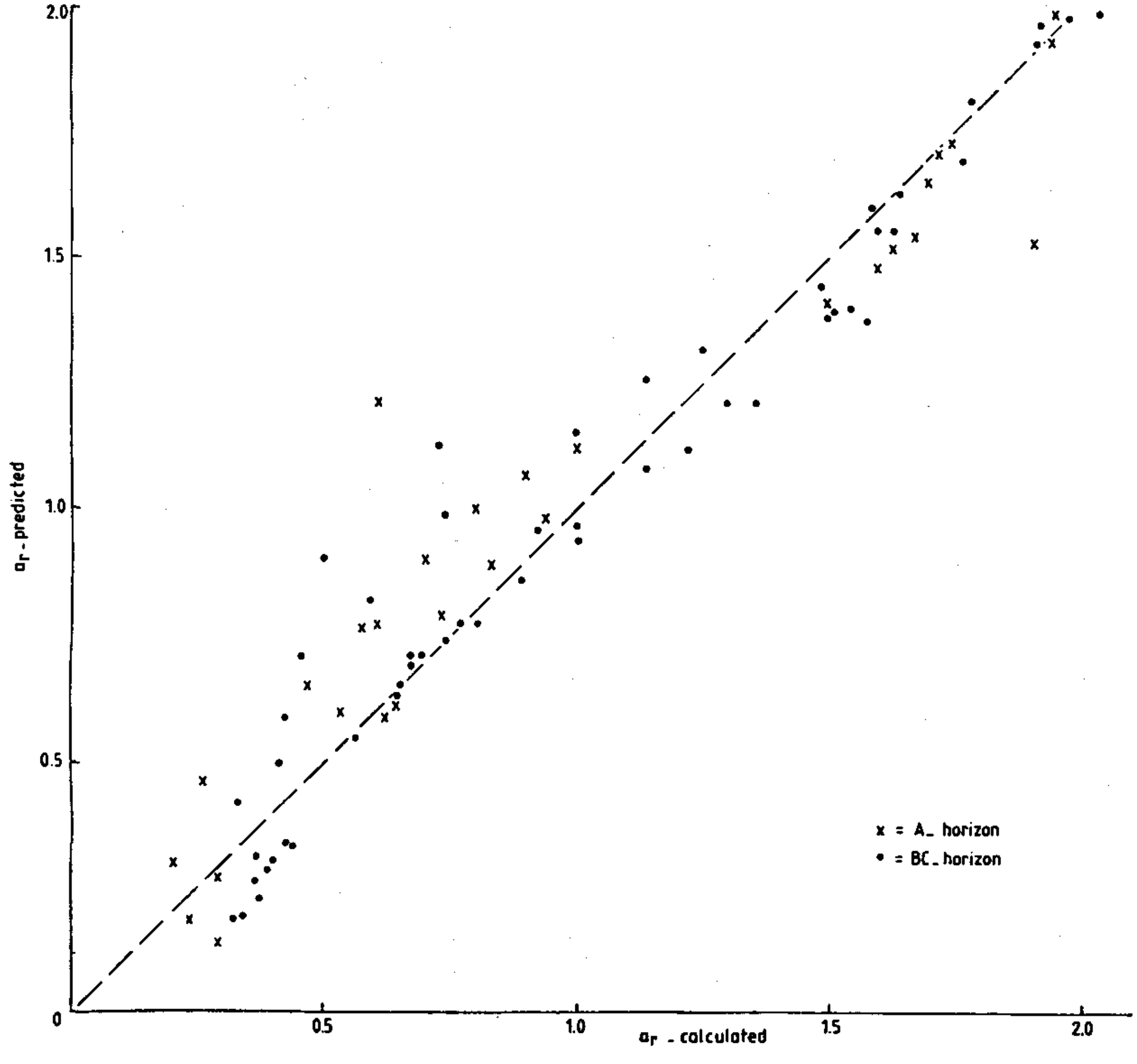


Figure 16. Plot of calculated versus predicted scale factor values for 3 sampling schemes combined.

In addition to the water retention curves, also all available conductivity data were scaled for the two horizons separately. The scaled mean water retention curves and hydraulic conductivity functions for both horizons are shown in Fig. 17 and 18, respectively. Van Genuchten's modified curve fitting procedure (RETC) was used to fit both the soil water characteristic and hydraulic conductivity function simultaneously. The fitted parameters to describe the hydraulic functions (Eq. [1] and [2]) are listed in Table 20.

If the soils at the sampled locations of the Hupsel watershed were perfect similar media, then the set of scale factor values calculated from water retention data (a-h) would have been identical to those calculated from conductivity data (a-K). Hence, a plot of a-h versus a-K values should fall along the 1:1-line.

It must be remembered, however, that although the sample replicates were from the same horizon, $\theta(h)$ and $K(\theta)$ were measured from different samples. Given the variation that already existed between the replicates, it should come as no surprise that the a_h-a_K plot (Fig. 19) exhibits a rather wide band. Better agreement between the two scale factor values would have been obtained if the replicate hydraulic properties were combined before scaling (Hopmans, 1987).

Inclusion of spatial dependency of the soil hydraulic properties in 2-dimensional water flow simulation requires knowledge of the spatial structure of the relevant properties in the 2-dimensional plane. Since it is proposed to express the variability of both the water retention curve and the hydraulic conductivity function with the single scaling parameter a_1-h, semivariograms of the scaling factor for both the A and B horizon are necessary. The semi-variograms of both horizons are displayed in Fig. 20. Similarly to the semi-variograms of θ_s^* and log K_s^* (Fig. 14 and 15), spatial structure is apparent up till a between point distance of ca. 10 meter. Values of the semi-variance and overall variance for Θ_s^*, log K_s^*, and scale factor a are listed in Table 21. The values in this table can be used to derive the appropriate semi-variogram, which is necessary to generate 2-dimensional fields of the parameter in question using for example the nearest neighbor autoregressive model (Smith and Freeze, 1979). To check for dependence between the calculated a-values in the vertical direction, the correlation coefficient (R) between the scale factor values of the A-horizon and B-horizon for all sampling schemes combined was calculated to be 0.140. I.e., scale factors values between the A and B horizont were virtually independent.

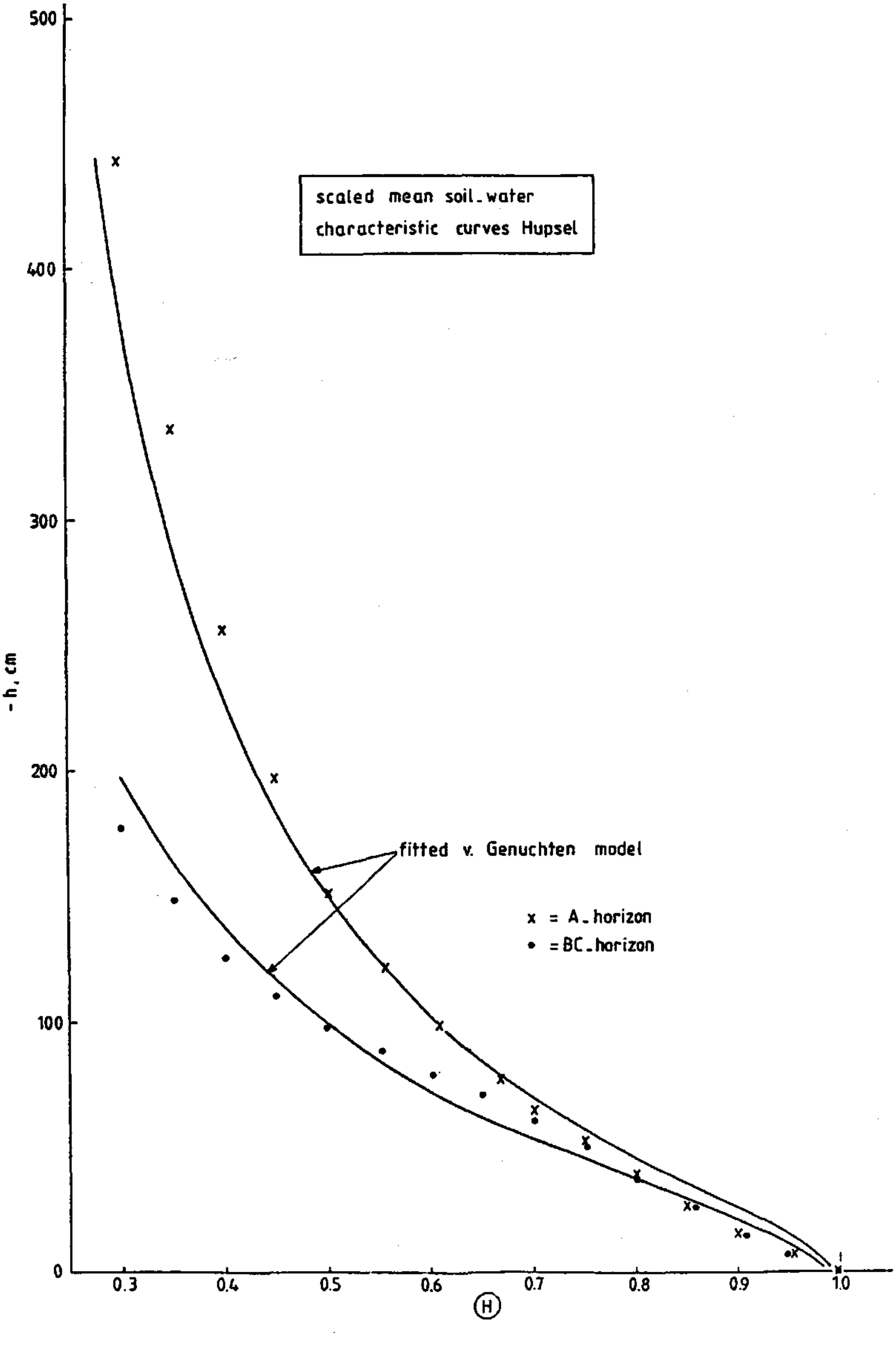


Figure 17. Scaled mean water retention curves Hupsel of A and BC-horizon.

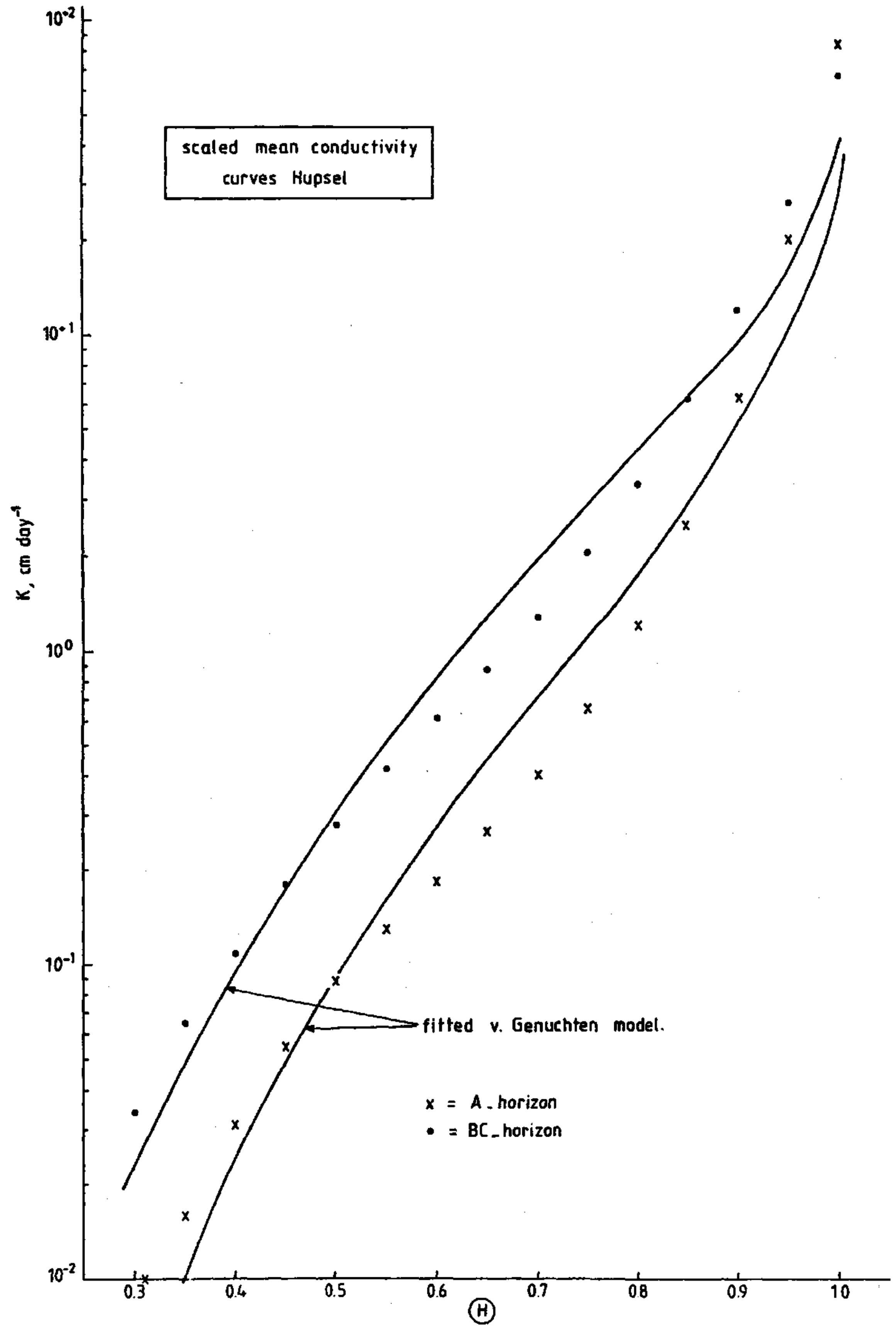


Figure 18. Scaled mean hydraulic conductivity curves Hupsel of A and BC-horizon.

Parameter	Horizon	
	A	BC
θ_r	0.00	0.00
θ_s	0.4024	0.3195
α	0.01924	0.02043
n	1.5931	1.8187
K_s (cm day^{-1})	33.7	40.55

Table 20. Parameters of van Genuchten model to describe scaled mean hydraulic functions for A and BC-horizon.

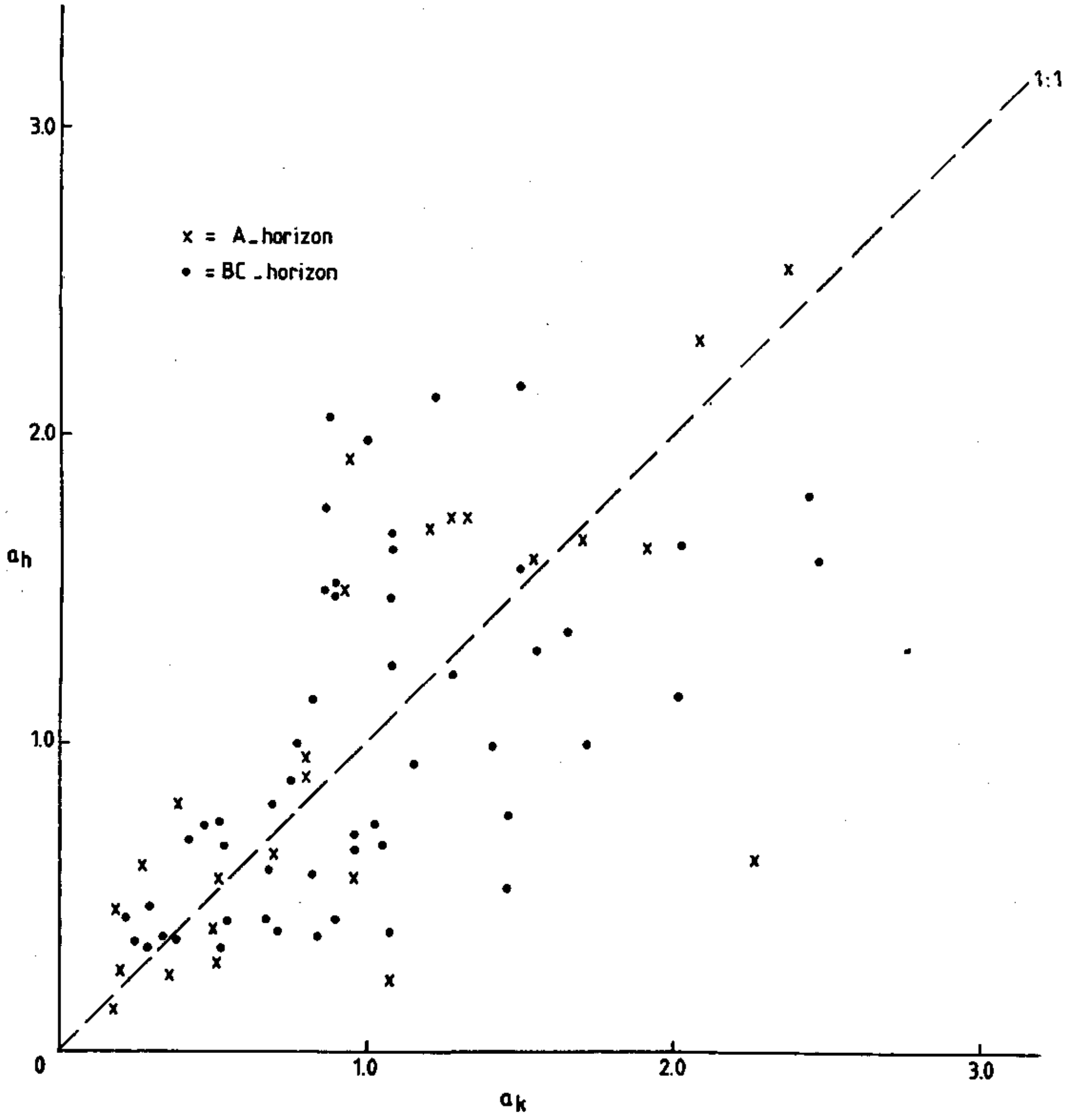


Figure 19. Comparison of scale factor values, as calculated from water retention (a-h) and conductivity (a-K) data.

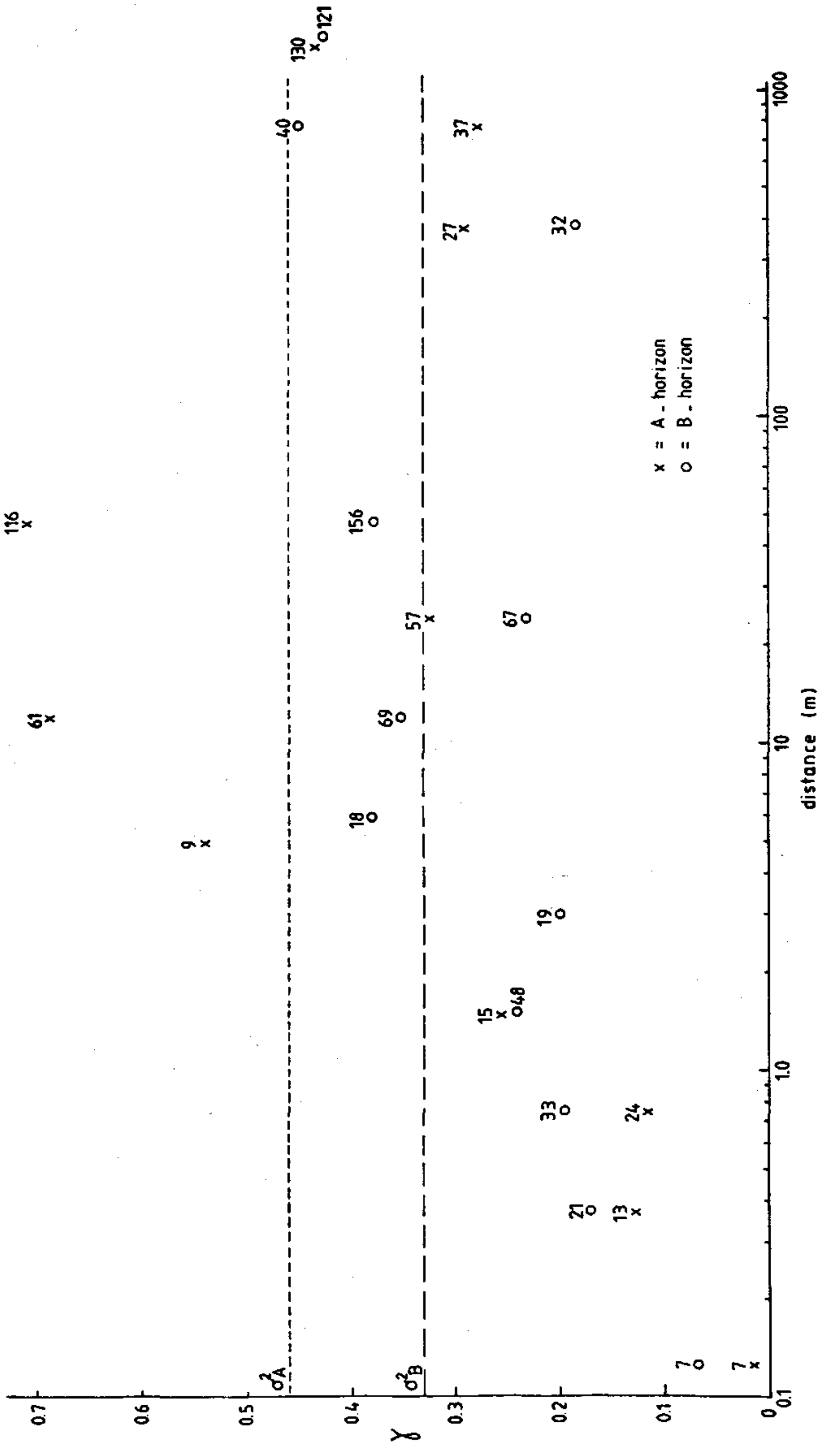


Figure 20. Semi-variograms of scale factor values of A and BC-horizon.

			Semi-variance at distance (m)				
Variable	Horizon	Variance	0.125	0.375	0.75	1.5	3
θ_s^*	A	$.125*10^{-2}$	$.100*10^{-2}$	$.497*10^{-3}$	$.757*10^{-3}$	$.107*10^{-2}$	-
	B	$.160*10^{-2}$	$.311*10^{-3}$	$.921*10^{-3}$	$.933*10^{-3}$	$.120*10^{-2}$	$.120*10^{-2}$
log K_s^*	A	0.221	-	-	0.0481	0.107	-
	B	0.432	-	-	0.103	0.216	-
a	A	0.461	0.0151	0.127	0.114	0.257	-
	B	0.329	0.075	0.172	0.196	0.239	0.200

		Semi-variance at distance (m)						
Variable	Horizon	5	6	12	24	48	384	768
θ_s	A	$.139*10^{-2}$	-	$.835*10^{-3}$	$.147*10^{-2}$	$.136*10^{-2}$	$.562*10^{-2}$	$.129*10^{-2}$
	B	-	$.189*10^{-2}$	$.171*10^{-2}$	$.108*10^{-2}$	$.197*10^{-2}$	$.480*10^{-2}$	$.805*10^{-3}$
log K_s^*	A	0.103	-	0.349	0.188	0.228	-	-
	B	0.326	-	0.471	0.433	0.591	0.313	0.259
a	A	0.542	-	0.690	0.322	0.709	0.294	0.272
	B	-	0.380	0.350	0.229	0.372	0.175	0.452

Table 21. Semi variance values of θ_s^*, log K_s^* and a for A and B horizon.

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APPENDIX

```
    1111  242778.8  453068.2      10.0
      18         0    0.0539    1.3478    0.4003 99.9999
    .092       383
   0.102       272
   0.130       554
   0.144       634
   0.146       109
   0.164       106
   0.182       286
    .231       169
    .232        87
    .238       144
    .265        59
    .275        48
    .276        77
    .284        43
    .321        14
    .357        13
    .385         5
    .396         5
    1121  242778.8  453068.2      35.0
      11        29    0.0200    1.7501    0.4207   25.04
    .110       321
    .148       134
    .173       134
    .230        77
    .230       105
    .272       105
    .309        41
    .318        37
    .391        41
    .398         5
    .438         5
   .0032       332     0.110            SORP
   .0071       237     0.122
   .0115       148     0.148
   .0121       112     0.185
   .0387       125     0.17
   .0738       121     0.175
   .0305       109     0.189
   .0501       100     0.2
   .0529        75     0.275
   .1026       124     0.17
   .1957       112     0.185
   .1724       104     0.19
   .2710        81     0.255
   .192         76     0.275
   .5482        95     0.222
   .7833        95     0.222
  1.182         89     0.24
   .5257        77     0.273
   .5329        62     0.29
  2.159         62     0.29
  4.064         48     0.32
  5.576         29     0.365
  9.479         27     0.37
 10.66          18     0.391            CRUST
 14.75          12     0.408
 24.14          11     0.408
 31.4            9     0.413
 79.85           2     0.43
134.7            1     0.438
    1131  242778.8  453068.2     110.0
      10         5    0.0107    4.4548     .3125    5.30
```

```
      .104         126
      .168         103
      .169          89
      .183          89
      .239          80
      .268          69
      .283          24
      .304          26
      .314          60
       .33           5
     .1441          15     0.10             SORP
     1.115          20     0.311            CRUST
    2.69            10     0.329
     8.774           2     0.358
   10.7              1     0.358
      1141    242778.8  453068.2     140.0
         9           6    0.0143    5.3812      .3001  29.0
      .142          72
      .169          71
      .186          70
      .203          63
      .214          62
      .222          61
      .284          33
      .295          25
      .315           5
     .7384          94     0.130            SORP
     1.611          40     0.275            CRUST
    14.94           25     0.296
    29.92           11     0.315
   102.3             7     0.322
   205.7             1     0.340
      1211    242047.7  454043.6      10.0
        15           0    0.0296    1.3751      .4200  99.9999
      .157         741
      .157         335
      .158         206
      .163         643
      .165         432
      .211         143
      .235          99
      .261          79
      .283          98
      .285          66
      .303          85
      .334          50
      .342          81
      .401           5
      .416           5
      1221    242047.7  454043.6      25.0
        12          13    0.0142    1.9791      .3594   9.33
      .065         554
      .076         202
      .079         395
      .085         340
      .104         163
      .144         164
      .180         145
      .224         115
      .234          90
      .258          62
      .346          13
      .365           5
     .0020         517     0.071            SORP
```

```
  .0060       358     0.085
  .0030       227     0.106
  .009        151     0.18
  .0284       124     0.21
  .096        124     0.21
  .2919        90     0.25
  .5454        58     0.29                 CRUST
 1.014         37     0.315
 5.744         28     0.33
24.75           9     0.362
59.74           3     0.38
99.64           1     0.38
   1231  242047.7  454043.6     60.0
      8         4    0.0146   3.4627     0.3120    25.3
   .106        98
   .128        92
   .133        82
   .213        66
   .235        58
   .258        46
   .290        27
   .325         5
 2.6920        30     0.281
34.38          10     0.33
39.94           5     0.34
58.4            1     0.34
   1241  242047.7  454043.6    100.0
     11         8    0.0292   1.5800     0.3429    38.5
   .145       102
   .156        75
   .162       109
   .195       105
   .20         50
   .214        60
   .239        80
   .272        50
   .326        12
   .331         5
   .34          5
  .1005        98     0.18                 SORP
  .4498        91     0.19
 2.018         29     0.31                 CRUST
 4.884         22     0.316
10.15           9     0.335
14.75           7     0.338
17.43           6     0.340
28.3100         1     0.340
   1311  242131.1  452103.1     40.0
     14         0    0.0432   1.3107     0.5026    99.9999
  0.196       422
   .213       639
   .217       314
   .227       258
   .233       323
   .273       132
   .296        81
   .315        75
   .334        69
   .408        46
   .436        37
   .446        15
   .472         5
   .503         5
   1321  242131.1  452103.1     95.0
```

```
      15        17    0.0709    1.6050    0.3820  911.0
    .059       255
    .072       507
    .073       178
    .076       223
    .079       419
    .085       176
    .097       102
    .103        74
    .105       173
    .143        53
    .147        70
    .168        46
    .204        43
    .378         5
    .385         5
   .0002       456     0.063            SORP
   .0009       300     0.075
   .0044       187     0.088
   .0106       143     0.097
   .0517        96     0.12
   .1863        78     0.132
  1.634         70     0.14
   .7172        60     0.16
  1.586         60     0.16
  1.532         51     0.17
  3.625         52     0.169
  6.974         47     0.19
 11.56          45     0.2
 29.38          42     0.21             CRUST
146.0            9     0.365
224.9            8     0.378
460.9            1     0.385
    1331  242131.1  452103.1     125.0
       9        15    0.0349    2.9558    0.3688  367.0
    .030       446
    .039       249
    .047       119
    .046        85
    .061        63
    .075        57
    .094        56
    .334        17
    .359         5
   .0001       272     0.035            SORP
   .0003       157     0.04
   .0046       100     0.05
   .0405        76     0.066
   .2562        74     0.065
  1.073         72     0.069
  1.072         65     0.07
  3.766         61     0.11
  6.015         59     0.12
15.7            56     0.13
 25.32          52     0.14
 76.43          41     0.23
 92.45          23     0.32             CRUST
418.7000         6     0.358
705.0000         1     0.359
    1341  242131.1  452103.1     200.0
      15        14    0.0288    1.8752    0.3309  115.0
    .070       237
    .074       318
    .082       231
```

```
     .082       100
     .095       116
     .144        69
     .150        78
     .168        59
     .177        69
     .253        28
     .261        28
     .265        41
     .314         5
     .324         9
     .330         5
    .0003       328     0.068              SORP
    .0023       247     0.075
    .0121       184     0.085
    .0857       127     0.1
    .2405       106     0.11
    .5267        94     0.125
   1.0270        84     0.138
   1.016         65     0.16
   2.818         65     0.16
   9.577         50     0.22
  19.64          35     0.255              CRUST
  25.01          31     0.268
  62.32           3     0.33
  87.0700         1     0.33
     1411  241974.2  454126.5      15.0
       10         0    0.0215    1.7478     0.3992    99.9999
     .078       590
     .086       416
     .095       255
     .149       125
     .182       118
     .240        90
     .248        69
     .262        65
     .392         5
     .399         5
     1421  241974.2  454126.5      50.0
       12         6    0.0249    1.6168     0.341     24.8
     .083       443
     .087       477
     .119       129
     .126       129
     .152       124
     .238        92
     .265        58
     .270        26
     .279        26
     .331        10
     .338         5
     .347         5
    .0175       282      .097              SORP
    .1900       180      .120
    .2885        43      .271
   2.6760        10      .330              CRUST
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   8.8660         1      .35
     1431  241974.2  454126.5      80.0
       22        11    0.0164    2.3806     0.3158     4.9
     .038       455
     .086       110
     .094       114
     .105       112
```

```
   .116       101
   .153        80
   .161        97
   .174        84
   .185        81
   .206        90
   .206        55
   .207        70
   .217        68
   .229        47
   .254        46
   .271        29
   .291        28
   .300         9
   .317         9
   .324         5
   .317         5
   .330         5
  .0001       395     0.050            SORP
  .0003       269     0.06
  .0014       162     0.085
  .006        132     0.100
  .0384       110     0.11
  .3351       100     0.13
  .314         67     0.21             CRUST
 4.784         10     0.312
11.0500         8     0.32
10.47           6     0.328
22.44           1     0.332
   1441  241974.2  454126.5     120.0
     21         9    0.0201    2.0253    0.33     12.2
   .028       454
   .044       460
   .090       172
   .114        93
   .132        65
   .149        72
   .158        71
   .164        89
   .212        79
   .225        71
   .234        65
   .235        43
   .253        70
   .275        26
   .295        30
   .316        26
   .306         9
   .311         5
   .318         5
   .32          9
   .328         5
  .0009       296      .06             SORP
  .005        186      .076
  .0226       120      .10
  .1658        91      .12
  .2679        54      .24             CRUST
 4.429          9      .32
 7.609          5      .325
20.54           2      .33
37.44           1      .33
   1511  242008.0  453355.9      15.0
     16         0    0.0177    1.4454    0.4011   99.9999
   .142       427
```

```
      .162       550
      .21        163
      .217       164
      .227       225
      .265       116
      .274       115
      .277        84
      .286       127
      .287        83
      .296        83
      .338        56
      .366        27
      .387         5
      .393         9
      .406         5
      1521  242008.0  453355.9       35.0
        20        17    0.0336     1.6632     0.3936   103.0
      .064       446
      .104       532
      .104       256
      .105       462
      .128       104
      .142        97
      .149        79
      .154        92
      .176        69
      .182        92
      .188        91
      .214        53
      .224        66
      .263        39
      .300        35
      .312        46
      .352        28
      .364         9
      .372         5
      .383         5
     .0004       378      .082             SORP
     .001        297      .089
     .0026       224      .096
     .0074       170      .108
     .0214       143      .115
     .0633       109      .13
     .5085        92      .16
     .6585        38      .28
    2.493         70      .19
    1.682         37      .29
    6.013         42      .27
    7.505         32      .30              CRUST
   19.81          12      .356
  114.9            1      .38
  143.6            1      .38
  127.8            1      .38
  157.0            1      .383
      1531  242008.0  453355.9       65.0
        22        16    0.0226     2.2420     0.3363   60.7
      .021       469
      .043       237
      .044       268
      .071       125
      .079       125
      .086        98
      .093       394
      .096        99
```

```
    .114        82
    .115        97
    .138        97
    .150        87
    .15         76
    .165        62
    .206        61
    .216        47
    .246        43
    .286        26
    .315        25
    .321         5
    .327         9
    .339         5
   .0001       313      .060            SORP
   .001        253      .07
   .0061       208      .075
   .0306       163      .084
   .1389       134      .095
   .5677       105      .112
  1.572        100      .12
  3.087         94      .13
  1.374         65      .18             CRUST
  3.368         53      .22
  5.002         53      .221
 18.03          11      .324
 70.26           1      .335
103.0            1      .335
 76.29           1      .34
110.8            1      .34
    1541  242008.0  453355.9     125.0
      13         7    0.0286    1.1069    0.4256     5.40
    .324       227
    .333       470
    .338       213
    .34         97
    .342       264
    .343       183
    .352        96
    .359        95
    .386         5
    .404       127
    .422        90
    .435         5
    .443         5
   .0042       343      .333            HAM
   .0104       149      .356
   .0429        40      .388
   .0519        20      .401
   .1064         7      .425
   .0882         4      .435            CRUST
   .0929         1      .45
    1551  242008.0  453355.9     160.0
       6         3    0.0044    2.1800    0.4572     0.028
    .417        72
    .439         3
    .46          3
    .461       102
    .471       102
    .496        71
   .0222        75      .45             HAM
   .0104        27      .455
   .0479         1      .46             CRUST
    1611  241002.6  453498.8      20.0
```

```
   27          0    0.0311     1.3940    0.4214    99.9999
  .151       370
  .163       300
  .174       418
  .195       436
  .195       138
  .199        91
  .203       194
  .208       164
  .215       171
  .223        89
  .245       112
  .252        54
  .254        88
  .261        86
  .30         63
  .311        83
  .315        55
  .316        86
  .356        43
  .362        11
  .377        42
  .392        27
  .402         9
  .402         5
  .412         5
  .413         9
  .424         5
  1621  241002.6  453498.8       90.0
    24        15    0.0955     1.0884     0.6108 1823.0
  .425       615
  .436       350
  .456       330
  .447        63
  .493        26
  .503        26
  .514        83
  .527        84
  .522         9
  .532        31
  .541        61
  .551        27
  .554        43
  .562        25
  .568        28
  .578         9
  .587        25
  .589         5
  .592        16
  .595        25
  .592         5
  .605         4
  .606         4
  .615         4
 .0059       181      .48               HAM
 .0098       144      .485
 .0332        61      .52
 .0802        24      .55
 .2444        24      .55               CRUST
 .9596        13      .565
9.3450        15      .563
9.831          7      .578
19.55         10      .57
131.9          2      .605
```

```
385.7            2      .60
358.4            1      .6
425.1            1      .615
503.8            1      .615
627.6000         1      .615
    1711  241593.2  454269.7      15.0
       8         0    0.0044    1.5447    0.3788   99.9999
    .264       331
    .304        89
    .313       171
    .327       120
    .341        85
    .344       147
    .364        88
    .403        87
    1721  241593.2  454269.7      40.0
      11        15    0.0394    1.6233    0.3073  318.0
    .064       394
    .121        79
    .131        75
    .135        96
    .143        85
    .176        48
    .185        48
    .192        49
    .201        49
    .295         5
    .304         5
   .0013       317      .07             HAM
   .0134       239      .08
   .0755       187      .088
   .2154       148      .1
   .4488       122      .11
   .5549       108      .116
   .38          84      .135
  1.064         73      .155
  2.547         67      .16
  1.152         59      .18
  6.815         62      .17
 18.13          40      .22             CRUST
 15.23          12      .286
 56.69           2      .32
 80.52           1      .32
    1731  241593.2  454269.7      65.0
      10        14    0.1698    1.1472    0.2528  611.0000
    .144       363
    .153       171
    .157        62
    .159        51
    .174        90
    .182        37
    .190        52
    .198        36
    .219        35
    .233         5
   .0032       349      .15             HAM
   .0052       163      .16
   .0186        63      .192
   .5288        23      .225            CRUST
  1.391         21      .225
   .7324        19      .231
   .9452        16      .235
   .5676        16      .235
  1.1830        16      .24
```

```
  2.631         13      .241
 24.46          12      .245
 27.42          10      .25
207.1            1      .255
402.2000         1      .255
    2111 242505.5 453069.0      10.0
      12        15    0.0088    1.3723    0.4025   10.3010
   0.408         1
   0.406        10
   0.404        32
   0.376       100
   0.268       200
   0.260       501
   0.383         1
   0.381        10
   0.381        32
   0.371       100
   0.236       200
   0.221       501
  1.0000        45     0.377            CRUST
  1.3000        38     0.381
 13.0           28     0.388
 76.0            1     0.4
  0.0673       139     0.320   0.00160  HAM
  0.0772       161     0.310   0.00202
  0.0658       185     0.300   0.00191
  0.0498       211     0.290   0.00161
  0.0354       241     0.280   0.00129
  0.0249       274     0.270   0.00102
  0.0177       312     0.260   0.00083
  0.0131       355     0.250   0.00070
  0.0121       405     0.240   0.00075
  0.0090       462     0.230   0.00065
  0.0050       529     0.220   0.00042
    2121 242505.0 453069.0      50.0
      12        26    0.0098    1.8508    0.2802    3.5280
   0.293         1
   0.288        10
   0.277        32
   0.236       100
   0.078       200
   0.074       501
   0.265         1
   0.265        10
   0.248        32
   0.233       100
   0.120       200
   0.117       501
  0.6900       110     0.195            CRUST
  5.3000        66     0.237
 80.0000         7     0.279
 95.0            1     0.28
  0.3222        94     0.210   0.00423  HAM
  0.0428       106     0.200   0.00059
  0.0382       118     0.190   0.00057
  0.0193       132     0.180   0.00031
  0.0151       147     0.170   0.00027
  0.0170       163     0.160   0.00033
  0.0137       181     0.150   0.00030
  0.0104       201     0.140   0.00026
  0.0085       224     0.130   0.00025
  0.0066       251     0.120   0.00022
  0.0046       283     0.110   0.00018
  0.1938        94     0.210   0.00255
```

```
 0.1337       106     0.200   0.00186
 0.0929       118     0.190   0.00138
 0.0686       132     0.180   0.00111
 0.0518       147     0.170   0.00092
 0.0402       163     0.160   0.00079
 0.0276       181     0.150   0.00061
 0.0189       201     0.140   0.00047
 0.0148       224     0.130   0.00043
 0.0129       251     0.120   0.00043
 0.0113       283     0.110   0.00045
   2211  242479.0  453057.0      10.0
     12        11    0.0146    1.3461    0.3781   80.129
  0.374         1
  0.371        10
  0.359        32
  0.328       100
  0.169       200
  0.150       501
  0.375         1
  0.367        10
  0.352        32
  0.286       100
  0.275       200
  0.247       501
 1.8000        48     0.333            CRUST
 2.8000        32     0.350
29.0            6     0.37
73.0            4     0.376
75.0            3     0.377
 0.0756       256     0.230   0.00329  HAM
 0.0631       297     0.220   0.00324
 0.0114       345     0.210   0.00070
 0.0094       404     0.200   0.00069
 0.0224       474     0.190   0.00201
 0.0189       560     0.180   0.00209
   2221  242479.0  453057.0      50.0
     12        15    0.0090    1.6281    0.3318    9.9150
  0.358         1
  0.352        10
  0.340        32
  0.310       100
  0.160       200
  0.142       501
  0.303         1
  0.300        10
  0.289        32
  0.269       100
  0.178       200
  0.139       501
 2.1000        80     0.280            CRUST
23.0000        28     0.319
37.0           14     0.327
39.0            3     0.331
40.0            1     0.331
 0.0528       144     0.232   0.00100  HAM
 0.0257       161     0.222   0.00053
 0.0710       180     0.212   0.00162
 0.0641       200     0.202   0.00162
 0.0161       223     0.192   0.00045
 0.0036       279     0.172   0.00013
 0.0293       313     0.162   0.00124
 0.0298       352     0.152   0.00146
 0.0117       399     0.142   0.00068
 0.0001       454     0.132   0.00000
```

```
   2311  242462.0  453050.0      10.0
     12         6    0.0083    1.2608    0.4463   25.461
  0.482         1
  0.472        10
  0.463        32
  0.432       100
  0.391       200
  0.368       501
  0.413         1
  0.405        10
  0.402        32
  0.367       100
  0.315       200
  0.231       501
 0.6900        66     0.410            CRUST
 1.1000        46     0.422
 2.0000        35     0.428
17.0            7     0.443
18.0            6     0.444
 0.0102       769     0.270   0.00141  HAM
   2321  242462.0  453050.0      50.0
     12        18    0.0388    1.3187    0.3542  695.0
  0.336         1
  0.327        10
  0.316        32
  0.185       100
  0.175       200
  0.153       501
  0.350         1
  0.348        10
  0.320        32
  0.182       100
  0.179       200
  0.166       501
 2.1000        66     0.247            CRUST
 6.6000        66     0.247
 7.3           66     0.247
24.00          44     0.27
73.0           12     0.33
 0.3546        53     0.260   0.00364  HAM
 0.5414        62     0.250   0.00639
 0.6176        73     0.240   0.00853
 0.6283        86     0.230   0.01024
 0.6022       102     0.220   0.01178
 0.5570       121     0.210   0.01317
 0.4162       143     0.200   0.01192
 0.2557       171     0.190   0.00904
 0.1710       205     0.180   0.00753
 0.1062       248     0.170   0.00591
 0.0543       303     0.160   0.00388
 0.0284       373     0.150   0.00264
 0.0176       466     0.140   0.00217
   2411  242458.0  453063.0      10.0
     12        15    0.0377    1.3712    0.3910    96.33
  0.390         1
  0.374        10
  0.325        32
  0.211       100
  0.179       200
  0.163       501
  0.374         1
  0.369        10
  0.336        32
  0.211       100
```

```
  0.153       200
  0.145       501
 0.4800        57     0.271            CRUST
 1.3000        53     0.277
 9.99           9     0.371
35.0            4     0.382
 0.3124        92     0.235   0.00450  HAM
 0.0954       106     0.225   0.00161
 0.0358       122     0.215   0.00071
 0.0219       140     0.205   0.00051
 0.0147       163     0.195   0.00042
 0.0131       189     0.185   0.00044
 0.0131       222     0.175   0.00054
 0.0116       262     0.165   0.00060
 0.0087       313     0.155   0.00056
 0.0067       376     0.145   0.00055
 0.0053       458     0.135   0.00058
   2421  242458.0  453063.0      50.0
     12        13    0.0707    1.3122    0.4033  420.185
  0.387         1
  0.358        10
  0.300        32
  0.190       100
  0.182       200
  0.181       501
  0.395         1
  0.391        10
  0.305        32
  0.169       100
  0.157       200
  0.141       501
 1.4000        23     0.315            CRUST
 4.0000        10     0.360
14.0            4     0.384
52.0            1     0.399
 0.1795       100     0.215   0.00333  HAM
 0.0125       118     0.205   0.00028
 0.0462       139     0.195   0.00128
 0.0279       166     0.185   0.00096
 0.0177       200     0.175   0.00077
 0.0174       243     0.165   0.00097
 0.0142       298     0.155   0.00103
 0.0107       370     0.145   0.00103
 0.0073       467     0.135   0.00095
   2511  242475.0  453072.0      10.0
     12        16    0.0109    1.5044    0.3529   11.03
  0.389         0
  0.381        10
  0.357        32
  0.326       100
  0.182       200
  0.171       501
  0.315         1
  0.310        10
  0.302        32
  0.285       100
  0.171       200
  0.159       501
 1.8000        29     0.333            CRUST
 6.2000        16     0.345
 6.6           11     0.348
 6.3           10     0.349
25.0            7     0.35
 0.0242       152     0.240   0.00052  HAM
```

```
  0.0333        172     0.230   0.00079
  0.0384        194     0.220   0.00103
  0.0339        219     0.210   0.00103
  0.0294        247     0.200   0.00102
  0.0311        279     0.190   0.00124
  0.0278        316     0.180   0.00129
  0.0196        360     0.170   0.00107
  0.0177        412     0.160   0.00115
  0.0165        474     0.150   0.00130
  0.0107        549     0.140   0.00103
    2521   242475.0  453072.0      50.0
      12         17    0.0329    1.4123      0.3315   138.5
   0.323          1
   0.318         10
   0.297         32
   0.229        100
   0.183        200
   0.185        501
   0.325          1
   0.310         10
   0.284         32
   0.115        100
   0.086        200
   0.071        501
  1.6000         67     0.221             CRUST
  7.7000         29     0.271
 46.0            11     0.311
 48.0             1     0.33
  0.2930         58     0.230   0.00291   HAM
  0.3584         67     0.220   0.00406
  0.2682         77     0.210   0.00349
  0.1639         90     0.200   0.00252
  0.1246        104     0.190   0.00225
  0.1415        121     0.180   0.00304
  0.1479        142     0.170   0.00386
  0.1106        167     0.160   0.00353
  0.0613        198     0.150   0.00243
  0.0311        236     0.140   0.00155
  0.0359        285     0.130   0.00230
  0.0392        349     0.120   0.00330
  0.0264        434     0.110   0.00299
    2611   242491.0  453072.0      10.0
      12         24    0.0196    1.3997      0.3955    31.14
   0.418          1
   0.413         10
   0.391         32
   0.340        100
   0.210        200
   0.170        501
   0.365          1
   0.355         10
   0.325         32
   0.230        100
   0.180        200
   0.174        501
  1.5000         40     0.339             CRUST
  1.6000         19     0.371
 4.8              5     0.391
94.0              1     0.395
  0.1275         39     0.340   0.00104   HAM
  0.1404         46     0.330   0.00122
  0.1338         54     0.320   0.00126
  0.1361         63     0.310   0.00140
  0.1470         72     0.300   0.00165
```

```
  0.1559        82     0.290   0.00193
  0.1553        93     0.280   0.00213
  0.1576       106     0.270   0.00243
  0.1863       120     0.260   0.00324
  0.1763       136     0.250   0.00347
  0.1092       155     0.240   0.00247
  0.0770       176     0.230   0.00201
  0.0750       200     0.220   0.00227
  0.0672       228     0.210   0.00237
  0.0591       262     0.200   0.00247
  0.0529       301     0.190   0.00262
  0.0454       348     0.180   0.00271
  0.0339       406     0.170   0.00247
  0.0234       476     0.160   0.00211
  0.0168       563     0.150   0.00189
    2621  242491.0  453072.0      50.0
      12        19    0.0133    1.6260   0.2976   19.063
   0.299         1
   0.296        10
   0.279        32
   0.214       100
   0.090       200
   0.060       501
   0.296         1
   0.287        10
   0.267        32
   0.227       100
   0.165       200
   0.143       501
  9.2000        32     0.274           CRUST
 10.9000        25     0.280
 13.0           16     0.289
104.3            1     0.297
  0.3882        60     0.243   0.00433 HAM
  0.3556        69     0.233   0.00417
  0.2989        80     0.223   0.00377
  0.2390        91     0.213   0.00326
  0.1844       104     0.203   0.00277
  0.1676       117     0.193   0.00279
  0.1387       133     0.183   0.00260
  0.1126       150     0.173   0.00239
  0.0893       170     0.163   0.00218
  0.0698       192     0.153   0.00197
  0.0531       219     0.143   0.00177
  0.0401       251     0.133   0.00160
  0.0307       288     0.123   0.00148
  0.0240       335     0.113   0.00143
  0.0194       393     0.103   0.00146
    2711  242501.0  453084.0      10.0
      12        16    0.0264    1.3299   0.4263   40.062
   0.440         1
   0.425        10
   0.389        32
   0.332       100
   0.192       200
   0.183       501
   0.402         1
   0.394        10
   0.373        32
   0.257       100
   0.236       200
   0.214       501
  0.1700       110     0.285           CRUST
  2.3000        39     0.359
```

```
 2.55          36        0.361
 0.0375        89        0.300     0.00052  HAM
 0.0439       101        0.290     0.00068
 0.0432       116        0.280     0.00077
 0.0409       132        0.270     0.00083
 0.0329       151        0.260     0.00078
 0.0258       174        0.250     0.00071
 0.0243       199        0.240     0.00078
 0.0200       230        0.230     0.00077
 0.0132       266        0.220     0.00060
 0.0075       309        0.210     0.00041
 0.0031       362        0.200     0.00021
 0.0017       426        0.190     0.00014
 0.0019       504        0.180     0.00019
   2721  242501.0   453084.0        50.0
     12        17     0.0161      1.4275      0.3740     47.323
  0.380         1
  0.376        10
  0.322        32
  0.291       100
  0.186       200
  0.172       501
  0.365         1
  0.364        10
  0.339        32
  0.300       100
  0.182       200
  0.156       501
 4.1000        29      0.341                CRUST
11.0000        19      0.356
12.0           17      0.357
12.0           15      0.36
15.5           10      0.365
 0.1223       113      0.260     0.00205  HAM
 0.1433       128      0.250     0.00269
 0.1870       146      0.240     0.00398
 0.1315       166      0.230     0.00320
 0.1038       188      0.220     0.00289
 0.1105       214      0.210     0.00356
 0.0827       244      0.200     0.00311
 0.0535       280      0.190     0.00238
 0.0342       322      0.180     0.00181
 0.0265       372      0.170     0.00169
 0.0257       433      0.160     0.00200
 0.0174       508      0.150     0.00167
   2112  242505.5   453069.0        10.0
      6         0     0.0106      1.3020      0.4151      10.3010
  0.408         1
  0.406        10
  0.404        32
  0.376       100
  0.268       200
  0.260       501
   2113  242505.7   453069.0        10.0
      6         0     0.0075      1.4578      0.3901     10.3010
  0.383         1
  0.381        10
  0.381        32
  0.371       100
  0.236       200
  0.221       501
   2122  242505.5   453069.0        50.0
      6         0     0.0089      2.3711      0.2915      3.5280
  0.293         1
```

```
  0.288         10
  0.277         32
  0.236        100
  0.078        200
  0.074        501
   2123   242505.7   453069.0       50.0
      6          0     0.0105     1.5805     0.2676     3.5280
  0.265          1
  0.265         10
  0.248         32
  0.233        100
  0.120        200
  0.117        501
   2212   242479.0   453057.0       10.0
      6          0     0.0092     1.7024     0.3776    80.129
  0.374          1
  0.371         10
  0.359         32
  0.328        100
  0.169        200
  0.150        501
   2213   242479.2   453057.0       10.0
      6          0     0.0417     1.1480     0.3803    80.129
  0.375          1
  0.367         10
  0.352         32
  0.286        100
  0.275        200
  0.247        501
   2222   242479.0   453057.0       50.0
      6          0     0.0095     1.6913       0.3595     9.915
  0.358          1
  0.352         10
  0.340         32
  0.310        100
  0.160        200
  0.142        501
   2223   242479.2   453057.0       50.0
      6          0     0.0081     1.5812     0.3039     9.915
  0.303          1
  0.300         10
  0.289         32
  0.269        100
  0.178        200
  0.139        501
   2312   242462.0   453050.0       10.0
      6          0     0.0198     1.1195     0.4826    25.461
  0.482          1
  0.472         10
  0.463         32
  0.432        100
  0.391        200
  0.368        501
   2313   242462.2   453050.0       10.0
      6          0     0.0056     1.4953     0.4107    25.461
  0.413          1
  0.405         10
  0.402         32
  0.367        100
  0.315        200
  0.231        501
   2322   242462.0   453050.0       50.0
      6          0     0.0344     1.3317     0.3452   695.0
  0.336          1
```

```
0.327        10
0.316        32
0.185       100
0.175       200
0.153       501
 2323  242462.2  453050.0      50.0
    6         0    0.0433    1.3084    0.3633  695.0
0.350         1
0.348        10
0.320        32
0.182       100
0.179       200
0.166       501
 2412  242458.0  453063.0      10.0
    6         0    0.0493    1.3202    0.3986   96.33
0.390         1
0.374        10
0.325        32
0.211       100
0.179       200
0.163       501
 2413  242458.2  453063.0      10.0
    6         0    0.0296    1.4331    0.3841   96.33
0.374         1
0.369        10
0.336        32
0.211       100
0.153       200
0.145       501
 2422  242458.0  453063.0      50.0
    6         0    0.1000    1.2435    0.3972  420.185
0.387         1
0.358        10
0.300        32
0.190       100
0.182       200
0.181       501
 2423  242458.2  453063.0      50.0
    6         0    0.0555    1.3903    0.4107  420.185
0.395         1
0.391        10
0.305        32
0.169       100
0.157       200
0.141       501
 2512  242475.0  453072.0      10.0
    6           0    0.0120    1.5176    0.3888    11.03
0.389         0
0.381        10
0.357        32
0.326       100
0.182       200
0.171       501
 2513  242475.2  453072.0      10.0
    6         0    0.0095    1.4908    0.3173   11.03
0.315         1
0.310        10
0.302        32
0.285       100
0.171       200
0.159       501
 2522  242475.0  453072.0      50.0
    6         0    0.0386    1.2282    0.3305  138.5
0.323         1
```

```
0.318       10
0.297       32
0.229      100
0.183      200
0.185      501
 2523  242475.2  453072.0      50.0
    6         0    0.0256    1.8038    0.3285  138.5
0.325        1
0.310       10
0.284       32
0.115      100
0.086      200
0.071      501
 2612  242491.0  453072.0      10.0
    6         0    0.0112    1.5673    0.4194   31.14
0.418        1
0.413       10
0.391       32
0.340      100
0.210      200
0.170      501
 2613  242491.2  453072.0      10.0
    6         0    0.0375    1.3011    0.3727   31.14
0.365        1
0.355       10
0.325       32
0.230      100
0.180      200
0.174      501
 2622  242491.0  453072.0      50.0
    6         0    0.0103    2.2015    0.2973   19.063
0.299        1
0.296       10
0.279       32
0.214      100
0.090      200
0.060      501
 2623  242491.2  453072.0      50.0
    6         0    0.0194    1.3377    0.2963   19.063
0.296        1
0.287       10
0.267       32
0.227      100
0.165      200
0.143      501
 2712  242501.0  453084.0      10.0
    6         0    0.0179    1.4488    0.4389   40.062
0.440        1
0.425       10
0.389       32
0.332      100
0.192      200
0.183      501
 2713  242501.2  453084.0      10.0
    6         0    0.0392    1.2474    0.4120   40.062
0.402        1
0.394       10
0.373       32
0.257      100
0.236      200
0.214      501
 2722  242501.0  453084.0      50.0
    6         0    0.0242    1.3438    0.3827   47.323
0.380        1
```

```
   0.376        10
   0.322        32
   0.291       100
   0.186       200
   0.172       501
    2723  242501.2  453084.0      50.0
       6         0    0.0119    1.5256    0.3676  47.323
   0.365         1
   0.364        10
   0.339        32
   0.300       100
   0.182       200
   0.156       501
    3111  242507.4  453081.9      32.0
       6        16    0.0467    1.3483    0.4536  280.5      0.6200    1.1943
   0.437         3
   0.431        10
   0.361        32
   0.232       100
   0.221       158
   0.191       331
187.8100         0     0.454           CRUST
161.7700         1     0.452
127.0800         2     0.449
  5.3300         9     0.423
  1.7700        37     0.339
  0.3000        31     0.353
  0.7100        38     0.337
  0.9000        31     0.353
  0.2200        30     0.355
  0.2800        27     0.363
  0.1700        28     0.360
  0.1264       340     0.172   0.00850 HAM
  0.0342       488     0.152   0.00370
  0.0049       736     0.132   0.00091
  0.0025      1183     0.112   0.00087
  0.0223      1153     0.113   0.00760
    3121  242507.4  453081.9      64.0
      19        10    0.0382    1.5380    0.3530  323.4      0.2476    1.3535
   0.399         1
   0.395         3
   0.333        10
   0.330        32
   0.208       100
   0.199       159
   0.151       501
   0.300         3
   0.289        10
   0.250        32
   0.138       100
   0.133       158
   0.062       331
   0.357         3
   0.341        10
   0.248        32
   0.096       100
   0.090       158
   0.051       331
  0.8252        99     0.165   0.01200 HAM
  0.0908       149     0.135   0.00230
  0.0191       204     0.115   0.00076
  0.0089       295     0.095   0.00061
  0.0043       462     0.075   0.00058
  0.5914        99     0.165   0.00860
```

```
  0.1882        129     0.145   0.00390
  0.0349        174     0.125   0.00110
  0.0153        244     0.105   0.00079
  0.0070        365     0.085   0.00066
    3131   242507.4  453081.9      90.0
      21         14    0.0171    1.7349    0.3180   31.6        0.2675    1.4693
   0.314          1
   0.316          3
   0.313         10
   0.254         32
   0.168        100
   0.102        159
   0.041        501
   0.348          1
   0.344          3
   0.347         10
   0.269         32
   0.199        100
   0.164        159
   0.054        501
   0.303          1
   0.302          3
   0.298         10
   0.250         32
   0.216        100
   0.202        159
   0.045        501
  0.8137         68     0.223   0.00690  HAM
  0.6013         84     0.203   0.00600
  0.4851        103     0.183   0.00590
  0.2716        127     0.163   0.00420
  0.0737        157     0.143   0.00150
  0.0165        199     0.123   0.00047
  0.0138        260     0.103   0.00059
  0.8028         75     0.213   0.00730
  0.6214         84     0.203   0.00620
  0.5656         93     0.193   0.00620
  0.2499        114     0.173   0.00340
  0.1077        141     0.153   0.00190
  0.0186        301     0.093   0.00100
  0.0092        425     0.073   0.00087
    3221   242507.4  453081.3      64.0
      13         21    0.0342    1.7389    0.3140   73.2        0.1721    1.4683
   0.306          1
   0.305          3
   0.292         10
   0.240         32
   0.105        100
   0.098        159
   0.055        501
   0.311          3
   0.306         10
   0.225         32
   0.106        100
   0.088        158
   0.056        331
 59.4200          0     0.314            CRUST
 22.47            2     0.313
 21.2900          3     0.311
  6.1000          6     0.306
  0.2700         19     0.266
  0.1500         23     0.253
  2.6000         25     0.247
 11.0900         17     0.273
```

```
    9.2400         7      0.304
    8.7600         0      0.314
    0.8190        72      0.148    0.00750  HAM
    0.5379        91      0.128    0.00680
    0.2846       118      0.108    0.00530
    0.1220       158      0.088    0.00360
    0.0389       228      0.068    0.00210
    0.0140       368      0.048    0.00170
    0.5961        89      0.130    0.00730
    0.0736       114      0.110    0.00130
    0.0293       153      0.090    0.00082
    0.0127       219      0.070    0.00064
    0.0052       348      0.050    0.00057
      3231  242507.4   453081.3       90.0
        14        39     0.0191     1.7602    0.3170    44.9        0.2058     1.4443
     0.327         1
     0.304         3
     0.298        10
     0.267        32
     0.159       100
     0.112       159
     0.058       501
     0.306         1
     0.330         3
     0.332        10
     0.264        32
     0.203       100
     0.138       159
     0.051       501
  206.7700         0      0.317             CRUST
  178.4100         2      0.317
  168.6100         6      0.314
   29.0600        30      0.276
    9.1000        26      0.284
   65.5000        12      0.307
  141.2400         6      0.314
  164.8700         0      0.317
    0.2983        65      0.099    0.00520  SORP
    0.2137        72      0.095    0.00430
    8.3700        24      0.150    0.03800
   22.5651         7      0.230    0.02800
   29.7225         4      0.260    0.02700
    0.0005       373      0.046    0.00011
    0.0153        88      0.087    0.00041
    1.6152        17      0.170    0.00480
   30.9096         5      0.250    0.03100
    1.0194        59      0.223    0.00740  HAM
    0.7873        73      0.203    0.00670
    0.4278        89      0.183    0.00440
    0.1777       109      0.163    0.00230
    0.0036       135      0.143    0.00006
    0.0236       192      0.113    0.00067
    0.0100       253      0.093    0.00044
    0.0059       354      0.073    0.00045
    0.0020       545      0.053    0.00032
    0.8043        55      0.230    0.00560
    0.7972        68      0.210    0.00640
    0.6681        83      0.190    0.00640
    0.3721       101      0.170    0.00440
    0.1559       125      0.150    0.00240
    1.0380        61      0.220    0.00770
    0.4591        75      0.200    0.00400
    0.2628        92      0.180    0.00280
    0.1121       112      0.160    0.00150
```

```
    0.0845       139     0.140   0.00150
    0.0561       176     0.120   0.00140
    0.0321       229     0.100   0.00120
    0.0178       312     0.080   0.00110
      3311  242508.6  453081.9      35.0
        13        27    0.0237    1.6635    0.4260   72.0       0.2907    1.2703
     0.426         3
     0.414        10
     0.364        32
     0.316        63
     0.180       100
     0.161       148
     0.141       331
     0.413         3
     0.359        32
     0.302        63
     0.166       100
     0.164       148
     0.143       331
  181.5500         0     0.426            CRUST
   95.1600         1     0.426
   43.9200         5     0.421
    6.2700         8     0.416
    2.8700        23     0.376
   16.0400        19     0.388
   28.5400         5     0.421
  132.8000         0     0.426
    0.7806       112     0.207   0.00880  HAM
    0.2168       134     0.187   0.00310
    0.0697       162     0.167   0.00130
    0.0126       200     0.147   0.00032
    0.0085       253     0.127   0.00031
    0.0036       332     0.107   0.00020
    0.9768        96     0.225   0.00910
    0.1561       114     0.205   0.00180
    0.0584       137     0.185   0.00086
    0.0238       166     0.165   0.00046
    0.0072       205     0.145   0.00019
    0.0032       260     0.125   0.00012
    0.0011       341     0.105   0.00006
    0.6243       114     0.205   0.00720
    0.2714       137     0.185   0.00400
    0.1862       166     0.165   0.00360
    0.1174       205     0.145   0.00310
    0.0922       230     0.135   0.00290
    0.0451       296     0.115   0.00210
      3321  242508.6  453081.9      60.0
        18        46    0.0155    2.2327    0.3230   70.9       0.0629    1.5995
     0.320         3
     0.303        32
     0.252        63
     0.105       100
     0.074       148
     0.058       331
     0.317         3
     0.288        32
     0.231        63
     0.138       100
     0.069       148
     0.043       331
     0.326         3
     0.292        32
     0.244        63
     0.175       100
```

```
    0.144       148
    0.105       331
 154.5000         0     0.323            CRUST
 160.6800         6     0.322
 155.4800         7     0.322
  84.5100        17     0.314
  32.6800        23     0.306
  88.2300        19     0.312
 100.7300         5     0.322
 104.3600         0     0.323
   0.0190       228     0.065   0.00130  SORP
   0.7735       109     0.100   0.01700
  14.4881        68     0.130   0.16000
  44.0716        59     0.140   0.40000
  97.8254        52     0.150   0.75000
   0.0492       141     0.086   0.00160
   0.0004       367     0.049   0.00006
   0.0375       147     0.084   0.00130
   1.1703        79     0.120   0.01600
  18.3263        46     0.160   0.12000
   5.2886        59     0.140   0.04800
  19.8535        46     0.160   0.13000
  10.8456        15     0.250   0.02600
   0.1090       167     0.078   0.00460
   3.8767        79     0.120   0.05300
   1.6399        92     0.110   0.02800
  10.8660        68     0.130   0.12000
  96.2132        46     0.160   0.63000
 177.6343        40     0.170   0.98000
   0.9832       116     0.137   0.00990  HAM
   0.1773       136     0.117   0.00230
   0.0623       162     0.097   0.00110
   0.0153       199     0.077   0.00040
   0.0095       258     0.057   0.00042
   0.0038       370     0.037   0.00036
   1.0655       109     0.145   0.00980
   0.3624       127     0.125   0.00420
   0.1301       150     0.105   0.00200
   0.0441       182     0.085   0.00097
   0.0097       230     0.065   0.00034
   0.0034       315     0.045   0.00023
   0.9767       101     0.155   0.00810
   0.5904       118     0.135   0.00610
   0.4362       138     0.115   0.00580
   0.1806       165     0.095   0.00330
   0.0400       204     0.075   0.00110
   0.0233       266     0.055   0.00110
   0.0079       388     0.035   0.00084
     3331  242508.6  453081.9      90.0
       13        30    0.0151    2.1261    0.2930   53.5        0.0621    1.6279
    0.278         3
    0.262        32
    0.202        63
    0.112       100
    0.066       148
    0.036       331
    0.311         3
    0.292        10
    0.279        32
    0.230        63
    0.172       100
    0.144       148
    0.081       331
 272.2200         0     0.293            CRUST
```

```
192.8700        10     0.290
175.3400        14     0.287
 51.6000        24     0.277
 22.4500        18     0.284
122.4000        19     0.283
104.3600         2     0.293
250.6300         0     0.293
  0.0170       204     0.059   0.00110  SORP
  2.5332        72     0.110   0.03300
 19.6759        41     0.150   0.12000
  8.8477        54     0.130   0.07700
 45.0111        28     0.180   0.18000
  0.0007       258     0.051   0.00007
  0.0016       210     0.058   0.00011
  0.1272       100     0.091   0.00270
  0.5415        85     0.100   0.00900
 62.0486        54     0.130   0.54000
  0.0014       340     0.043   0.00021
  0.0312       162     0.068   0.00140
  1.0747        72     0.110   0.01400
 27.7928        25     0.190   0.10000
  0.9719        73     0.190   0.00690  HAM
  0.9400        87     0.170   0.00770
  0.6579       102     0.150   0.00640
  0.3040       121     0.130   0.00370
  0.0543       145     0.110   0.00087
  0.0188       179     0.090   0.00043
  0.0070       228     0.070   0.00025
  0.0022       313     0.050   0.00015
    3411  242508.6  453081.3      35.0
      14        25    0.0235    1.7183    0.4190   75.5         0.3064    1.2670
   0.400         3
   0.394        10
   0.340        32
   0.280        63
   0.145       100
   0.134       148
   0.117       331
   0.423         3
   0.418        10
   0.363        32
   0.302        63
   0.200       100
   0.162       148
   0.134       331
186.0500         0     0.419            CRUST
 85.9600         3     0.417
 36.7700         8     0.409
 23.9800        23     0.370
  0.1400        45     0.307
 13.9900        25     0.364
 20.6500        20     0.379
 38.3400         8     0.409
108.6800         0     0.419
  0.3575       111     0.195   0.00390  HAM
  0.0940       132     0.175   0.00130
  0.0240       160     0.155   0.00044
  0.0215       197     0.135   0.00054
  0.0115       250     0.115   0.00042
  0.0012       330     0.095   0.00007
  0.1053       141     0.168   0.00160
  0.0323       172     0.148   0.00066
  0.0143       214     0.128   0.00041
  0.0068       274     0.108   0.00029
```

```
    0.0035        368      0.088   0.00024
    0.2955        139      0.170   0.00440
    0.2133        168      0.150   0.00420
    0.0980        209      0.130   0.00270
    0.0344        267      0.110   0.00140
    0.0116        356      0.090   0.00076
      3421   242508.6   453081.3      60.0
        21         41     0.0169    1.9728    0.3060     62.2       0.0410     1.7274
     0.351          3
     0.346         10
     0.306         32
     0.241         63
     0.124        100
     0.091        148
     0.071        331
     0.280          3
     0.268         10
     0.254         32
     0.205         63
     0.157        100
     0.091        148
     0.039        331
     0.290          3
     0.281         10
     0.258         32
     0.211         63
     0.174        100
     0.138        148
     0.097        331
  110.0700          0      0.306             CRUST
  101.0400          8      0.303
  110.5000         13      0.299
    3.1300         34      0.265
   57.9600          6      0.304
   54.2100          6      0.304
   98.2300          0      0.306
    0.0001        318      0.047   0.00001  SORP
    0.0002        291      0.050   0.00002
    0.0007        237      0.058   0.00004
    0.5780         94      0.110   0.00860
    0.6385         94      0.110   0.00950
   42.6290         72      0.130   0.43000
    0.0015        384      0.041   0.00023
    0.0404        193      0.067   0.00190
    0.6819        121      0.093   0.01500
   38.4404         64      0.140   0.33000
   21.8102         72      0.130   0.22000
   57.0782         64      0.140   0.49000
    0.0681        193      0.067   0.00320
    1.3013        122      0.092   0.02900
   11.4251         94      0.110   0.17000
   25.5179         82      0.120   0.31000
   57.4996         72      0.130   0.58000
   44.7029         57      0.150   0.33000
    0.6027         98      0.160   0.00600  HAM
    0.4328        117      0.140   0.00540
    0.1271        142      0.120   0.00210
    0.0687        176      0.100   0.00160
    0.0205        227      0.080   0.00074
    0.0047        309      0.060   0.00030
    0.6384        113      0.144   0.00760
    0.3451        137      0.124   0.00540
    0.1576        168      0.104   0.00340
    0.0396        215      0.084   0.00130
```

```
    0.0303       289     0.064   0.00170
    0.4914       126     0.132   0.00680
    0.1547       154     0.112   0.00290
    0.0361       194     0.092   0.00099
    0.0151       254     0.072   0.00067
    0.0056       360     0.052   0.00047
      3431  242508.6  453081.3      90.0
        21        36    0.0137    1.7127     0.2960     45.5        0.1332     1.3515
     0.298         3
     0.290        10
     0.277        32
     0.237        63
     0.167       100
     0.113       148
     0.055       331
     0.296         3
     0.292        10
     0.280        32
     0.250        63
     0.206       100
     0.180       148
     0.133       331
     0.298         3
     0.280        10
     0.265        32
     0.233        63
     0.195       100
     0.172       148
     0.121       331
  214.7200         0     0.296             CRUST
  135.2900         3     0.295
  141.6200         5     0.295
   35.2200        26     0.277
   20.0000        30     0.273
   92.5400        10     0.292
   87.5700         9     0.293
  176.9600         0     0.296
    0.3773       183     0.096   0.02400   SORP
   15.5135        49     0.150   0.18000
    3.4643        95     0.120   0.09300
   16.3754        49     0.150   0.19000
    0.0237       401     0.073   0.00430
    1.1165       123     0.110   0.04200
   21.4497        60     0.140   0.32000
    1.8874       123     0.110   0.07100
    8.0831        75     0.130   0.16000
  172.8419        27     0.180   1.00000
   10.4302        95     0.120   0.28000
    1.8482       162     0.100   0.10000
    4.2533       123     0.110   0.16000
   43.5698        60     0.140   0.65000
  373.2965        19     0.200   1.50000
    0.7260        94     0.200   0.00910   HAM
    0.1768       118     0.180   0.00270
    0.0504       148     0.160   0.00098
    0.0247       187     0.140   0.00064
    0.0166       241     0.120   0.00061
    0.0045       319     0.100   0.00025
    0.0029       446     0.080   0.00027
    0.5368       112     0.185   0.00780
    0.3890       140     0.165   0.00710
    0.2750       176     0.145   0.00660
    0.1132       226     0.125   0.00380
    0.0379       297     0.105   0.00190
```

```
   0.0135       407     0.085   0.00110
     3511  242509.4  453081.9      28.0
       21        16    0.0397    1.5182     0.4000   212.3        0.2841     1.2793
    0.363         3
    0.347        10
    0.298        32
    0.215        63
    0.175       100
    0.132       148
    0.124       331
    0.439         3
    0.373        10
    0.308        32
    0.231        63
    0.184       100
    0.134       148
    0.122       331
    0.372        10
    0.388         3
    0.324        32
    0.241        63
    0.193       100
    0.146       148
    0.124       331
 406.8500         0     0.400            CRUST
 104.3900         7     0.382
  55.7200         8     0.379
  18.5000        30     0.301
   6.1800        34     0.290
   0.0600        46     0.261
   0.3100        42     0.270
  13.6800        25     0.316
  30.8000        18     0.341
  55.7500         9     0.375
 193.3800         0     0.400
   0.9800        72     0.217   0.00870  HAM
   0.6007        90     0.197   0.00700
   0.2021       114     0.177   0.00320
   0.0410       146     0.157   0.00091
   0.0146       265     0.117   0.00076
     3521  242509.4  453081.9      59.0
       21        59    0.0169    2.4484     0.3080    18.8        0.0219     2.2183
    0.309         3
    0.289        10
    0.267        32
    0.211        63
    0.125       100
    0.061       148
    0.051       331
    0.338         3
    0.320        10
    0.291        32
    0.209        63
    0.126       100
    0.068       148
    0.050       331
    0.291         3
    0.280        10
    0.260        32
    0.184        63
    0.127       100
    0.052       148
    0.031       331
 151.9900         0     0.308            CRUST
```

```
108.7100         8     0.307
 63.5100        15     0.302
 30.8500        28     0.282
 19.6600        35     0.267
  0.3300        53     0.220
  0.5100        39     0.257
 17.2900        41     0.252
117.0200         0     0.308
  0.0022       290     0.032   0.00019  SORP
  0.0016       306     0.030   0.00016
  0.0027       283     0.033   0.00022
  0.7837       140     0.075   0.01500
 11.8878       108     0.100   0.14000
 26.1210        98     0.110   0.26000
  2.9915       122     0.087   0.04400
 41.5898        90     0.120   0.36000
121.1514        77     0.140   0.83000
232.8472        61     0.170   1.20000
  0.0097       218     0.045   0.00046
  0.3866       140     0.075   0.00740
  4.2456       108     0.100   0.05000
 13.0605        98     0.110   0.13000
  4.1607       108     0.100   0.04900
161.0953        71     0.150   0.99000
  0.0010       324     0.028   0.00011
  0.0007       345     0.026   0.00009
  0.0056       246     0.039   0.00034
  0.5373       138     0.076   0.01000
  4.9284       109     0.099   0.05900
 12.0559        98     0.110   0.12000
  4.0428       111     0.097   0.05000
 64.2248        77     0.140   0.44000
 98.9601        61     0.170   0.51000
  1.5755        67     0.185   0.00790  HAM
  1.3112        76     0.165   0.00740
  0.5258        87     0.145   0.00350
  0.2607        99     0.125   0.00210
  0.1058       115     0.105   0.00110
  0.0585       137     0.085   0.00085
  0.0359       168     0.065   0.00080
  0.0201       219     0.045   0.00081
  0.7976        48     0.233   0.00350
  0.6015        55     0.213   0.00270
  0.2919        63     0.193   0.00140
  0.0936        72     0.173   0.00050
  0.0633        82     0.153   0.00039
  0.0605        94     0.133   0.00045
  0.0634       108     0.113   0.00059
  0.0294       139     0.083   0.00044
  0.0155       195     0.053   0.00048
  1.5757        53     0.220   0.00700
  1.0086        60     0.200   0.00470
  0.5255        69     0.180   0.00270
  0.3615        78     0.160   0.00210
  0.3203        89     0.140   0.00220
  0.2213       103     0.120   0.00190
  0.1424       120     0.100   0.00160
  0.0947       143     0.080   0.00150
    3531  242509.4  453081.9      90.0
      21        46    0.0150    3.0602    0.2740     8.1       0.0198    2.6245
   0.274         3
   0.263        10
   0.243        32
   0.182        63
```

```
       0.098       100
       0.047       148
       0.037       331
       0.283         3
       0.271        10
       0.256        32
       0.182        63
       0.109       100
       0.028       148
       0.017       331
       0.287         3
       0.269        10
       0.256        32
       0.195        63
       0.100       100
       0.041       148
       0.032       331
      0.0116       187     0.032   0.00050  SORP
      0.0146       180     0.034   0.00057
      0.9269       108     0.073   0.01100
     32.0057        74     0.120   0.19000
     57.6140        69     0.130   0.31000
     17.8902        80     0.110   0.12000
      6.8068        89     0.095   0.05500
    192.0770        57     0.160   0.84000
    138.6676        20     0.260   0.94000
      0.0062       130     0.056   0.00011
      0.1289       107     0.074   0.00150
      0.0023       140     0.050   0.00005
      0.6090        97     0.085   0.00580
     31.3079        80     0.110   0.21000
     48.8509        74     0.120   0.29000
    538.9698        69     0.130   2.90000
      0.0010       237     0.022   0.00008
      0.0027       208     0.027   0.00015
      0.0315       162     0.040   0.00095
      0.4955       127     0.058   0.00840
     14.2188        95     0.087   0.13000
      8.8923       100     0.082   0.09000
     10.2885        98     0.084   0.10000
    102.2184        69     0.130   0.55000
    153.2043        57     0.160   0.67000
      0.6863        35     0.250   0.00440  HAM
      1.1921        44     0.230   0.00580
      1.5002        52     0.210   0.00650
      1.7764        59     0.190   0.00750
      1.8533        67     0.170   0.00810
      1.6840        75     0.150   0.00800
      1.4059        83     0.130   0.00750
      0.8980        94     0.110   0.00580
      0.4927       106     0.090   0.00400
      1.3026        58     0.195   0.00550
      0.8353        65     0.175   0.00360
      0.5177        73     0.155   0.00240
      0.0948        81     0.135   0.00049
      1.3848        52     0.210   0.00600
      0.7106        59     0.190   0.00300
      0.5720        67     0.170   0.00250
      0.4421        75     0.150   0.00210
      0.1162        83     0.130   0.00062
      0.1037        94     0.110   0.00067
      0.0875       106     0.090   0.00071
      0.0663       123     0.070   0.00075
        3611  242509.4  453081.3      28.0
```

```
         21        20    0.0367    1.5572    0.3810  190.6       0.3100    1.2824
      0.368         3
      0.328        10
      0.282        32
      0.212        63
      0.173       100
      0.134       148
      0.123       331
      0.361         3
      0.339        10
      0.279        32
      0.190        63
      0.147       100
      0.099       148
      0.090       331
      0.409         3
      0.382        10
      0.334        32
      0.249        63
      0.195       100
      0.143       148
      0.131       331
   180.8700         0     0.381            CRUST
   101.2500         5     0.372
    80.2600         7     0.366
    10.2400        40     0.263
     0.7600        47     0.248
     0.0300        59     0.226
     0.6700        49     0.244
     0.8000        46     0.250
    21.4500        29     0.292
    24.8400        26     0.301
   123.9600         0     0.381
     0.1652       100     0.176   0.00220  HAM
     0.0915       128     0.156   0.00170
     0.0448       166     0.136   0.00120
     0.0265       224     0.116   0.00110
     0.0097       318     0.096   0.00068
     0.0034       488     0.076   0.00046
     0.0537       201     0.123   0.00190
     0.0143       280     0.103   0.00083
     0.0053       416     0.083   0.00056
       3621  242509.4  453081.3      59.0
         14        45    0.0159    2.3654    0.2910    18.3       0.0331    1.8683
      0.306         3
      0.288        10
      0.264        32
      0.191        63
      0.113       100
      0.067       148
      0.041       331
      0.290         3
      0.272        10
      0.259        32
      0.212        63
      0.153       100
      0.066       148
      0.056       331
    87.4700         0     0.291            CRUST
    83.2600         4     0.291
    85.9600        13     0.287
    30.9700        30     0.265
     0.1100        43     0.239
     1.5000        38     0.250
```

```
  59.3700        18     0.283
  52.9900        17     0.284
  68.4300         0     0.291
   0.0003       382     0.032   0.00005  SORP
   0.0016       256     0.045   0.00012
   0.0317       149     0.071   0.00093
   2.5290        86     0.110   0.03000
  18.9863        68     0.130   0.16000
   0.0018       294     0.040   0.00018
   0.0048       244     0.047   0.00034
   0.0899       151     0.070   0.00270
   3.2138        97     0.100   0.04600
  28.3856        76     0.120   0.28000
  19.2617        76     0.120   0.19000
  51.0257        68     0.130   0.43000
 150.8646        61     0.140   1.10000
1320.9187        45     0.170   6.80000
   0.0037       368     0.033   0.00055
   0.1902       179     0.061   0.00770
  12.1653        76     0.120   0.12000
   0.8891        55     0.150   0.00570
   8.4299        86     0.110   0.10000
   9.2729        86     0.110   0.11000
  11.0358        68     0.130   0.09300
   0.2915        75     0.170   0.00180  HAM
   0.0999        86     0.150   0.00071
   0.1053       100     0.130   0.00091
   0.0508       117     0.110   0.00056
   0.0427       139     0.090   0.00064
   0.0312       172     0.070   0.00071
   0.6726        60     0.200   0.00360
   0.3938        70     0.180   0.00230
   0.2741        80     0.160   0.00180
   0.1917        93     0.140   0.00150
   0.1444       108     0.120   0.00140
   0.1024       127     0.100   0.00130
   0.0713       154     0.080   0.00130
   0.0325       194     0.060   0.00095
   0.0124       265     0.040   0.00072
     3631  242509.4  453081.3      90.0
       21        51    0.0170    2.6120    0.2790   16.9         0.0243    2.2608
    0.295         3
    0.276        10
    0.248        32
    0.180        63
    0.102       100
    0.057       148
    0.043       331
    0.263         3
    0.247        10
    0.232        32
    0.166        63
    0.074       100
    0.034       148
    0.025       331
    0.293         3
    0.276        10
    0.257        32
    0.197        63
    0.117       100
    0.061       148
    0.034       331
 206.6000         0     0.279            CRUST
  86.3900         6     0.279
```

```
 73.0000        11     0.277
  5.9100        33     0.247
  0.1800        43     0.223
  0.4700        53     0.197
 29.2600        28     0.257
 49.0200        20     0.269
190.9200         0     0.279
  0.0010       211     0.035   0.00006  SORP
  0.0053       171     0.045   0.00019
  0.0110       157     0.050   0.00033
  0.4021       110     0.076   0.00590
  8.8856        78     0.110   0.07100
 63.8909        61     0.140   0.36000
  1.7008        95     0.089   0.01900
 58.5667        61     0.140   0.33000
179.0373        31     0.220   0.67000
  0.0012       253     0.028   0.00010
  0.0037       211     0.035   0.00021
  0.0041       206     0.036   0.00022
  0.2125       128     0.064   0.00420
  1.8863       102     0.083   0.02400
 59.2800        66     0.130   0.37000
 13.7664        78     0.110   0.11000
 74.5394        61     0.140   0.42000
165.6763        31     0.220   0.62000
  0.0027       245     0.029   0.00021
  0.0004       377     0.017   0.00008
  0.0338       163     0.048   0.00110
  1.1167       105     0.080   0.01500
  0.1156       139     0.058   0.00270
 11.6389        78     0.110   0.09300
 55.0172        61     0.140   0.31000
 24.5650        71     0.120   0.17000
 30.5114        40     0.190   0.12000
  1.3074        49     0.205   0.00580  HAM
  1.6384        57     0.185   0.00750
  1.3336        65     0.165   0.00660
  0.8274        75     0.145   0.00470
  0.3292        85     0.125   0.00220
  0.1193        98     0.105   0.00100
  1.5557        44     0.220   0.00700
  0.8996        51     0.200   0.00400
  0.6665        59     0.180   0.00310
  0.4865        68     0.160   0.00250
  0.3754        77     0.140   0.00220
  0.2700        88     0.120   0.00190
  0.1445       102     0.100   0.00130
  0.0455       120     0.080   0.00056
  0.0126       147     0.060   0.00024
    3112  242507.5  453082.0      32.0
       6         0    0.0467    1.3483      0.4536   280.5
   0.437         3
   0.431        10
   0.361        32
   0.232       100
   0.221       158
   0.191       331
    3122  242507.5  453082.0      64.0
       7         0    0.0650    1.2888      0.3973   323.4
   0.399         1
   0.395         3
   0.333        10
   0.33         32
   0.208       100
```

```
0.199        159
0.151        501
 3125   242507.1  453082.0      64.0
    6          0    0.0238    1.7008    0.3010  323.4
0.300          3
0.289         10
0.25          32
0.138        100
0.133        158
0.062        331
 3128   242507.4  453081.7      64.0
    6          0    0.0378    1.8423    0.3623  323.4
0.357          3
0.341         10
0.248         32
0.096        100
0.09         158
0.051        331
 3132   242507.5  453082.0      90.0
    7          0    0.0212    1.8265    0.3156   31.6
0.314          1
0.316          3
0.313         10
0.254         32
0.168        100
0.102        159
0.041        501
 3135   242507.1  453082.0      90.0
    7          0    0.0226    1.6309    0.3469   31.6
0.348          1
0.344          3
0.347         10
0.269         32
0.199        100
0.164        159
0.054        501
 3138   242507.4  453081.7      90.0
    7          0    0.0074    2.2002    0.2898   31.6
0.303          1
0.302          3
0.298         10
0.25          32
0.216        100
0.202        159
0.045        501
 3225   242507.1  453081.4      64.0
    7          0    0.0319    1.7268    0.3081   73.2
0.306          1
0.305          3
0.292         10
0.24          32
0.105        100
0.098        159
0.055        501
 3228   242507.4  453081.1      64.0
    6          0    0.0365    1.7513    0.3195   73.2
0.311          3
0.306         10
0.225         32
0.106        100
0.088        158
0.056        331
 3235   242507.1  453081.4      90.0
    7          0    0.0221    1.7413    0.3142   44.9
```

```
0.327         1
0.304         3
0.298        10
0.267        32
0.159       100
0.112       159
0.058       501
 3238  242507.4  453081.1      90.0
    7         0    0.0157    1.8151     0.3198    44.9
0.306         1
0.33          3
0.332        10
0.264        32
0.203       100
0.138       159
0.051       501
 3312  242508.8  453082.0      35.0
    7         0    0.0233    1.6737     0.4312    72.0
0.426         3
0.414        10
0.364        32
0.316        63
0.18        100
0.161       148
0.141       331
 3318  242508.6  453081.7      35.0
    6         0    0.0248    1.6437     0.4222    72.0
0.413         3
0.359        32
0.302        63
0.166       100
0.164       148
0.143       331
 3322  242508.8  453082.0      60.0
    6         0    0.0141    2.9511     0.3242    70.9
0.320         3
0.303        32
0.252        63
0.105       100
0.074       148
0.058       331
 3325  242508.4  453082.0      60.0
    6         0    0.0143    2.7001     0.3153    70.9
0.317         3
0.288        32
0.231        63
0.138       100
0.069       148
0.043       331
 3328  242508.6  453081.7      60.0
    6         0    0.0192    1.6815     0.3312    70.9
0.326         3
0.292        32
0.244        63
0.175       100
0.144       148
0.105       331
 3332  242508.8  453082.0      90.0
    6         0    0.0146    2.7256     0.2806    53.5
0.278         3
0.262        32
0.202        63
0.112       100
0.066       148
```

```
0.036       331
 3338  242508.6  453081.7      90.0
    7         0    0.0157    1.8078    0.3062    53.5
0.311         3
0.292        10
0.279        32
0.23         63
0.172       100
0.144       148
0.081       331
 3412  242508.8  453081.4      0.35
    7         0    0.0237    1.7821    0.4075    75.5
0.400         3
0.394        10
0.34         32
0.28         63
0.145       100
0.134       148
0.117       331
 3418  242508.6  453081.1      35.0
    7         0    0.0231    1.6706    0.4304    75.5
0.423         3
0.418        10
0.363        32
0.302        63
0.2         100
0.162       148
0.134       331
 3422  242508.8  453081.4      60.0
    7         0    0.0185    2.1928    0.3529    62.2
0.351         3
0.346        10
0.306        32
0.241        63
0.124       100
0.091       148
0.071       331
 3425  242508.4  453081.4      60.0
    7         0    0.0130    2.3811    0.2735    62.2
0.28          3
0.268        10
0.254        32
0.205        63
0.157       100
0.091       148
0.039       331
 3428  242508.6  453081.1      60.0
    7         0    0.0189    1.6179    0.2907    62.2
0.29          3
0.281        10
0.258        32
0.211        63
0.174       100
0.138       148
0.097       331
 3432  242508.8  453081.4      90.0
    7         0    0.0124    2.2924    0.2957    45.5
0.298         3
0.290        10
0.277        32
0.237        63
0.167       100
0.113       148
0.055       331
```

```
 3435  242508.4  453081.4      90.0
    7         0    0.0137    1.5393    0.2989    45.5
0.296         3
0.292        10
0.28         32
0.25         63
0.206       100
0.18        148
0.133       331
 3438  242508.6  453081.1      90.0
    7         0    0.0170    1.5006    0.2939    45.5
0.298         3
0.28         10
0.265        32
0.233        63
0.195       100
0.172       148
0.121       331
 3512  242509.6  453082.0      28.0
    7         0    0.0358    1.5232    0.3700   212.3
0.363         3
0.347        10
0.298        32
0.215        63
0.175       100
0.132       148
0.124       331
 3515  242509.2  453082.0      28.0
    7         0    0.0603    1.4667    0.4400   212.3
0.439         3
0.373        10
0.308        32
0.231        63
0.184       100
0.134       148
0.122       331
 3518  242509.4  453081.7      28.0
    7         0    0.0299    1.5722    0.3930   212.3
0.372        10
0.388         3
0.324        32
0.241        63
0.193       100
0.146       148
0.124       331
 3522  242509.6  453082.0      59.0
    7         0    0.0158    2.4824    0.2999    18.8
0.309         3
0.289        10
0.267        32
0.211        63
0.125       100
0.061       148
0.051       331
 3525  242509.2  453082.0      59.0
    7         0    0.0181    2.3593    0.3319    18.8
0.338         3
0.32         10
0.291        32
0.209        63
0.126       100
0.068       148
0.050       331
 3528  242509.4  453081.7      59.0
```

```
       7          0    0.0160    2.5981    0.2862   18.8
   0.291          3
    0.28         10
    0.26         32
   0.184         63
   0.127        100
   0.052        148
   0.031        331
    3532   242509.6  453082.0      90.0
       7          0    0.0158    2.7589    0.2687    8.1
   0.274          3
   0.263         10
   0.243         32
   0.182         63
   0.098        100
   0.047        148
   0.037        331
    3535   242509.2  453082.0      90.0
       7          0    0.0147    3.2663    0.2751    8.1
   0.283          3
   0.271         10
   0.256         32
   0.182         63
   0.109        100
   0.028        148
   0.017        331
    3538   242509.4  453081.7      90.0
       7          0    0.0145    3.1589    0.2767    8.1
   0.287          3
   0.269         10
   0.256         32
   0.195         63
     0.1        100
   0.041        148
   0.032        331
    3612   242509.6  453081.4      28.0
       7          0    0.0481    1.4475    0.3700  190.6
   0.368          3
   0.328         10
   0.282         32
   0.212         63
   0.173        100
   0.134        148
   0.123        331
    3618   242509.4  453081.1      28.0
       7          0    0.0341    1.6885    0.3639  190.6
   0.361          3
   0.339         10
   0.279         32
    0.19         63
   0.147        100
   0.099        148
    0.09        331
    3615   242509.2  453081.4      28.0
       7          0    0.0314    1.5683    0.4090  190.6
   0.409          3
   0.382         10
   0.334         32
   0.249         63
   0.195        100
   0.143        148
   0.131        331
    3625   242509.2  453081.4      59.0
       7          0    0.0178    2.3751    0.2998   18.3
```