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E SEDIMENTATION

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PARTICLE SIZE AND SETTLING RATE DISTRIBUTIONS OF SAND-SIZED MATERIALS

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Particle Size and Settling Rate Distributions of Sand-Sized Materials

Jiri Brezina*

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TITLE. The content of the article had been considerably changed after the PARTEC Symposium editor board accepted it, but the title could not change since the original announcement This is why the *keywords* below should be considered to see the correct subject.

KEYWORDS. Influence of particle *shape* on sedimentation; rotational ellipsoid as a shape reference; *drag coefficient* as a function of Reynolds' number *and particle shape;* equations for particle size and sedimentation velocity; Hydraulic Shape Factor (SF') calculation; influence of other factors on sedimentation of *single particle,* such as fluid viscosity and specific gravity, gravity acceleration, specific gravity of solid; temperature distribution in the sedimentation space and its change in time; influence of particle concentration on sedimentation of a *particle collective;* a *sample size* formula conforming to statistical representativity and hydrodynamic instability due to streaming; instrumentation for measuring of sedimentation velocity distribution: ***MacroGranometer*™** - an *advanced settling tube system;* measuring range in terms of particle size and specific gravity; *calculation of a hydraulic shape factor (SF') distribution* from linking of a PHI-grain-size distribution to a PSI-sedimentation velocity distribution equaling their inverse distribution function; 10 figures; 50 references; tables of PSI-sedimentation velocity, sedimentation time (per sedimentation length of 200 cm), Reynolds' number, drag coefficient as functions of PHI-particle-size (0.02 PHI steps) for SF'=0.6 and 1.2; tables of PHI-particle-size as function of PSI-settling-rate (0.02 PSI steps) for SF'=0.1 through 1.0 by 0.1-SF'-steps, 1.2 and 1.5

TEXT ERRORS. Please, note the changes listed below.

Page 9, the parameters of the eq. 4 should read:

$$K = -2^{-PHI}*(R_s-R_f)*G/(7.5*R_f)$$
$$L = 10*A*n*2^{PHI}$$
$$M = (10*n)^{0.5}*B*2^{0.5PHI}$$

Page 17, in the chapter *TABLES*, the first paragraph numbering should read "2)", and the second paragraph numbering should read "1)"; at the end of the first paragraph, now numbered by "2)", expand the text in parentheses to read "(9 pages = page 36 - 44)"; at the end of the second paragraph, now numbered by "1)", the line beginning with "a)", expand the text in parentheses to read "(7 pages = p. 22 - 28)"; at the end of the second paragraph, now numbered by "1)", the line beginning with "b)", expand the text in parentheses to read "(7 pages = p. 29 - 35)"; the second paragraph, line 2, the word "function" should be in plural: "functions".

Pages 22 - 44, *headings printed in orange color:* "T" accompanied with the value "24.0" means temperature and should be printed in *lower* case, "t"; the *upper* case "T" stands for time; all dimensions are in CGS units, except for grain size which is in millimeters.

A greater publication on these topics is under preparation. *It will include definitions of sedimentation variables, such as logarithmic sedimentation velocity PSI_{lab} (PSI-laboratory), PSI_{loc} (PSI-local), PSI_{std} (PSI-standard), compound variable Reynolds Number defined under similar terms, etc., and principles of sedimentational separation of sand-sized materials, using the Sand Sedimentation Separator™ 3S™ product of the author, introduced 1986*

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PARTICLE SIZE AND SETTLING RATE DISTRIBUTIONS OF SAND-SIZED MATERIALS

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ABSTRACT

For an irregular particle, the best *size criterion* is *volume*, for it is independent of shape. A more accurately measurable size criterion is *settling rate* but it depends also on the shape and specific gravity under given sedimentation terms, and so both the shape and specific gravity must be specified. While the specific gravity can easily be determined and variously heavy material separated, the *role of particle shape* has been frequently underrated.

Non-spherical shape of a sand-sized particle dramatically reduces its size expressed by a diameter of a settling-rate-equivalent *sphere:* to 70% through 12% of its actual size, ie reduction by 1.5x through 8x (Fig. 1). The size reduction is suppressed by *specifying the particle shape instead of taking it spherical*. Expressing particle flatness, Corey's Shape Factor SF is a simple and hydraulically effective shape characteristics (pages 2 - 3).

For drag coefficient as function of Reynolds' number Re and SF, an equation has been developed and used for regression on critically sellected available data (eq. 1). It is valid for $0.01 \leq Re \leq 10000$, and for $0.1 \leq SF' \leq 1.2$. For SF'=1.2, the drag coefficient values approach very closely those for smooth spheres, and the equation validity extends to much lower Re values. Eq. 4 and 7 relate size, SF', and settling rate of irregular particles.

Macrogranometer, a computerized sedimentation balance for sand-sized (about 0.05mm to 4mm) particles, has been developed. It determines settling rate and particle size distributions using gravity sedimentation from one level in water. Particle interaction and suspension streaming do not influence the analysis measurably due to suppressed concentration effects. The suppression is accomplished with a minute sample sufficient for a sensitive underwater balance, with a wide settling tube, and with an even sample introduction. The fast weighing response allows for a high settling rate or particle size resolution: up to 351 grades of size or settling rate can be distinguished.

On the Macrogranometer 1979, the particle size distribution is measured using eq. 4 through 6. SF' values can be entered either *constant* or *variable with particle size*. A program section SHAPE calculates the variable SF' values from a particle size distribution determined by a non-sedimentational technique (eg by a DIN or ASTM sieving) and from a settling rate distribution of the same sample. The SF' values of all size grades represent easy calibration to a non-sedimentational technique, eg DIN or ASTM sieving, for size analyses of similar material. This way, the Macrogranometer exceeds requirements of any standard.

Eq. 1, 4, and 7 enable mutual conversions of the distributions with different variables by the Kapteyn's transformation (BREZINA, 1963). A frequency distribution of two variables - size and settling rate of particles - is introduced. Three-dimensional and contour diagrams reveal valuable information about particle shape and specific gravity relationships of the given material.

ROTATIONAL ELLIPSOID VERSUS SPHERE AS SHAPE REFERENCE IN PARTICLE SIZE ANALYSIS BY SEDIMENTATION

Most sand-sized particles are irregularly and variously shaped. Ignorance of the nonsphericity by using a *sphere as a standard shape* introduces a *significant error*. Its kind depends on the sizing method.

Using *sedimentation* for size determination, the sphere as standard shape causes apparent *reduction of particle size*. The size reduction is involved in the current hydrodynamic particle size definitions such as the hydraulic value of SCHÖNE (1868), equivalent radius of ODEN (1915), sedimentation radius of WADELL (1934) and LANE (1947), and (standard) fall diameter of COLBY and CHRISSTENSEN (1957).

The size reduction is enormous especially with coarse particles, but it does not vanish completely even with fine particles (Fig. 1).

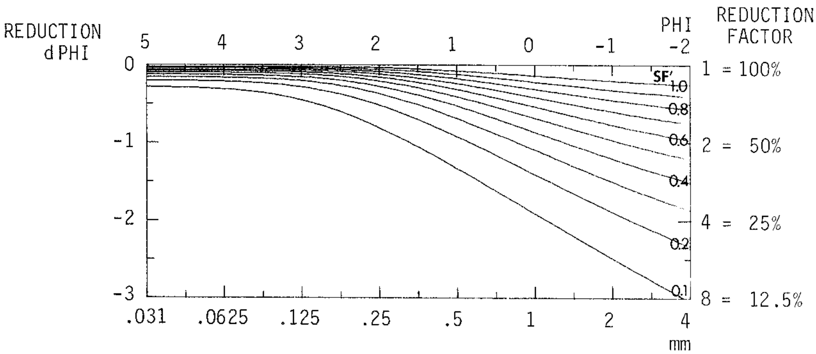

FIG. 1: Particle size reduction due to neglecting the actual shape of the particles, and considering it spherical. For Hydraulic Shape Factor SF' (page 3), naturally worn irregular particles; data are calculated from the eq. (4) through (7); distilled water 24°C; gravity acceleration G = 981 cm/sec^2, particle specific gravity R_s = 2.5*).

Fig. 5 reveals the size reduction as the horizontal distance of each curve from that for spheres (SF'=1.2; see page 3 concerning definition of the shape factor). For instance, a 4-millimeter quartz*) particle with a typical shape SF'≐0.6 has the same settling rate as a 2-millimeter quartz*) sphere: the size reduction is by 2.0 (=1.04 PHI). A 4-millimeter quartz*) particle with SF'=0.1 has the same settling rate as a 0.48-millimeter quartz*) sphere: the size reduction is by 8.3 (=3.06 PHI).

*) The specific gravity R_s=2.5 instead of R_s=2.65 for quartz practically does not influence the size reduction, since the shifting of the curves of the Fig. 5 and 6, due to the specific gravity change, is parallel.

SERR (1948) used the size reduction as a *shape measure*. The settling rate reduction, which corresponds to the vertical distance of each curve from that for smooth spheres (SF'=1.2) on Fig. 5, has been used as a shape measure by McNOWN and MALAIKA (1950) and by BRIGGS, McCULLOCH and MOSER (1962).

The sphere as standard shape in sedimentation size analysis has been employed exclusively, since all formulas for hydraulic particle behavior have been available for spheres only: both the drag coefficient (some are listed in Table 1) and settling rate equations (eg GIBBS, MATTHEWS and LINK, 1971).

Independently COREY (1949) and McNOWN and MALAIKA (1950) concluded after detailed studies, that the hydraulically most effective shape characteristic is a dimensionless ratio number relating the minimum, medium and maximum mutually perpendicular particle dimensions, a, b, c respectively, known as the *Corey's Shape Factor*:

$$SF = a/(b.c)^{0.5}$$

This original notation SF is used if its value is calculated from *directly measured particle dimensions*. A notation SF' is used in this paper, if it is *defined by a hydraulic behavior* of the particle, such as by the equations (1), (4) and (7) here, or (12) through (14) of KOMAR and REIMERS (1978). Then a term "*Hydraulic (Corey's) Shape Factor*" can describe it.

Although the Corey's Shape Factor has been frequently discussed and alternatives have been proposed (ALGER, 1964; ALGER and SIMONS, 1968; BRIGGS, McCULLOCH and MOSER, 1962), most experiments corroborate its efficiency (eg STRINGHAM, SIMONS and GUY, 1969), recently also those of KOMAR and REIMERS (1978).

Already COLBY and CHRISTENSEN (1957, page 21) noted that "data for naturally worn particles with a shape factor of 1.0 diverge from the relation for spheres". They constructed two best-fit drag coefficient versus Reynolds' number curves for the Corey's SF'=1.0: one for *naturally worn particles*, and another for *smooth spheres*.

In order to lessen that ambiguity, this paper defines the Hydraulic Shape Factor, SF', and the hypothetical body defined by it: the *rotational ellipsoid* with short vertical axis and horizontal circular section. Since this hypothetical ellipsoid is defined by the eq. 1 obtained from regression of data on *naturally worn particles*, it absorbs some undefined *roughnes* of the particles, and the drag coefficient values for *smooth spheres* corresponds to the SF'=1.2 - an impossible value of an actually measured SF. The ratio of the Hydraulic Shape Factor (SF') values for smooth spheres to those for naturally worn isometrical particles with SF'=1.0 is about 1.2; it indicates the effect of the undefined particle roughness, probably also for more non-spherical particles.

A criterion for particle *roughness* (roundness, angularity etc.) is demanded. As a fine shape feature, it should be capable of a continuous transition to the coarse (dominant) shape such as defined by the Corey's shape, and terminate with the extreme shape of the smooth sphere. WEICHERT and HULLER (1979: paper of this Conference, Session 2, 25 September) not only applied the Fourier analysis which meets the above requirement but they also developed an effective measuring technique.

The Hydraulic Shape Factor SF' can be calculated from a settling rate and particle size (eq. 8). With some limitations, it can be calculated even from a settling rate and particle size distributions of the same sample. In this case, the SF'-values to each particle size grade can be used for calibration of the sedimentation analysis to the employed sizing method. Since the commonly used sizing includes a lot of measuring errors, the resulting SF' values may strongly deviate from actual SF values, but they still are valuable calibrating factors.

TABLE 1

Parameters of polynomial equations for drag coefficient C_D of sedimenting spheres as function of Reynolds' number Re. Equations of KOMAR et al (1978) are given for comparison since they are not valid for spheres. Validity limits are approximate.

$$C_D = A\,Re^{a} + B\,Re^{b} + C\,Re^{c} + D\,Re^{d} + E\,Re^{e} + F\,Re^{f}$$

Authors	Year	*a*	A	*b*	B	*c*	C	*d*	D	*e*	E	*f*	F	Re minimum	Re maximum
NEWTON	1687					*0*	(0.44)							10^3	2.10^5
STOKES	1845	*-1*	24											10^{-7}	10^{-1}
KOMAR, et al. Eq.12	1978	*-1*	22.704					*given for SF'=1*, valid: 0.4≤SF'≤0.8						10^{-7}	2
Eq.13		*-0.9721*	23.928					*given for SF'=1*, valid: 0.4<SF'≤0.8						5.10^{-2}	1
Eq.14		*-1*	2.16					*given for SF'=1*, valid: SF'≤0.4						5.10^{-2}	2
OSEEN	1910	*-1*	24			*0*	4.5							10^{-7}	1
GOLDSTEIN	1929	*-1*	24			*0*	4.5	*1*	-0.35625	2	0.0832	3	-0.0210512	10^{-7}	2
SCHILLER	1933	*-1*	24	*-0.313*	3.6									10^{-7}	8.10^2
WADEL	1934	*-1*	24	*-0.30103*	1.92			*valid for Stokes' Reynolds number*						10^{-7}	3.10^3
LANGMUIR et al	1959	*-1*	24	*-0.37*	4.728			*0.38*	0.0624					10^{-7}	10^2
RUBEY	1933	*-1*	24			*0*	2	*derived for non-spherical part.*						10^{-7}	2.10
DALLAVALLE	1943	*-1*	24.4			*0*	0.4							10^{-7}	2.10^5
WATSON	1969	*-1*	14.928			*0*	1.061	*includes streaming errors*						-	-
GIBBS et al.	1971	*-1*	24			*0*	0.4 (=convergence value for large Re)							10^{-7}	2.10^5
WEBER	1974	*-0.8*	26			*0*	0.4							1	2.10^5
KÜRTEN et al.	1966	*-1*	21	*-0.5*	6	*0*	0.28							10^{-7}	10^4
KASKAS	1964	*-1*	24	*-0.5*	4	*0*	0.4							10^{-7}	2.10^5
BREZINA	1979	*-1*	23.963	*-0.5*	4.058	*0*	0.37965	*for SF'=1.2*; valid: 0.1≤SF'≤1.2						10^{-7}	10^4

DRAG COEFFICIENT as FUNCTION OF REYNOLDS' NUMBER and SHAPE of IRREGULAR PARTICLE

For *smooth spheres*, many equations have been proposed for the drag coefficient as function of Reynolds' number. Most of them can be expressed in form of a polynomial as shown in TABLE 1.

For *irregular particles*, most experimental data on drag coefficient, Reynolds' number and Corey's Shape Factor have been compiled by SCHULZ, WILDE and ALBERTSON (1954). COLBY and CHRISTENSEN (1957) disclosed inconsistency in the drag coefficient definition and experimental terms of some data of SCHULZ et al., and constructed an improved best fit plot of the drag coefficient logarithm as function of the Reynolds' number logarithm (Nikuradze diagram) for various SF' values.

In order to express the available data on irregular particles mathematically, BREZINA (1977) extended the equation of KASKAS (1964, 1970) by adding the SF' shape as a third variable to each term of the polynomial:

$$C_D = A\,Re^{-1} + B\,Re^{-0.5} + C \qquad [Re \leq 10^4] \qquad (1).$$

In this paper, the parameters of the equation are slightly modified in order to fit the recent experimental data of KOMAR and REIMERS (1978), which reveal a much stronger influence of particle shape onto the drag coefficient under low Reynolds' numbers than assumed earlier:

	for SF' =		
	1.2	1.0	0.3
$A = P_2\,SF'^{P_1}$	23.963	24.66	29.80
$B = P_4\,SF'^{P_3}$	4.058	4.07	4.15
$C = P_6\,SF'^{P_5}$	0.37967	0.49	2.64

The parameters P_1 through P_6 are defined by the following values:

P_1 = -0.1572509737	P_3 = -0.0161675868	P_5 = -1.398809673
P_2 = 24.66	P_4 = 4.07	P_6 = 0.49

The plot of the equation (1) in the Nikuradze diagram is exhibited by the FIG. 2, together with two systems of parallel straight lines of particle size and settling rate data for quartz sedimenting in water under standard conditions. One system represents PHI-particle size, the other PSI-settling rate

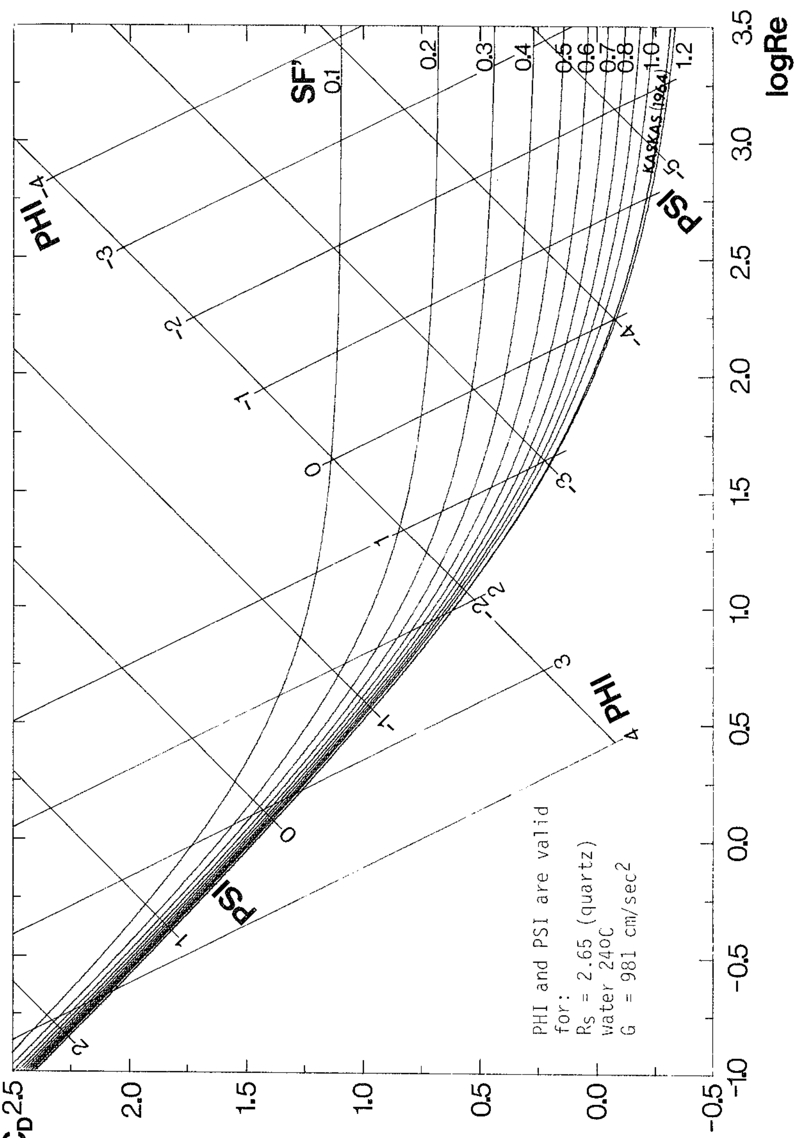

FIG. 2: Drag coefficient ($\log C_D$) as function of Reynolds' number (logRe) for various Hydraulic Shape Factor (SF') - Nikuradze diagram; naturally worn sedimenting particles; according to eq. (1) PHI-particle size and PSI-settling rate: quartz particles, distilled water 24°C, gravity acceleration G = 981 cm/sec^2.

(see page 9 for PHI and PSI notations). FIG. 3 reveals a three-dimensional picture of the eq. 1; the surface plot in contour isolines is shown in FIG. 4.

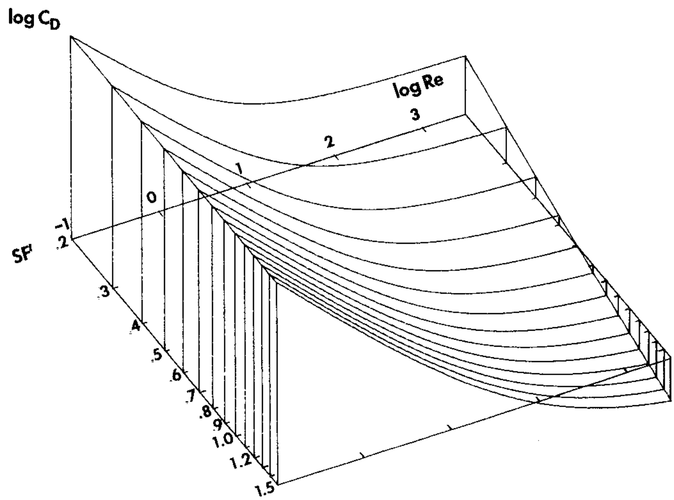

FIG. 3: Drag coefficient ($\log C_D$) as function of Reynolds' number (logRe) and Hydraulic Shape Factor (logSF'); naturally worn sedimenting particles; data calculated from the equation (1).

Comparison of the eq. (1) with pertinent data is given in TABLE 2.

logRe	(1) log C_D eq. 1 SF'=1.2	(2) log C_D KASKAS	(3) Difference (1) - (2)	(4) log C_D eq. 1 SF'=0.3	(5) log C_D COLBY SF'=0.3	(6) *logC_D KOMAR SF'=0.3*	(7) Difference (4)-(5)	(8) Difference (4)-(6)
-3	4.3819	4.3825	-.0006	4.4762				
-2	3.3869	3.3875	-.0006	3.4806				
-1	2.4029	2.4032	-.0003	2.4966	2.415	*2.537*	+.082	*-.040*
0	1.4533	1.4533	+.0000	1.5634	1.533	*1.537*	+.030	*+.026*
1	0.6084	0.6091	-.0007	0.8409	0.860		-.019	
2	0.0108	0.0170	-.0062	0.5254	0.461		+.064	
3	-0.2741	-.2592	-.0149	0.4473	0.441		+.006	
4	-0.3740	-.3542	-.0198	0.4289	0.441		-.012	

TABLE 2

Data refer to: KASKAS (1964), COLBY + CHRISTENSEN (1956), KOMAR + REIMERS (1978).

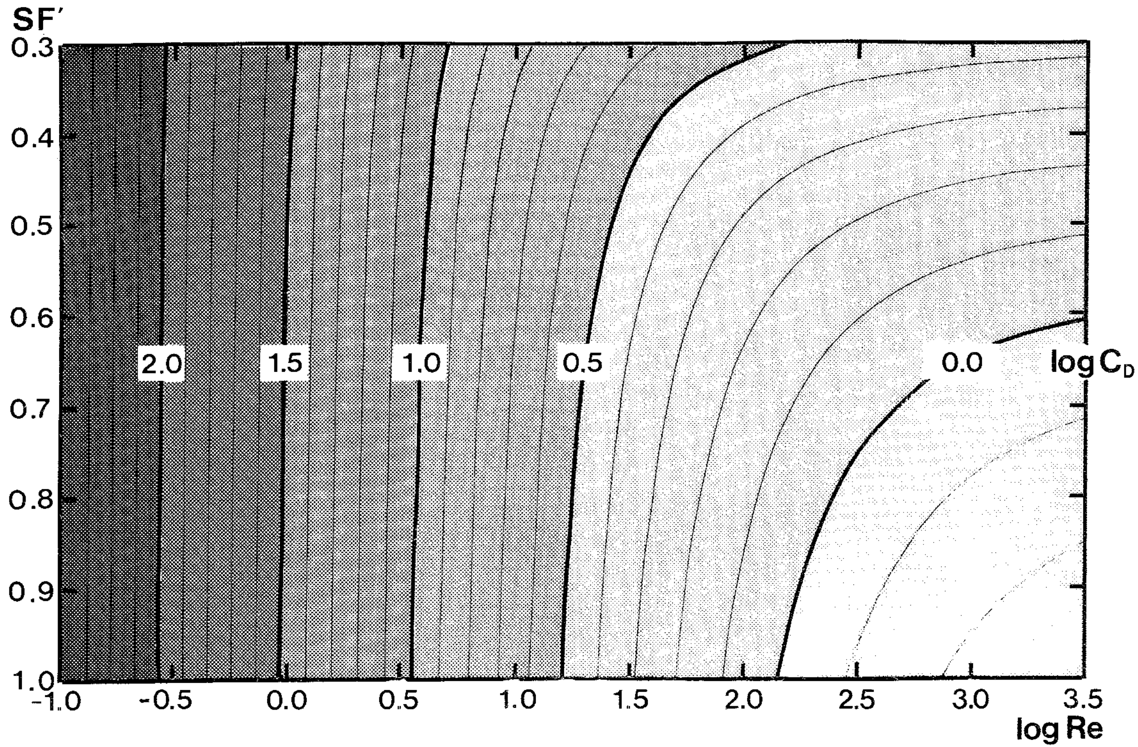

FIG. 4: Contours of drag coefficient ($\log C_D$) in terms of Reynolds number (logRe) and Hydraulic Shape Factor (SF′). Naturally worn sedimenting particles, data calculated from the eq. 1 using parameters of BREZINA (1977)

The drag coefficient values for SF'=1.2 approach very closely those for smooth spheres defined by KASKAS (1964), and even closer experimental data in the range 3 logRe 4. A satisfactory agreement for SF'=0.3 with the data of COLBY and CHRISTENSEN (1957) and with the equation (14) of KOMAR and REIMERS (1978) is evident (Table 2).

While the Corey's Shape Factor is defined by three particle dimensions only, and the experimental data resulted from studies on *naturally worn particles, the smooth spheres have a smaller drag coefficient value than naturally worn irregular particles with SF=1.0 (isometrical particles). This smaller drag coefficient value corresponds to SF'=1.2 from the eq. (1)*. Logically, there is a strong difference between an actually measured SF and the Hydraulic Shape Factor SF' defined by a regression equation (see page 3).

LOGARITHMIC NOTATIONS OF PARTICLE SIZE (PHI) and SETTLING RATE (PSI).

Retaining the geometric grade scale of J.A. UDDEN (1898), W.C. KRUMBEIN (1934) introduced binary logarithm of particle size, PHI (transcription of the greek letter ø), which became popular among geologists because it makes calculations and expressions easy. G.V. MIDDLETON (1967) applied the binary logarithm to settling rate, and defined PSI (transcription of the greek letter ψ):

$$PHI = -\log_2 X_i \quad , \qquad (2a)$$

inversely

$$X_i = 2^{-PHI} \quad ; \qquad (2b)$$

$$PSI = -\log_2 Y_i \quad , \qquad (3a)$$

inversely

$$Y_i = 2^{-PSI} \quad ; \qquad (3b)$$

$\log_2$ is a logarithmus to the base 2 (=binary logarithmus);

X_i is a dimensionless ratio of a given particle size, d_i, in millimeters, to the standard particle size of 1 millimeter, d_o ($=d_i/d_o$) (D.A. McMANUS, 1963; W.C. KRUMBEIN, 1964);

Y_i is a dimensionless ratio of a given settling rate, v_i, in centimeters per second, to the standard settling rate of 1 centimeter per second, v_o ($=v_i/v_o$).

PARTICLE SIZE AND SETTLING RATE EQUATIONS. When rewriting the equation (1), an equation for settling rate v (in centimeters per second) can be expressed:

$$K\, v^{-2} + L\, v^{-1} + M\, v^{-0.5} + C = 0 \quad , \qquad (4)$$

in which

$$K = -2^{-PHI}(R_s - R_f)G/R_f.750 \quad ,$$

$$L = A.n.2^{PHI} \quad ,$$

$$M = B.n^{0.5}.2^{0.5\,PHI} \quad ,$$

R_s is specific gravity of the solid (R_s of quartz is 2.65),

R_f is specific gravity of the fluid; R_f of distilled water varies with temperature; within the temperature range 15°C through 30°C, the following equation has been found satisfactory:

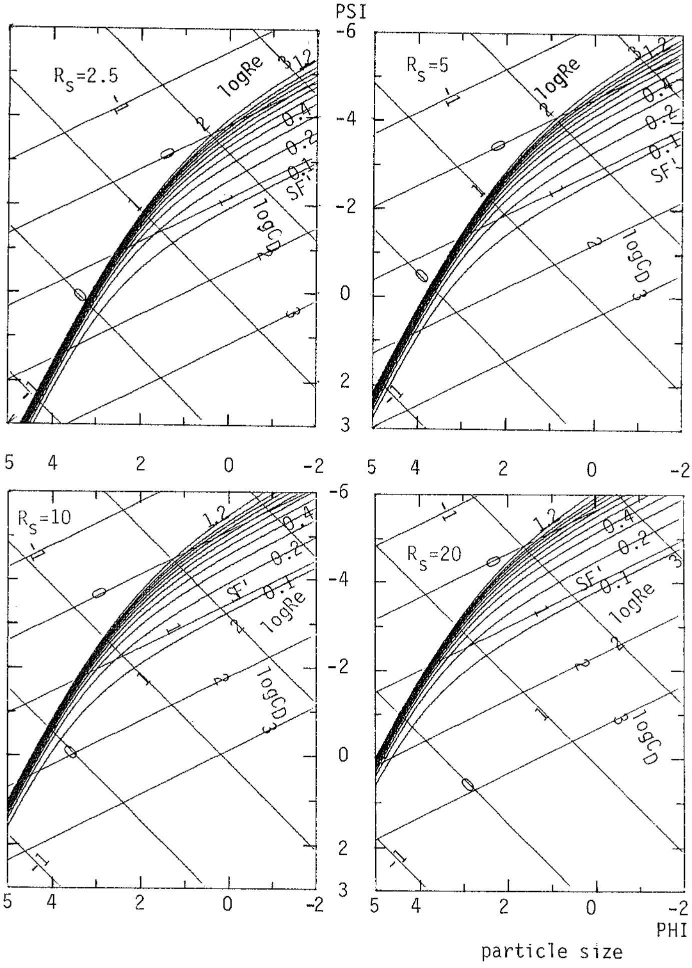

FIG. 5: Influence of particle shape (SF') onto the PSI-settling rate plotted as function of the PHI-nominal diameter; naturally worn irregular particles sedimenting in distilled water 24°C, under gravity acceleration G=981 cm/sec^2; calculated from the eq. (4); four specific gravity values of particles:

a) Rs = 2.5 b) Rs = 5 c) Rs = 10 d) Rs = 20

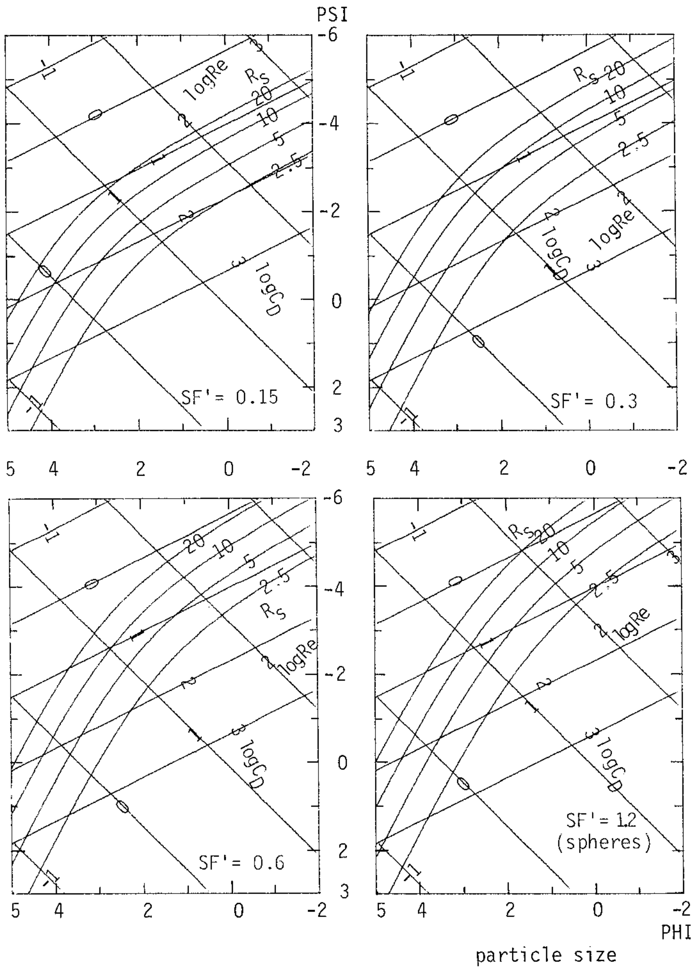

FIG. 6: Influence of specific gravity of particles (Rs = 2.5; 5; 10; 20) onto their PSI-settling rate plotted as function of their PHI-nominal diameter; naturally worn irregular particles sedimenting in distilled water 24°C, under gravity acceleration G=981 cm/sec^2; calculated from the eq. (4); four SF'-shape values of particles:

a) SF'=0.15 b) SF'=0.3 c) SF'=0.6 d) SF'=1.2

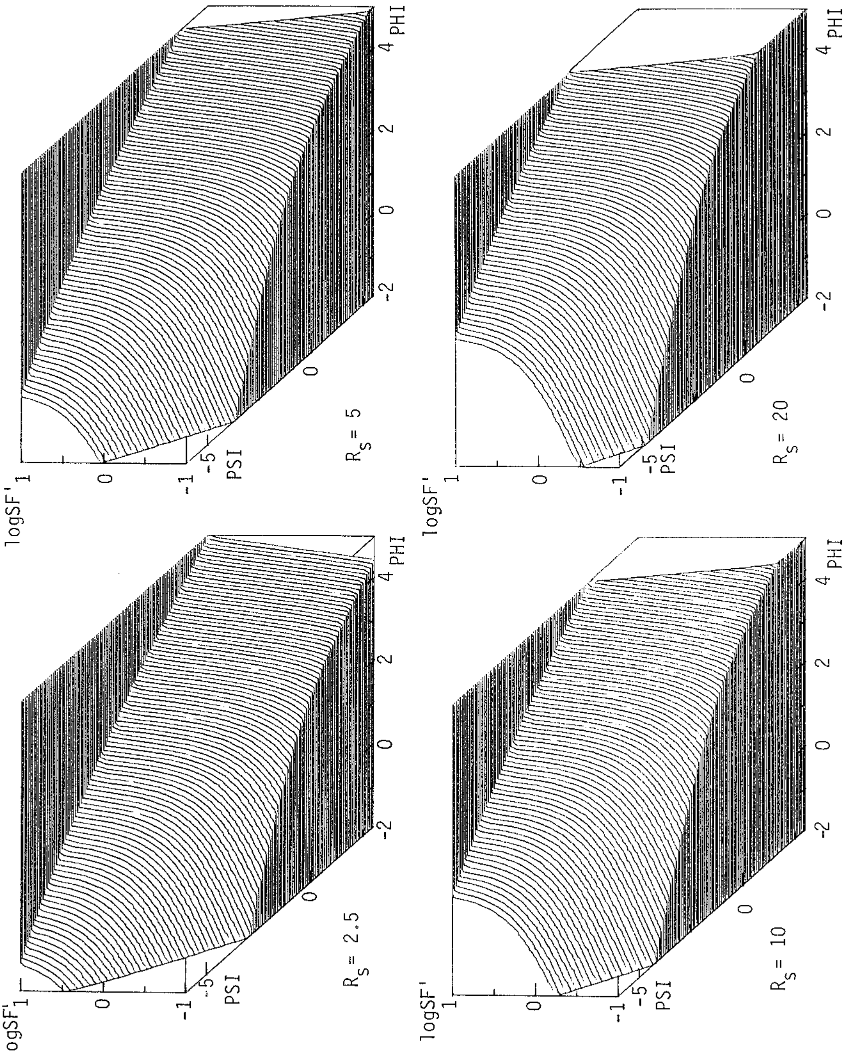

FIG. 7: Hydraulic Shape Factor (log SF') as function of PHI-particle size and PSI-settling rate; naturally worn irregular particles sedimenting in distilled water 24°C under gravity acceleration G=981 cm/sec^2 ; data calculated from the eq. (1):

a) Rs = 2.5 b) Rs = 5 c) Rs = 10 d) Rs = 20

$$R_{fw} = a . t^{b} \quad , \qquad (5)$$

in which

R_{fw} is specific gravity of distilled water under temperature t in centigrades,

a = 1.013176326

b =-0.0049852

n is kinematic viscosity of the fluid in stoke. The following equation for the kinematic viscosity of distilled water, developed by Dr. R. E. Manning of the Cannon Instrument Company (MARVIN, 1979) may be used:

$$n_w = n_{w20} . \exp\left([B_0(t-20) + B_1(t-20)^2] / [B_2 + t] \right) \quad , \qquad (6)$$

in which

n_{w20} is kinematic viscosity of distilled water under 20^{o}C; it is taken 0.010038 stoke; the pertinent literature is evaluated by NAGASHIMA (1977);

B_0 = -2.930861

B_1 = -0.00179426

B_2 = 100.495

exp z is exponential function e^{z}, in which e is the basis of natural logarithms, 2.71828...

G is acceleration due to gravity

The settling rate v can be calculated as a real positive root of the equation (4) by a numerical method; the computer of the Macrogranometer employs the halving method which converges fastest.

The equation (1) can be rewritten into an equation for particle size d (in millimeters):

$$P\,d + R\,d^{-1} + S\,d^{-0.5} + C = 0 \quad , \qquad (7a)$$

in which

$$P = -(R_s - R_f).G.2^{2PSI} / 7.5\,R_f$$

$$R = 10.A.n.2^{PSI}$$

$$S = B.(10n)^{0.5}.2^{0.5\,PSI}$$

The equation (7a) can be formulated for PHI-particle size:

$$P.2^{-PHI} + R.2^{PHI} + S.2^{0.5\,PHI} + C = 0 \qquad (7b)$$

HYDRAULIC SHAPE FACTOR (SF') CALCULATION. From a known particle size and settling rate, the Reynolds' number and drag coefficient are calculated:

$$Re = vd/10n = (2^{-PHI-PSI})/10n \qquad (8a)$$

$$C_D = d(R_s-R_f)G/7.5\,Rf\,v^2 = (2^{2PSI-PHI}).(R_s-R_f)G/7.5\,Rf \qquad (8b)$$

The Re and C_D values are entered into the eq. (1) which can then easily be solved for SF'. This method has been used for construction of the diagrams in FIG. 7, and in the SHAPE program section of the Macrogranometer.

INFLUENCE OF OTHER FACTORS THAN PARTICLE SHAPE ON THE SEDIMENTATIONAL PARTICLE SIZE ANALYSIS

While the particle shape strongly affects the particle size calculated from settling rate, influence of other variables is less important.

STATIC FACTORS. Particle size is calculated *by 0.01 PHI coarser*, if the following terms are effective:

Water kinematic viscosity, n, is lower by -0.0001 stoke
(maximum effect with fine and spherical particles);
caused by: a) temperature is higher by about +0.5°C in average
b) water impurities, particularly due to microorganisms (such as algae), salt, etc.

Water specific gravity, R_f, is lower by about -0.003
(maximum effect with coarse and non-spherical particles);
caused by: a) temperature is higher by about +12°C in average,
b) water impurities, particularly due to salt and clay.

Gravity acceleration, G, is higher by about 1 gal
(maximum effect with non-spherical coarse particles).

Conclusions: a) A strong observance of water cleanliness is recommended;
b) Water temperature should be watched with ±0.25°C accuracy;
c) Gravity acceleration should be known within ±0.25 gal accuracy.

DYNAMIC FACTORS causing water streaming introduce serious errors if a slow sedimentation (fine, light-weight or non-spherical particles) is involved. Two main reasons of streaming are recognized:

a) Temperature influence, such as heating, eg by radiation onto a lower, or cooling, eg by evaporation in an upper part of the settling tube. Instable stratification with a negative temperature gradient as low as -0.01°C/cm in a wide settling tube can cause streaming with a velocity which approaches the settling rate of eg 0.05mm quartz particles (about 0.2 cm/sec). Because the static water temperature influence is by far less important, a *positive temperature gradient within the settling tube is recommended: +0.005 to +0.05°C/cm*.

b) Sedimenting suspension influence from excessive sample size sedimentation. A minimum sample size defined by statistical representativity (BREZINA, 1970) is inevitable. Analyzing large samples in parts (splits) is suitable particularly for coarse material. The Macrogranometer program segments "Split Cumulation" and "Mean" make this technique fast and easy.

MACROGRANOMETER - THE COMPUTERIZED SEDIMENTATION BALANCE

A sedimentation balance for sand-sized particles has been developed (BREZINA, 1969 through 1979). It employs stratified gravity sedimentation above the Stokes' range. The term "stratified sedimentation" involves sample introduction on the top of the sedimentation liquid. The resulting sedimentation distributes the particles so that each level *theoretically* contains those with the same free settling rate. Applications of stratified sedimentation to particle size analysis are commonly referred to as layer (IRANI and CALLIS, 1963) or two-layer (ALLEN, 1968) methods, and correspond to line-start methods (KAYE, 1969). *Practically*, many factors cause that each level of the sedimentation liquid contains particles with a free settling rate which is different from the theoretical and randomly spread. Since these factors are proportional to a local momentaneous particle *concentration*, the extreme concentration at the top of the liquid when the stratified sedimentation begins restricts the layer methods to particles sedimenting with $Re \geq 0.1$ (BREZINA, 1970). The corresponding measuring range of the Macrogranometer varying with particle specific gravity is shown in the FIG. 8 by a shadow area.

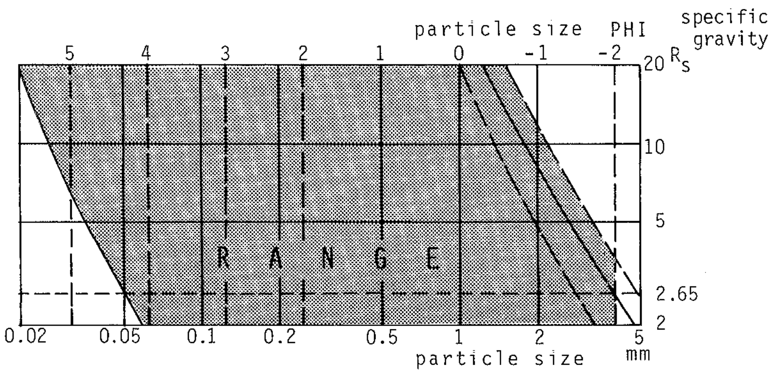

FIG. 8: Particle size measuring range of the Macrogranometer varies with particle specific gravity as indicated by the shadowed area. The upper measuring limit depends also on particle shape,and available sample size for mean split technique (dashed lines).

The hydrodynamically defined maximum concentration of particles restricts also the sample size for each sedimentation analysis (BREZINA, 1970): maximum about 15,000 to 20,000 particles with a quartz specific gravity (2.5 to 2.8), and in a settling tube with about 20 cm inner diameter. Since the particle *number* delimiting the sample size results for the most part from the fine tail of a particle size distribution, the critical particle size refers to that which separates about 10% of the finest particles from the particle size distribution, ie, the 10th percentile of undersize or the 90th percentile of oversize. The above given number of particles for 20cm diameter settling tube meets the requirements of statistical representativity. A diagram for estimating the correct sample weight of quartz sand is shown in FIG. 9. The width of the shaded curve corresponds to weight variation possibilities.

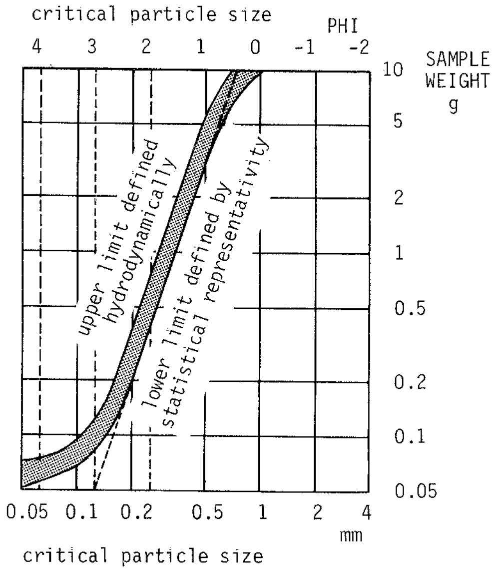

FIG. 9: Diagram for estimating optimum sample weight of quartz sand. Constructed according to the empirical equation of BREZINA (1970, p. 265 - 266), for 20 cm diameter settling tube.

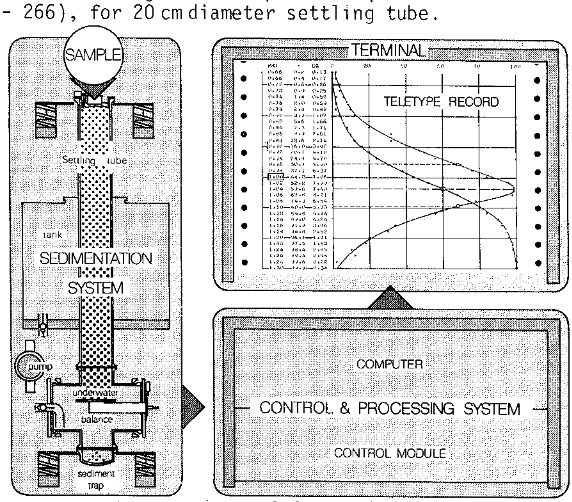

FIG. 10: The Macrogranometer consists of four main parts: Sedimentation System, Electronic (Control) Module, Computer and a Terminal. The Sedimentation System includes a sample introduction device, settling tube, underwater electronic balance and antivibration assembly. The Electronic Module includes an amplifier, control circuitry and interfaces.

The four main parts of the Macrogranometer are shown schematically in FIG. 10. To insure a versatile operation of the Macrogranometer, a *SOFTWARE*, resident in the computer, interprets a system of instructions in terms of a computer - operator dialogue on a terminal, and in terms of signals to the Electronic Module. While the "Standard 1978" Software has been available for the computer series 21MX of Hewlett-Packard, and Alpha LSI-2 and LSI-4 of Computer Automation Inc., the Software "Macrogranometer 1979" has been developed for the 11 computer family of Digital Equipment Corp. (DEC), such as PDP-11 and LSI-11.

The Software 1979 consists of two parts callable from the operation system:
1) "SEDIM", covering a modified Standard 1978 performance, and
2) "SHAPE", performing a Gauss-multicomponental regression (I. CLARK, 1977), and calculation of Hydraulic Shape Factor SF' values to each 0.02 PHI-particle size step from a PHI-non-sedimentational, eg. sieving, analysis, and from a PSI-sedimentation analysis, matched by PSI-inverse distribution function of the PHI-distribution function.

The Software 1979 requires 32kw (=64kByte) memory space. While the Macrogranometer hardware is fully described in BREZINA (1977), its Software 1978 and 1979 facilities are characterized in BREZINA (1978) and (1979) respectively.

CONCLUSIONS

The hydrodynamically specified shape of irregular non-spherical sand-sized particles (equation 1) allows for a closer approach to the nominal diameter (=volume-equivalent sphere diameter) by sedimentation analysis.

Sedimentation analysis of sand-sized material contributes significantly to its characteristics.

A direct sedimentational measuring of particulate distributions with different variables, such as PHI-particle size specified by shape, PSI-settling rate, logRe with specified particle shape, enable new insights into disperse systems in different fields.

TABLES

The following tables are enclosed to this paper:

1) PHI-particle size as function of PSI-settling rate and SF'-Hydraulic Shape: PHI = F(PSI, SF'); gravity acceleration G = 981, particle specific gravity R_s=2.65, distilled water temperature T=24°C. (9 pages)

2) Reynolds' number, drag coefficient, PSI-settling rate, settling time and settling time difference, as function of PHI-particle size with hydraulically defined shape:
[logRe, $\log C_D$, PSI, T/L, dT/L] = F(PHI, SF'); gravity acceleration G = 981, sedimentation length 200cm, particle specific gravity R_s=2.65, distilled water temperature T=24°C;

   a) for Hydraulic Shape Factor SF'=0.6 (7 pages)
   b) for Hydraulic Shape Factor SF'=1.2 (7 pages)

All values of the Tables have been calculated using the equations of this paper.

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NOTATION

A, B, C	Parameters of the polynomial equation (1) defined on the page 5; they appear also in the eq. (4) and (7).
A, B, C, D, E, F a, b, c, d, e, f	Parameters of the general polynomial equation of the TABLE 1, page 4.
a, b	Parameters of the eq. (5), page 13 for specific gravity of distilled water as function of temperature in centigrades.
a, b, c	The minimum, medium and maximum mutually perpendicular dimensions of a particle, defining the Corey's Shape Factor, SF, page 3.
B_0, B_1, B_2	Parameters of the eq. (6), page 13, for kinematic viscosity of distilled water.
d	particle size in millimeters; it refers to the diameter of

	a sphere with volume equivalent to that of an irregular particle, or of the hydraulically equivalent shape-defined ellipsoid (the hydraulic equivalence is discussed on the page 3.
dT/L	settling time difference (in seconds) between particles differing in their size by 0.02 PHI (appears in the Tables of the Appendix).
C_D	drag coefficient defined by the eq. (8b); it corresponds to the German term "Widerstandsbeiwert" indicated by C_W; see page 14.
e	basis of natural logarithms, 2.71828...
exp	exponential function e^z .
G	Gravity acceleration in gal (cm/sec^2); it appears in eq. (4), page 9, eq. (7), page 13, and eq. (8), page 14.
g	gramm
K, L, M	Parameters of the polynomial eqation (4), defined on the p.4.
L	Sedimentation length in centimeters; it appears in the Tables of the Appendix.
$\log_2$	logarithmus to the base 2 (=binary logarithmus), page 9.
n	kinematic viscosity of a fluid in stoke; page 13.
n_w	kinematic viscosity of distilled water; page 13.
n_{w20}	kinematic viscosity of distilled water at 20^oC; page 13
P, R, S	Parameters of the polynomial eq. (7), defined on the page 13.
P_1 through P_6	Parameters of the polynomial eq. (1), defined on the page 3.
PHI, PSI	logarithmic notations of particle size and settling rate respectively, defined on the page 9.
Re	Reynolds' number defined by the eq. (8a), page 14.
R_f	Specific gravity of fluid.
R_{fw}	Specific gravity of distilled water; eq. (5), page 13.
R_s	Specific gravity of solid.
SF	Corey's Shape Factor defined on the page 3 (calculated from *geometrically* measured values).
SF'	Hydraulic Shape Factor defined on the page 3 (calculated by using a regression equation, eg eq. (1) of this paper as described on the page 14, from settling rate and particle size values); it appears in eq. (1), (4) and (7).
t	Temperature in centigrades.
T	Time in seconds - appears in the Tables of the Appendix.
v	particle settling rate in centimeters per second.
X_i, Y_i	Dimensionless ratio of a given particle size, d_i, in millimeters, to the standard particle size of 1 millimeter, d_o, $X_i = d_i/d_o$, and of a given settling rate in centimeters per second, v_i, to the standard settling rate of 1 centimeter per second, v_o, $Y_i = v_i/v_o$, respectively; page 9.

G	L	Rs	SF'	T
981.0	200.	2.65	0.6	24.0

n	PHI	mm	logRe	logC$_D$	PSI	T/L	dT/L
1	-2.00	4.00000	3.08170	0.05746	-4.78454	7.257	
2	-1.98	3.94493	3.07233	0.05813	-4.77342	7.313	0.056
3	-1.96	3.89062	3.06296	0.05881	-4.76229	7.369	0.057
4	-1.94	3.83706	3.05359	0.05950	-4.75115	7.427	0.057
5	-1.92	3.78423	3.04421	0.06019	-4.74000	7.484	0.058
6	-1.90	3.73213	3.03482	0.06090	-4.72882	7.542	0.058
7	-1.88	3.68075	3.02544	0.06161	-4.71764	7.601	0.059
8	-1.86	3.63008	3.01604	0.06234	-4.70644	7.660	0.059
9	-1.84	3.58010	3.00665	0.06307	-4.69522	7.720	0.060
10	-1.82	3.53081	2.99724	0.06381	-4.68399	7.781	0.060
11	-1.80	3.48220	2.98784	0.06456	-4.67274	7.841	0.061
12	-1.78	3.43426	2.97843	0.06532	-4.66147	7.903	0.061
13	-1.76	3.38698	2.96901	0.06610	-4.65019	7.965	0.062
14	-1.74	3.34035	2.95959	0.06688	-4.63890	8.028	0.063
15	-1.72	3.29436	2.95016	0.06767	-4.62758	8.091	0.063
16	-1.70	3.24901	2.94073	0.06847	-4.61625	8.155	0.064
17	-1.68	3.20428	2.93129	0.06928	-4.60490	8.219	0.064
18	-1.66	3.16017	2.92185	0.07010	-4.59354	8.284	0.065
19	-1.64	3.11666	2.91240	0.07094	-4.58215	8.350	0.066
20	-1.62	3.07375	2.90295	0.07178	-4.57075	8.416	0.066
21	-1.60	3.03143	2.89349	0.07264	-4.55933	8.483	0.067
22	-1.58	2.98970	2.88403	0.07350	-4.54789	8.550	0.068
23	-1.56	2.94854	2.87456	0.07438	-4.53644	8.618	0.068
24	-1.54	2.90795	2.86508	0.07527	-4.52496	8.687	0.069
25	-1.52	2.86791	2.85560	0.07617	-4.51346	8.757	0.069
26	-1.50	2.82843	2.84612	0.07708	-4.50195	8.827	0.070
27	-1.48	2.78949	2.83662	0.07800	-4.49041	8.898	0.071
28	-1.46	2.75108	2.82712	0.07894	-4.47886	8.969	0.072
29	-1.44	2.71321	2.81762	0.07989	-4.46728	9.042	0.072
30	-1.42	2.67586	2.80811	0.08085	-4.45569	9.115	0.073
31	-1.40	2.63902	2.79859	0.08183	-4.44407	9.188	0.074
32	-1.38	2.60268	2.78907	0.08281	-4.43243	9.263	0.074
33	-1.36	2.56685	2.77953	0.08381	-4.42077	9.338	0.075
34	-1.34	2.53151	2.77000	0.08482	-4.40909	9.414	0.076
35	-1.32	2.49666	2.76045	0.08585	-4.39738	9.490	0.077
36	-1.30	2.46229	2.75090	0.08689	-4.38565	9.568	0.077
37	-1.28	2.42839	2.74134	0.08795	-4.37390	9.646	0.078
38	-1.26	2.39496	2.73178	0.08901	-4.36213	9.725	0.079
39	-1.24	2.36199	2.72221	0.09010	-4.35033	9.805	0.080
40	-1.22	2.32947	2.71263	0.09119	-4.33851	9.886	0.081
41	-1.20	2.29740	2.70304	0.09230	-4.32666	9.967	0.082
42	-1.18	2.26577	2.69345	0.09343	-4.31479	10.050	0.082
43	-1.16	2.23457	2.68385	0.09457	-4.30290	10.133	0.083
44	-1.14	2.20381	2.67424	0.09573	-4.29098	10.217	0.084
45	-1.12	2.17347	2.66462	0.09690	-4.27903	10.302	0.085
46	-1.10	2.14355	2.65499	0.09809	-4.26706	10.388	0.086
47	-1.08	2.11404	2.64536	0.09929	-4.25506	10.474	0.087
48	-1.06	2.08493	2.63572	0.10051	-4.24303	10.562	0.088
49	-1.04	2.05623	2.62607	0.10175	-4.23098	10.651	0.089
50	-1.02	2.02792	2.61641	0.10300	-4.21889	10.740	0.090

G	L	R_S	SF′	T
981.0	200.	2.65	0.6	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
51	-1.00	2.00000	2.60675	0.10427	-4.20678	10.831	0.091
52	-0.98	1.97247	2.59707	0.10556	-4.19465	10.922	0.092
53	-0.96	1.94531	2.58739	0.10686	-4.18248	11.015	0.093
54	-0.94	1.91853	2.57770	0.10819	-4.17028	11.108	0.094
55	-0.92	1.89212	2.56800	0.10953	-4.15805	11.203	0.095
56	-0.90	1.86607	2.55829	0.11089	-4.14580	11.298	0.096
57	-0.88	1.84038	2.54857	0.11226	-4.13351	11.395	0.097
58	-0.86	1.81504	2.53884	0.11366	-4.12119	11.493	0.098
59	-0.84	1.79005	2.52910	0.11508	-4.10884	11.592	0.099
60	-0.82	1.76541	2.51935	0.11651	-4.09646	11.692	0.100
61	-0.80	1.74110	2.50959	0.11796	-4.08404	11.793	0.101
62	-0.78	1.71713	2.49982	0.11944	-4.07159	11.895	0.102
63	-0.76	1.69349	2.49005	0.12093	-4.05911	11.998	0.103
64	-0.74	1.67018	2.48026	0.12245	-4.04659	12.103	0.105
65	-0.72	1.64718	2.47046	0.12398	-4.03404	12.208	0.106
66	-0.70	1.62450	2.46065	0.12554	-4.02146	12.315	0.107
67	-0.68	1.60214	2.45083	0.12712	-4.00884	12.424	0.108
68	-0.66	1.58008	2.44100	0.12872	-3.99618	12.533	0.109
69	-0.64	1.55833	2.43116	0.13034	-3.98348	12.644	0.111
70	-0.62	1.53688	2.42130	0.13199	-3.97075	12.756	0.112
71	-0.60	1.51572	2.41144	0.13365	-3.95798	12.869	0.113
72	-0.58	1.49485	2.40156	0.13534	-3.94517	12.984	0.115
73	-0.56	1.47427	2.39168	0.13706	-3.93233	13.100	0.116
74	-0.54	1.45397	2.38178	0.13880	-3.91944	13.218	0.118
75	-0.52	1.43396	2.37186	0.14056	-3.90652	13.337	0.119
76	-0.50	1.41421	2.36194	0.14234	-3.89355	13.457	0.120
77	-0.48	1.39474	2.35200	0.14416	-3.88054	13.579	0.122
78	-0.46	1.37554	2.34205	0.14599	-3.86749	13.702	0.123
79	-0.44	1.35660	2.33209	0.14785	-3.85440	13.827	0.125
80	-0.42	1.33793	2.32212	0.14974	-3.84126	13.954	0.126
81	-0.40	1.31951	2.31213	0.15166	-3.82808	14.082	0.128
82	-0.38	1.30134	2.30213	0.15360	-3.81486	14.212	0.130
83	-0.36	1.28343	2.29211	0.15557	-3.80159	14.343	0.131
84	-0.34	1.26576	2.28208	0.15756	-3.78827	14.476	0.133
85	-0.32	1.24833	2.27204	0.15959	-3.77491	14.611	0.135
86	-0.30	1.23114	2.26198	0.16164	-3.76150	14.747	0.136
87	-0.28	1.21419	2.25191	0.16372	-3.74804	14.885	0.138
88	-0.26	1.19748	2.24183	0.16583	-3.73454	15.025	0.140
89	-0.24	1.18099	2.23172	0.16797	-3.72098	15.167	0.142
90	-0.22	1.16473	2.22161	0.17014	-3.70738	15.311	0.144
91	-0.20	1.14870	2.21148	0.17234	-3.69372	15.456	0.146
92	-0.18	1.13288	2.20133	0.17457	-3.68002	15.604	0.148
93	-0.16	1.11729	2.19117	0.17684	-3.66626	15.753	0.150
94	-0.14	1.10191	2.18099	0.17913	-3.65245	15.905	0.152
95	-0.12	1.08673	2.17079	0.18146	-3.63858	16.059	0.154
96	-0.10	1.07177	2.16058	0.18382	-3.62466	16.214	0.156
97	-0.08	1.05702	2.15036	0.18621	-3.61068	16.372	0.158
98	-0.06	1.04247	2.14011	0.18864	-3.59665	16.532	0.160
99	-0.04	1.02811	2.12985	0.19110	-3.58256	16.694	0.162
100	-0.02	1.01396	2.11957	0.19360	-3.56841	16.859	0.165

G	L	R_S	SF′	T
981.0	200.	2.65	0.6	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	d T/L
101	0.00	1.00000	2.10927	0.19613	-3.55421	17.026	0.167
102	0.02	0.98623	2.09896	0.19870	-3.53994	17.195	0.169
103	0.04	0.97265	2.08862	0.20131	-3.52561	17.367	0.172
104	0.06	0.95926	2.07827	0.20395	-3.51123	17.541	0.174
105	0.08	0.94606	2.06790	0.20663	-3.49678	17.717	0.177
106	0.10	0.93303	2.05751	0.20934	-3.48226	17.896	0.179
107	0.12	0.92019	2.04710	0.21210	-3.46769	18.078	0.182
108	0.14	0.90752	2.03668	0.21489	-3.45304	18.262	0.184
109	0.16	0.89503	2.02623	0.21773	-3.43834	18.450	0.187
110	0.18	0.88270	2.01576	0.22060	-3.42356	18.640	0.190
111	0.20	0.87055	2.00527	0.22352	-3.40872	18.832	0.193
112	0.22	0.85857	1.99476	0.22648	-3.39380	19.028	0.196
113	0.24	0.84675	1.98423	0.22948	-3.37882	19.227	0.199
114	0.26	0.83509	1.97368	0.23252	-3.36377	19.428	0.202
115	0.28	0.82359	1.96310	0.23560	-3.34865	19.633	0.205
116	0.30	0.81225	1.95251	0.23873	-3.33345	19.841	0.208
117	0.32	0.80107	1.94189	0.24191	-3.31818	20.052	0.211
118	0.34	0.79004	1.93125	0.24513	-3.30283	20.267	0.214
119	0.36	0.77916	1.92059	0.24839	-3.28741	20.484	0.218
120	0.38	0.76844	1.90990	0.25170	-3.27191	20.706	0.221
121	0.40	0.75786	1.89919	0.25506	-3.25633	20.930	0.225
122	0.42	0.74742	1.88846	0.25847	-3.24067	21.159	0.228
123	0.44	0.73713	1.87770	0.26192	-3.22494	21.391	0.232
124	0.46	0.72699	1.86692	0.26542	-3.20912	21.627	0.236
125	0.48	0.71698	1.85611	0.26898	-3.19322	21.866	0.240
126	0.50	0.70711	1.84528	0.27258	-3.17723	22.110	0.244
127	0.52	0.69737	1.83442	0.27624	-3.16116	22.358	0.248
128	0.54	0.68777	1.82353	0.27994	-3.14500	22.609	0.252
129	0.56	0.67830	1.81262	0.28370	-3.12876	22.865	0.256
130	0.58	0.66896	1.80169	0.28751	-3.11243	23.126	0.260
131	0.60	0.65975	1.79072	0.29138	-3.09601	23.390	0.265
132	0.62	0.65067	1.77973	0.29530	-3.07949	23.660	0.269
133	0.64	0.64171	1.76871	0.29928	-3.06289	23.934	0.274
134	0.66	0.63288	1.75766	0.30331	-3.04619	24.212	0.279
135	0.68	0.62417	1.74659	0.30740	-3.02940	24.496	0.283
136	0.70	0.61557	1.73548	0.31155	-3.01251	24.784	0.288
137	0.72	0.60710	1.72435	0.31575	-2.99552	25.078	0.294
138	0.74	0.59874	1.71319	0.32002	-2.97844	25.376	0.299
139	0.76	0.59050	1.70199	0.32434	-2.96126	25.680	0.304
140	0.78	0.58237	1.69077	0.32873	-2.94397	25.990	0.310
141	0.80	0.57435	1.67952	0.33317	-2.92659	26.305	0.315
142	0.82	0.56644	1.66823	0.33768	-2.90910	26.626	0.321
143	0.84	0.55864	1.65691	0.34225	-2.89151	26.953	0.327
144	0.86	0.55095	1.64557	0.34689	-2.87381	27.285	0.333
145	0.88	0.54337	1.63418	0.35159	-2.85600	27.624	0.339
146	0.90	0.53589	1.62277	0.35636	-2.83808	27.969	0.345
147	0.92	0.52851	1.61132	0.36119	-2.82006	28.321	0.352
148	0.94	0.52123	1.59984	0.36609	-2.80192	28.679	0.358
149	0.96	0.51406	1.58833	0.37105	-2.78367	29.044	0.365
150	0.98	0.50698	1.57678	0.37609	-2.76531	29.416	0.372

G	L	R_S	SF'	T
981.0	200.	2.65	0.6	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
151	1.00	0.50000	1.56520	0.38119	-2.74683	29.796	0.379
152	1.02	0.49312	1.55358	0.38637	-2.72823	30.182	0.387
153	1.04	0.48633	1.54192	0.39161	-2.70952	30.576	0.394
154	1.06	0.47963	1.53023	0.39693	-2.69069	30.978	0.402
155	1.08	0.47303	1.51851	0.40232	-2.67173	31.388	0.410
156	1.10	0.46652	1.50675	0.40779	-2.65266	31.805	0.418
157	1.12	0.46009	1.49495	0.41333	-2.63346	32.231	0.426
158	1.14	0.45376	1.48311	0.41894	-2.61413	32.666	0.435
159	1.16	0.44751	1.47123	0.42463	-2.59468	33.109	0.443
160	1.18	0.44135	1.45932	0.43039	-2.57511	33.562	0.452
161	1.20	0.43528	1.44737	0.43624	-2.55540	34.023	0.462
162	1.22	0.42928	1.43537	0.44216	-2.53557	34.494	0.471
163	1.24	0.42337	1.42334	0.44816	-2.51560	34.975	0.481
164	1.26	0.41754	1.41127	0.45424	-2.49550	35.466	0.491
165	1.28	0.41180	1.39916	0.46040	-2.47527	35.967	0.501
166	1.30	0.40613	1.38701	0.46664	-2.45490	36.478	0.511
167	1.32	0.40053	1.37481	0.47297	-2.43439	37.000	0.522
168	1.34	0.39502	1.36258	0.47938	-2.41375	37.534	0.533
169	1.36	0.38958	1.35030	0.48587	-2.39297	38.078	0.545
170	1.38	0.38422	1.33798	0.49245	-2.37204	38.634	0.556
171	1.40	0.37893	1.32562	0.49911	-2.35098	39.203	0.568
172	1.42	0.37371	1.31322	0.50585	-2.32977	39.783	0.581
173	1.44	0.36857	1.30077	0.51269	-2.30842	40.376	0.593
174	1.46	0.36349	1.28828	0.51961	-2.28692	40.982	0.606
175	1.48	0.35849	1.27574	0.52662	-2.26528	41.602	0.619
176	1.50	0.35355	1.26316	0.53372	-2.24349	42.235	0.633
177	1.52	0.34869	1.25054	0.54091	-2.22155	42.882	0.647
178	1.54	0.34389	1.23787	0.54819	-2.19946	43.544	0.662
179	1.56	0.33915	1.22515	0.55555	-2.17722	44.220	0.676
180	1.58	0.33448	1.21239	0.56301	-2.15483	44.912	0.692
181	1.60	0.32988	1.19958	0.57057	-2.13228	45.619	0.707
182	1.62	0.32534	1.18673	0.57821	-2.10959	46.343	0.723
183	1.64	0.32086	1.17383	0.58595	-2.08673	47.083	0.740
184	1.66	0.31644	1.16088	0.59378	-2.06372	47.840	0.757
185	1.68	0.31208	1.14789	0.60171	-2.04056	48.614	0.774
186	1.70	0.30779	1.13485	0.60973	-2.01723	49.406	0.792
187	1.72	0.30355	1.12176	0.61785	-1.99375	50.217	0.811
188	1.74	0.29937	1.10862	0.62607	-1.97010	51.047	0.830
189	1.76	0.29525	1.09543	0.63438	-1.94630	51.896	0.849
190	1.78	0.29118	1.08220	0.64278	-1.92234	52.765	0.869
191	1.80	0.28717	1.06891	0.65129	-1.89821	53.655	0.890
192	1.82	0.28322	1.05558	0.65989	-1.87392	54.566	0.911
193	1.84	0.27932	1.04220	0.66859	-1.84947	55.499	0.933
194	1.86	0.27548	1.02877	0.67739	-1.82486	56.454	0.955
195	1.88	0.27168	1.01529	0.68629	-1.80008	57.432	0.978
196	1.90	0.26794	1.00176	0.69528	-1.77514	58.433	1.002
197	1.92	0.26425	0.98818	0.70438	-1.75003	59.459	1.026
198	1.94	0.26062	0.97455	0.71358	-1.72475	60.510	1.051
199	1.96	0.25703	0.96087	0.72287	-1.69931	61.587	1.076
200	1.98	0.25349	0.94715	0.73227	-1.67371	62.689	1.103

G	L	R_S	SF'	T
981.0	200.	2.65	0.6	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
201	2.00	0.25000	0.93337	0.74176	-1.64793	63.819	1.130
202	2.02	0.24656	0.91954	0.75136	-1.62199	64.977	1.158
203	2.04	0.24316	0.90566	0.76106	-1.59589	66.164	1.187
204	2.06	0.23982	0.89173	0.77086	-1.56961	67.380	1.216
205	2.08	0.23651	0.87775	0.78076	-1.54317	68.626	1.246
206	2.10	0.23326	0.86372	0.79076	-1.51656	69.904	1.277
207	2.12	0.23005	0.84964	0.80086	-1.48978	71.213	1.310
208	2.14	0.22688	0.83550	0.81106	-1.46284	72.556	1.342
209	2.16	0.22376	0.82132	0.82136	-1.43573	73.932	1.376
210	2.18	0.22068	0.80709	0.83176	-1.40845	75.343	1.411
211	2.20	0.21764	0.79281	0.84227	-1.38100	76.790	1.447
212	2.22	0.21464	0.77847	0.85287	-1.35339	78.274	1.484
213	2.24	0.21169	0.76409	0.86357	-1.32561	79.796	1.522
214	2.26	0.20877	0.74966	0.87438	-1.29767	81.357	1.561
215	2.28	0.20590	0.73518	0.88528	-1.26956	82.957	1.601
216	2.30	0.20306	0.72064	0.89628	-1.24129	84.599	1.642
217	2.32	0.20027	0.70606	0.90738	-1.21285	86.283	1.684
218	2.34	0.19751	0.69143	0.91858	-1.18424	88.011	1.728
219	2.36	0.19479	0.67675	0.92988	-1.15548	89.784	1.773
220	2.38	0.19211	0.66202	0.94128	-1.12655	91.602	1.819
221	2.40	0.18946	0.64724	0.95277	-1.09746	93.468	1.866
222	2.42	0.18686	0.63242	0.96436	-1.06820	95.383	1.915
223	2.44	0.18428	0.61754	0.97605	-1.03879	97.347	1.965
224	2.46	0.18175	0.60262	0.98784	-1.00922	99.363	2.016
225	2.48	0.17924	0.58765	0.99972	-0.97949	101.432	2.069
226	2.50	0.17678	0.57263	1.01169	-0.94960	103.555	2.123
227	2.52	0.17434	0.55757	1.02376	-0.91955	105.735	2.179
228	2.54	0.17194	0.54245	1.03592	-0.88935	107.972	2.237
229	2.56	0.16958	0.52730	1.04818	-0.85899	110.268	2.296
230	2.58	0.16724	0.51209	1.06053	-0.82848	112.624	2.357
231	2.60	0.16494	0.49684	1.07297	-0.79782	115.044	2.419
232	2.62	0.16267	0.48154	1.08550	-0.76701	117.527	2.484
233	2.64	0.16043	0.46620	1.09812	-0.73604	120.077	2.550
234	2.66	0.15822	0.45081	1.11083	-0.70493	122.695	2.618
235	2.68	0.15604	0.43538	1.12363	-0.67367	125.382	2.688
236	2.70	0.15389	0.41991	1.13652	-0.64226	128.142	2.759
237	2.72	0.15177	0.40439	1.14949	-0.61071	130.975	2.833
238	2.74	0.14968	0.38883	1.16256	-0.57901	133.884	2.909
239	2.76	0.14762	0.37322	1.17570	-0.54718	136.872	2.987
240	2.78	0.14559	0.35758	1.18893	-0.51520	139.939	3.068
241	2.80	0.14359	0.34189	1.20225	-0.48308	143.089	3.150
242	2.82	0.14161	0.32616	1.21565	-0.45083	146.325	3.235
243	2.84	0.13966	0.31039	1.22913	-0.41844	149.647	3.322
244	2.86	0.13774	0.29457	1.24269	-0.38591	153.059	3.412
245	2.88	0.13584	0.27872	1.25633	-0.35325	156.563	3.504
246	2.90	0.13397	0.26283	1.27005	-0.32046	160.163	3.599
247	2.92	0.13213	0.24690	1.28385	-0.28754	163.859	3.697
248	2.94	0.13031	0.23093	1.29773	-0.25449	167.656	3.797
249	2.96	0.12851	0.21492	1.31168	-0.22132	171.556	3.900
250	2.98	0.12674	0.19888	1.32571	-0.18802	175.562	4.006

G	L	R_S	SF′	T
981.0	200.	2.65	0.6	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
251	3.00	0.12500	0.18280	1.33981	-0.15459	179.677	4.115
252	3.02	0.12328	0.16668	1.35399	-0.12105	183.904	4.227
253	3.04	0.12158	0.15052	1.36824	-0.08738	188.246	4.342
254	3.06	0.11991	0.13433	1.38256	-0.05360	192.706	4.460
255	3.08	0.11826	0.11811	1.39695	-0.01970	197.288	4.582
256	3.10	0.11663	0.10185	1.41141	0.01432	201.995	4.707
257	3.12	0.11502	0.08555	1.42594	0.04845	206.831	4.836
258	3.14	0.11344	0.06922	1.44053	0.08269	211.799	4.968
259	3.16	0.11188	0.05286	1.45519	0.11705	216.903	5.104
260	3.18	0.11034	0.03647	1.46992	0.15151	222.146	5.243
261	3.20	0.10882	0.02004	1.48471	0.18608	227.533	5.387
262	3.22	0.10732	0.00358	1.49957	0.22075	233.068	5.535
263	3.24	0.10584	-0.01291	1.51448	0.25553	238.755	5.687
264	3.26	0.10439	-0.02943	1.52946	0.29041	244.597	5.843
265	3.28	0.10295	-0.04598	1.54450	0.32539	250.600	6.003
266	3.30	0.10153	-0.06256	1.55960	0.36047	256.768	6.168
267	3.32	0.10013	-0.07917	1.57476	0.39564	263.105	6.337
268	3.34	0.09876	-0.09581	1.58997	0.43091	269.617	6.512
269	3.36	0.09740	-0.11247	1.60524	0.46628	276.308	6.691
270	3.38	0.09605	-0.12917	1.62057	0.50173	283.183	6.875
271	3.40	0.09473	-0.14589	1.63595	0.53728	290.247	7.064
272	3.42	0.09343	-0.16264	1.65139	0.57292	297.506	7.259
273	3.44	0.09214	-0.17941	1.66688	0.60864	304.965	7.459
274	3.46	0.09087	-0.19621	1.68242	0.64446	312.630	7.665
275	3.48	0.08962	-0.21304	1.69801	0.68035	320.506	7.876
276	3.50	0.08839	-0.22989	1.71365	0.71633	328.599	8.093
277	3.52	0.08717	-0.24677	1.72934	0.75239	336.916	8.317
278	3.54	0.08597	-0.26367	1.74507	0.78853	345.463	8.547
279	3.56	0.08479	-0.28059	1.76086	0.82475	354.245	8.783
280	3.58	0.08362	-0.29754	1.77669	0.86104	363.271	9.025
281	3.60	0.08247	-0.31451	1.79257	0.89742	372.545	9.275
282	3.62	0.08133	-0.33150	1.80849	0.93386	382.077	9.531
283	3.64	0.08021	-0.34851	1.82446	0.97038	391.872	9.795
284	3.66	0.07911	-0.36555	1.84047	1.00697	401.938	10.066
285	3.68	0.07802	-0.38261	1.85652	1.04363	412.282	10.345
286	3.70	0.07695	-0.39968	1.87261	1.08036	422.914	10.631
287	3.72	0.07589	-0.41678	1.88874	1.11716	433.839	10.926
288	3.74	0.07484	-0.43390	1.90492	1.15402	445.067	11.228
289	3.76	0.07381	-0.45104	1.92113	1.19095	456.607	11.539
290	3.78	0.07280	-0.46819	1.93738	1.22794	468.466	11.859
291	3.80	0.07179	-0.48537	1.95367	1.26500	480.654	12.188
292	3.82	0.07081	-0.50256	1.97000	1.30211	493.180	12.526
293	3.84	0.06983	-0.51977	1.98636	1.33929	506.054	12.874
294	3.86	0.06887	-0.53700	2.00275	1.37652	519.284	13.231
295	3.88	0.06792	-0.55425	2.01919	1.41382	532.882	13.598
296	3.90	0.06699	-0.57151	2.03565	1.45117	546.858	13.976
297	3.92	0.06606	-0.58879	2.05215	1.48857	561.222	14.364
298	3.94	0.06515	-0.60609	2.06868	1.52603	575.984	14.763
299	3.96	0.06426	-0.62340	2.08525	1.56354	591.157	15.173
300	3.98	0.06337	-0.64073	2.10184	1.60110	606.751	15.594

G	L	R_S	SF'	T
981.0	200.	2.65	0.6	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
301	4.00	0.06250	-0.65807	2.11847	1.63872	622.779	16.028
302	4.02	0.06164	-0.67543	2.13512	1.67638	639.252	16.473
303	4.04	0.06079	-0.69281	2.15181	1.71410	656.183	16.931
304	4.06	0.05995	-0.71019	2.16852	1.75186	673.585	17.402
305	4.08	0.05913	-0.72760	2.18526	1.78967	691.471	17.886
306	4.10	0.05831	-0.74501	2.20203	1.82752	709.855	18.384
307	4.12	0.05751	-0.76244	2.21883	1.86542	728.750	18.895
308	4.14	0.05672	-0.77989	2.23566	1.90337	748.171	19.421
309	4.16	0.05594	-0.79734	2.25251	1.94136	768.133	19.962
310	4.18	0.05517	-0.81481	2.26938	1.97939	788.650	20.517
311	4.20	0.05441	-0.83229	2.28628	2.01746	809.739	21.089
312	4.22	0.05366	-0.84978	2.30321	2.05557	831.415	21.676
313	4.24	0.05292	-0.86729	2.32016	2.09372	853.695	22.280
314	4.26	0.05219	-0.88481	2.33713	2.13191	876.595	22.901
315	4.28	0.05147	-0.90234	2.35412	2.17014	900.134	23.539
316	4.30	0.05077	-0.91988	2.37114	2.20841	924.328	24.195
317	4.32	0.05007	-0.93743	2.38818	2.24671	949.197	24.869
318	4.34	0.04938	-0.95499	2.40524	2.28505	974.760	25.562
319	4.36	0.04870	-0.97256	2.42233	2.32342	1001.035	26.275
320	4.38	0.04803	-0.99014	2.43943	2.36183	1028.042	27.008
321	4.40	0.04737	-1.00774	2.45655	2.40027	1055.803	27.761
322	4.42	0.04671	-1.02534	2.47370	2.43874	1084.338	28.535
323	4.44	0.04607	-1.04295	2.49086	2.47725	1113.670	29.331
324	4.46	0.04544	-1.06057	2.50804	2.51579	1143.820	30.150
325	4.48	0.04481	-1.07820	2.52524	2.55436	1174.811	30.991
326	4.50	0.04419	-1.09584	2.54246	2.59296	1206.667	31.856
327	4.52	0.04359	-1.11349	2.55969	2.63158	1239.412	32.745
328	4.54	0.04299	-1.13115	2.57695	2.67024	1273.071	33.659
329	4.56	0.04239	-1.14882	2.59422	2.70893	1307.670	34.599
330	4.58	0.04181	-1.16649	2.61151	2.74764	1343.235	35.565
331	4.60	0.04123	-1.18417	2.62881	2.78638	1379.794	36.558
332	4.62	0.04067	-1.20186	2.64613	2.82515	1417.373	37.579
333	4.64	0.04011	-1.21956	2.66346	2.86394	1456.002	38.629
334	4.66	0.03955	-1.23727	2.68081	2.90276	1495.711	39.708
335	4.68	0.03901	-1.25498	2.69818	2.94160	1536.529	40.818
336	4.70	0.03847	-1.27270	2.71556	2.98047	1578.487	41.958
337	4.72	0.03794	-1.29043	2.73295	3.01936	1621.618	43.131
338	4.74	0.03742	-1.30817	2.75036	3.05828	1665.955	44.336
339	4.76	0.03691	-1.32591	2.76779	3.09722	1711.530	45.576
340	4.78	0.03640	-1.34366	2.78522	3.13618	1758.380	46.850
341	4.80	0.03590	-1.36141	2.80267	3.17516	1806.540	48.160
342	4.82	0.03540	-1.37917	2.82013	3.21416	1856.046	49.506
343	4.84	0.03492	-1.39694	2.83761	3.25319	1906.937	50.891
344	4.86	0.03443	-1.41472	2.85509	3.29223	1959.251	52.314
345	4.88	0.03396	-1.43250	2.87259	3.33130	2013.028	53.777
346	4.90	0.03349	-1.45028	2.89010	3.37038	2068.310	55.281
347	4.92	0.03303	-1.46808	2.90763	3.40948	2125.137	56.828
348	4.94	0.03258	-1.48587	2.92516	3.44861	2183.555	58.418
349	4.96	0.03213	-1.50368	2.94270	3.48775	2243.607	60.052
350	4.98	0.03169	-1.52148	2.96026	3.52691	2305.340	61.733

G	L	R_S	SF'	T
981.0	200.	2.65	1.2	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
1	-2.00	4.00000	3.26663	-0.31241	-5.39887	4.740	
2	-1.98	3.94493	3.25700	-0.31121	-5.38689	4.780	0.040
3	-1.96	3.89062	3.24737	-0.31000	-5.37488	4.820	0.040
4	-1.94	3.83706	3.23773	-0.30878	-5.36285	4.860	0.040
5	-1.92	3.78423	3.22808	-0.30754	-5.35079	4.901	0.041
6	-1.90	3.73213	3.21842	-0.30629	-5.33871	4.942	0.041
7	-1.88	3.68075	3.20875	-0.30502	-5.32661	4.984	0.042
8	-1.86	3.63008	3.19908	-0.30374	-5.31448	5.026	0.042
9	-1.84	3.58010	3.18940	-0.30245	-5.30233	5.068	0.043
10	-1.82	3.53081	3.17972	-0.30113	-5.29015	5.111	0.043
11	-1.80	3.48220	3.17002	-0.29981	-5.27795	5.155	0.043
12	-1.78	3.43426	3.16032	-0.29847	-5.26572	5.199	0.044
13	-1.76	3.38698	3.15061	-0.29711	-5.25347	5.243	0.044
14	-1.74	3.34035	3.14090	-0.29574	-5.24119	5.288	0.045
15	-1.72	3.29436	3.13117	-0.29435	-5.22888	5.333	0.045
16	-1.70	3.24901	3.12144	-0.29294	-5.21655	5.379	0.046
17	-1.68	3.20428	3.11170	-0.29152	-5.20419	5.425	0.046
18	-1.66	3.16017	3.10195	-0.29009	-5.19180	5.472	0.047
19	-1.64	3.11666	3.09219	-0.28863	-5.17938	5.519	0.047
20	-1.62	3.07375	3.08242	-0.28716	-5.16694	5.567	0.048
21	-1.60	3.03143	3.07265	-0.28567	-5.15447	5.615	0.048
22	-1.58	2.98970	3.06286	-0.28417	-5.14197	5.664	0.049
23	-1.56	2.94854	3.05307	-0.28264	-5.12944	5.714	0.049
24	-1.54	2.90795	3.04327	-0.28110	-5.11688	5.764	0.050
25	-1.52	2.86791	3.03346	-0.27954	-5.10429	5.814	0.051
26	-1.50	2.82843	3.02364	-0.27797	-5.09167	5.865	0.051
27	-1.48	2.78949	3.01381	-0.27637	-5.07902	5.917	0.052
28	-1.46	2.75108	3.00397	-0.27476	-5.06634	5.969	0.052
29	-1.44	2.71321	2.99413	-0.27312	-5.05363	6.022	0.053
30	-1.42	2.67586	2.98427	-0.27147	-5.04088	6.075	0.053
31	-1.40	2.63902	2.97440	-0.26980	-5.02811	6.129	0.054
32	-1.38	2.60268	2.96453	-0.26811	-5.01530	6.184	0.055
33	-1.36	2.56685	2.95464	-0.26640	-5.00246	6.239	0.055
34	-1.34	2.53151	2.94474	-0.26467	-4.98958	6.295	0.056
35	-1.32	2.49666	2.93484	-0.26292	-4.97667	6.352	0.057
36	-1.30	2.46229	2.92492	-0.26115	-4.96373	6.409	0.057
37	-1.28	2.42839	2.91499	-0.25935	-4.95075	6.467	0.058
38	-1.26	2.39496	2.90506	-0.25754	-4.93774	6.526	0.059
39	-1.24	2.36199	2.89511	-0.25570	-4.92469	6.585	0.059
40	-1.22	2.32947	2.88515	-0.25385	-4.91161	6.645	0.060
41	-1.20	2.29740	2.87518	-0.25197	-4.89849	6.706	0.061
42	-1.18	2.26577	2.86520	-0.25007	-4.88533	6.767	0.061
43	-1.16	2.23457	2.85520	-0.24815	-4.87214	6.829	0.062
44	-1.14	2.20381	2.84520	-0.24620	-4.85891	6.892	0.063
45	-1.12	2.17347	2.83519	-0.24423	-4.84564	6.956	0.064
46	-1.10	2.14355	2.82516	-0.24224	-4.83233	7.020	0.064
47	-1.08	2.11404	2.81512	-0.24023	-4.81898	7.086	0.065
48	-1.06	2.08493	2.80507	-0.23819	-4.80560	7.152	0.066
49	-1.04	2.05623	2.79501	-0.23612	-4.79217	7.218	0.067
50	-1.02	2.02792	2.78493	-0.23404	-4.77870	7.286	0.068

G	L	R_S	SF′	T
981.0	200.	2.65	1.2	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
51	-1.00	2.00000	2.77485	-0.23192	-4.76520	7.355	0.069
52	-0.98	1.97247	2.76475	-0.22979	-4.75165	7.424	0.069
53	-0.96	1.94531	2.75464	-0.22763	-4.73805	7.494	0.070
54	-0.94	1.91853	2.74451	-0.22544	-4.72442	7.565	0.071
55	-0.92	1.89212	2.73437	-0.22322	-4.71074	7.638	0.072
56	-0.90	1.86607	2.72422	-0.22098	-4.69702	7.711	0.073
57	-0.88	1.84038	2.71406	-0.21872	-4.68326	7.784	0.074
58	-0.86	1.81504	2.70388	-0.21642	-4.66945	7.859	0.075
59	-0.84	1.79005	2.69369	-0.21410	-4.65560	7.935	0.076
60	-0.82	1.76541	2.68348	-0.21176	-4.64170	8.012	0.077
61	-0.80	1.74110	2.67326	-0.20938	-4.62775	8.090	0.078
62	-0.78	1.71713	2.66303	-0.20698	-4.61376	8.169	0.079
63	-0.76	1.69349	2.65278	-0.20454	-4.59972	8.249	0.080
64	-0.74	1.67018	2.64252	-0.20208	-4.58563	8.329	0.081
65	-0.72	1.64718	2.63225	-0.19959	-4.57149	8.412	0.082
66	-0.70	1.62450	2.62196	-0.19707	-4.55730	8.495	0.083
67	-0.68	1.60214	2.61165	-0.19452	-4.54307	8.579	0.084
68	-0.66	1.58008	2.60133	-0.19194	-4.52878	8.664	0.085
69	-0.64	1.55833	2.59099	-0.18933	-4.51444	8.751	0.087
70	-0.62	1.53688	2.58064	-0.18669	-4.50006	8.838	0.088
71	-0.60	1.51572	2.57027	-0.18401	-4.48561	8.927	0.089
72	-0.58	1.49485	2.55989	-0.18131	-4.47112	9.018	0.090
73	-0.56	1.47427	2.54949	-0.17857	-4.45657	9.109	0.091
74	-0.54	1.45397	2.53907	-0.17580	-4.44197	9.202	0.093
75	-0.52	1.43396	2.52864	-0.17300	-4.42732	9.296	0.094
76	-0.50	1.41421	2.51819	-0.17016	-4.41260	9.391	0.095
77	-0.48	1.39474	2.50772	-0.16729	-4.39784	9.487	0.097
78	-0.46	1.37554	2.49724	-0.16438	-4.38301	9.585	0.098
79	-0.44	1.35660	2.48674	-0.16145	-4.36813	9.685	0.099
80	-0.42	1.33793	2.47622	-0.15847	-4.35319	9.786	0.101
81	-0.40	1.31951	2.46569	-0.15546	-4.33819	9.888	0.102
82	-0.38	1.30134	2.45513	-0.15242	-4.32314	9.992	0.104
83	-0.36	1.28343	2.44456	-0.14934	-4.30802	10.097	0.105
84	-0.34	1.26576	2.43397	-0.14622	-4.29284	10.204	0.107
85	-0.32	1.24833	2.42336	-0.14306	-4.27760	10.312	0.108
86	-0.30	1.23114	2.41274	-0.13987	-4.26229	10.422	0.110
87	-0.28	1.21419	2.40209	-0.13664	-4.24693	10.534	0.112
88	-0.26	1.19748	2.39143	-0.13337	-4.23150	10.647	0.113
89	-0.24	1.18099	2.38074	-0.13006	-4.21600	10.762	0.115
90	-0.22	1.16473	2.37004	-0.12671	-4.20044	10.879	0.117
91	-0.20	1.14870	2.35931	-0.12333	-4.18482	10.997	0.118
92	-0.18	1.13288	2.34857	-0.11990	-4.16913	11.117	0.120
93	-0.16	1.11729	2.33780	-0.11643	-4.15337	11.239	0.122
94	-0.14	1.10191	2.32702	-0.11292	-4.13754	11.363	0.124
95	-0.12	1.08673	2.31621	-0.10937	-4.12164	11.489	0.126
96	-0.10	1.07177	2.30538	-0.10578	-4.10567	11.617	0.128
97	-0.08	1.05702	2.29453	-0.10214	-4.08963	11.747	0.130
98	-0.06	1.04247	2.28366	-0.09847	-4.07352	11.879	0.132
99	-0.04	1.02811	2.27277	-0.09474	-4.05734	12.013	0.134
100	-0.02	1.01396	2.26186	-0.09098	-4.04109	12.149	0.136

G	L	R_S	SF′	T
981.0	200.	2.65	1.2	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
101	0.00	1.00000	2.25092	-0.08717	-4.02476	12.287	0.138
102	0.02	0.98623	2.23996	-0.08331	-4.00835	12.428	0.141
103	0.04	0.97265	2.22898	-0.07941	-3.99187	12.571	0.143
104	0.06	0.95926	2.21798	-0.07546	-3.97532	12.716	0.145
105	0.08	0.94606	2.20695	-0.07147	-3.95868	12.863	0.147
106	0.10	0.93303	2.19590	-0.06743	-3.94197	13.013	0.150
107	0.12	0.92019	2.18482	-0.06334	-3.92518	13.165	0.152
108	0.14	0.90752	2.17372	-0.05920	-3.90831	13.320	0.155
109	0.16	0.89503	2.16260	-0.05502	-3.89136	13.478	0.157
110	0.18	0.88270	2.15145	-0.05078	-3.87433	13.638	0.160
111	0.20	0.87055	2.14028	-0.04650	-3.85721	13.800	0.163
112	0.22	0.85857	2.12908	-0.04217	-3.84001	13.966	0.166
113	0.24	0.84675	2.11786	-0.03778	-3.82273	14.134	0.168
114	0.26	0.83509	2.10661	-0.03334	-3.80536	14.305	0.171
115	0.28	0.82359	2.09533	-0.02886	-3.78790	14.480	0.174
116	0.30	0.81225	2.08403	-0.02431	-3.77036	14.657	0.177
117	0.32	0.80107	2.07271	-0.01972	-3.75273	14.837	0.180
118	0.34	0.79004	2.06135	-0.01507	-3.73501	15.020	0.183
119	0.36	0.77916	2.04997	-0.01037	-3.71721	15.207	0.187
120	0.38	0.76844	2.03856	-0.00562	-3.69931	15.397	0.190
121	0.40	0.75786	2.02712	-0.00081	-3.68132	15.590	0.193
122	0.42	0.74742	2.01566	0.00406	-3.66323	15.787	0.197
123	0.44	0.73713	2.00417	0.00898	-3.64506	15.987	0.200
124	0.46	0.72699	1.99265	0.01396	-3.62679	16.190	0.204
125	0.48	0.71698	1.98110	0.01900	-3.60842	16.398	0.207
126	0.50	0.70711	1.96952	0.02409	-3.58996	16.609	0.211
127	0.52	0.69737	1.95791	0.02925	-3.57140	16.824	0.215
128	0.54	0.68777	1.94628	0.03446	-3.55274	17.043	0.219
129	0.56	0.67830	1.93461	0.03973	-3.53399	17.266	0.223
130	0.58	0.66896	1.92291	0.04506	-3.51513	17.493	0.227
131	0.60	0.65975	1.91118	0.05046	-3.49617	17.725	0.231
132	0.62	0.65067	1.89943	0.05591	-3.47711	17.960	0.236
133	0.64	0.64171	1.88764	0.06143	-3.45795	18.200	0.240
134	0.66	0.63288	1.87582	0.06700	-3.43869	18.445	0.245
135	0.68	0.62417	1.86397	0.07265	-3.41932	18.694	0.249
136	0.70	0.61557	1.85208	0.07835	-3.39984	18.949	0.254
137	0.72	0.60710	1.84017	0.08412	-3.38026	19.208	0.259
138	0.74	0.59874	1.82822	0.08995	-3.36057	19.471	0.264
139	0.76	0.59050	1.81624	0.09585	-3.34077	19.740	0.269
140	0.78	0.58237	1.80423	0.10182	-3.32086	20.015	0.274
141	0.80	0.57435	1.79218	0.10785	-3.30085	20.294	0.280
142	0.82	0.56644	1.78010	0.11395	-3.28072	20.580	0.285
143	0.84	0.55864	1.76799	0.12011	-3.26048	20.870	0.291
144	0.86	0.55095	1.75584	0.12634	-3.24012	21.167	0.297
145	0.88	0.54337	1.74366	0.13265	-3.21966	21.469	0.302
146	0.90	0.53589	1.73144	0.13902	-3.19907	21.778	0.308
147	0.92	0.52851	1.71919	0.14546	-3.17838	22.092	0.315
148	0.94	0.52123	1.70690	0.15197	-3.15756	22.413	0.321
149	0.96	0.51406	1.69458	0.15855	-3.13663	22.741	0.328
150	0.98	0.50698	1.68222	0.16520	-3.11558	23.075	0.334

G	L	R_S	SF′	T
981.0	200.	2.65	1.2	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
151	1.00	0.50000	1.66983	0.17193	-3.09441	23.416	0.341
152	1.02	0.49312	1.65740	0.17872	-3.07312	23.764	0.348
153	1.04	0.48633	1.64494	0.18559	-3.05171	24.120	0.355
154	1.06	0.47963	1.63243	0.19254	-3.03018	24.482	0.363
155	1.08	0.47303	1.61989	0.19955	-3.00853	24.853	0.370
156	1.10	0.46652	1.60732	0.20664	-2.98675	25.231	0.378
157	1.12	0.46009	1.59470	0.21381	-2.96485	25.617	0.386
158	1.14	0.45376	1.58205	0.22105	-2.94283	26.011	0.394
159	1.16	0.44751	1.56937	0.22836	-2.92067	26.413	0.402
160	1.18	0.44135	1.55664	0.23575	-2.89840	26.824	0.411
161	1.20	0.43528	1.54387	0.24322	-2.87599	27.244	0.420
162	1.22	0.42928	1.53107	0.25077	-2.85346	27.673	0.429
163	1.24	0.42337	1.51823	0.25839	-2.83080	28.111	0.438
164	1.26	0.41754	1.50535	0.26609	-2.80801	28.558	0.448
165	1.28	0.41180	1.49243	0.27387	-2.78509	29.016	0.457
166	1.30	0.40613	1.47947	0.28173	-2.76204	29.483	0.467
167	1.32	0.40053	1.46647	0.28966	-2.73886	29.961	0.478
168	1.34	0.39502	1.45343	0.29768	-2.71554	30.449	0.488
169	1.36	0.38958	1.44035	0.30577	-2.69210	30.948	0.499
170	1.38	0.38422	1.42723	0.31395	-2.66852	31.458	0.510
171	1.40	0.37893	1.41407	0.32221	-2.64481	31.979	0.521
172	1.42	0.37371	1.40087	0.33054	-2.62096	32.512	0.533
173	1.44	0.36857	1.38763	0.33896	-2.59698	33.057	0.545
174	1.46	0.36349	1.37435	0.34746	-2.57286	33.614	0.557
175	1.48	0.35849	1.36103	0.35604	-2.54861	34.184	0.570
176	1.50	0.35355	1.34767	0.36470	-2.52422	34.767	0.583
177	1.52	0.34869	1.33427	0.37345	-2.49970	35.363	0.596
178	1.54	0.34389	1.32082	0.38227	-2.47503	35.973	0.610
179	1.56	0.33915	1.30734	0.39118	-2.45023	36.596	0.624
180	1.58	0.33448	1.29381	0.40018	-2.42530	37.234	0.638
181	1.60	0.32988	1.28024	0.40925	-2.40022	37.887	0.653
182	1.62	0.32534	1.26663	0.41841	-2.37501	38.555	0.668
183	1.64	0.32086	1.25298	0.42766	-2.34966	39.239	0.684
184	1.66	0.31644	1.23928	0.43698	-2.32416	39.938	0.699
185	1.68	0.31208	1.22555	0.44639	-2.29853	40.654	0.716
186	1.70	0.30779	1.21177	0.45589	-2.27276	41.387	0.733
187	1.72	0.30355	1.19795	0.46547	-2.24685	42.137	0.750
188	1.74	0.29937	1.18409	0.47513	-2.22080	42.904	0.768
189	1.76	0.29525	1.17018	0.48488	-2.19462	43.690	0.786
190	1.78	0.29118	1.15624	0.49471	-2.16829	44.495	0.805
191	1.80	0.28717	1.14225	0.50462	-2.14182	45.319	0.824
192	1.82	0.28322	1.12822	0.51462	-2.11521	46.162	0.844
193	1.84	0.27932	1.11414	0.52471	-2.08846	47.026	0.864
194	1.86	0.27548	1.10003	0.53488	-2.06157	47.911	0.885
195	1.88	0.27168	1.08587	0.54513	-2.03454	48.817	0.906
196	1.90	0.26794	1.07167	0.55547	-2.00737	49.745	0.928
197	1.92	0.26425	1.05743	0.56589	-1.98006	50.696	0.951
198	1.94	0.26062	1.04314	0.57639	-1.95261	51.670	0.974
199	1.96	0.25703	1.02882	0.58698	-1.92502	52.667	0.998
200	1.98	0.25349	1.01445	0.59766	-1.89729	53.690	1.022

G	L	R_S	SF′	T
981.0	200.	2.65	1.2	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
201	2.00	0.25000	1.00004	0.60842	-1.86942	54.737	1.047
202	2.02	0.24656	0.98559	0.61926	-1.84141	55.810	1.073
203	2.04	0.24316	0.97110	0.63018	-1.81327	56.909	1.100
204	2.06	0.23982	0.95656	0.64119	-1.78498	58.036	1.127
205	2.08	0.23651	0.94198	0.65228	-1.75656	59.191	1.155
206	2.10	0.23326	0.92737	0.66346	-1.72800	60.374	1.183
207	2.12	0.23005	0.91271	0.67472	-1.69930	61.587	1.213
208	2.14	0.22688	0.89800	0.68606	-1.67046	62.830	1.243
209	2.16	0.22376	0.88326	0.69748	-1.64149	64.105	1.275
210	2.18	0.22068	0.86848	0.70898	-1.61238	65.412	1.307
211	2.20	0.21764	0.85366	0.72057	-1.58314	66.751	1.339
212	2.22	0.21464	0.83879	0.73223	-1.55376	68.124	1.373
213	2.24	0.21169	0.82389	0.74398	-1.52425	69.532	1.408
214	2.26	0.20877	0.80894	0.75581	-1.49460	70.976	1.444
215	2.28	0.20590	0.79396	0.76772	-1.46482	72.456	1.480
216	2.30	0.20306	0.77893	0.77971	-1.43491	73.974	1.518
217	2.32	0.20027	0.76387	0.79178	-1.40486	75.531	1.557
218	2.34	0.19751	0.74876	0.80393	-1.37469	77.127	1.597
219	2.36	0.19479	0.73362	0.81615	-1.34438	78.765	1.637
220	2.38	0.19211	0.71843	0.82846	-1.31394	80.444	1.679
221	2.40	0.18946	0.70321	0.84084	-1.28337	82.167	1.723
222	2.42	0.18686	0.68795	0.85330	-1.25268	83.934	1.767
223	2.44	0.18428	0.67265	0.86583	-1.22186	85.746	1.813
224	2.46	0.18175	0.65731	0.87845	-1.19091	87.606	1.859
225	2.48	0.17924	0.64194	0.89114	-1.15983	89.513	1.907
226	2.50	0.17678	0.62653	0.90390	-1.12863	91.470	1.957
227	2.52	0.17434	0.61108	0.91674	-1.09731	93.478	2.008
228	2.54	0.17194	0.59559	0.92965	-1.06586	95.538	2.060
229	2.56	0.16958	0.58006	0.94264	-1.03429	97.652	2.114
230	2.58	0.16724	0.56450	0.95570	-1.00259	99.820	2.169
231	2.60	0.16494	0.54891	0.96883	-0.97078	102.046	2.226
232	2.62	0.16267	0.53327	0.98204	-0.93885	104.330	2.284
233	2.64	0.16043	0.51760	0.99531	-0.90680	106.674	2.344
234	2.66	0.15822	0.50190	1.00866	-0.87463	109.079	2.405
235	2.68	0.15604	0.48616	1.02208	-0.84234	111.547	2.469
236	2.70	0.15389	0.47039	1.03556	-0.80994	114.081	2.534
237	2.72	0.15177	0.45458	1.04912	-0.77743	116.681	2.600
238	2.74	0.14968	0.43873	1.06274	-0.74480	119.350	2.669
239	2.76	0.14762	0.42286	1.07644	-0.71205	122.090	2.740
240	2.78	0.14559	0.40695	1.09020	-0.67920	124.902	2.812
241	2.80	0.14359	0.39100	1.10402	-0.64624	127.789	2.887
242	2.82	0.14161	0.37503	1.11791	-0.61317	130.752	2.963
243	2.84	0.13966	0.35902	1.13187	-0.57998	133.794	3.042
244	2.86	0.13774	0.34298	1.14589	-0.54670	136.917	3.123
245	2.88	0.13584	0.32690	1.15997	-0.51330	140.123	3.206
246	2.90	0.13397	0.31080	1.17412	-0.47980	143.415	3.292
247	2.92	0.13213	0.29466	1.18833	-0.44620	146.795	3.380
248	2.94	0.13031	0.27850	1.20260	-0.41250	150.264	3.470
249	2.96	0.12851	0.26230	1.21694	-0.37869	153.827	3.563
250	2.98	0.12674	0.24607	1.23133	-0.34478	157.485	3.658

G	L	R_S	SF'	T
981.0	200.	2.65	1.2	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	dT/L
251	3.00	0.12500	0.22981	1.24578	-0.31078	161.241	3.756
252	3.02	0.12328	0.21353	1.26029	-0.27668	165.098	3.857
253	3.04	0.12158	0.19721	1.27486	-0.24248	169.059	3.961
254	3.06	0.11991	0.18087	1.28949	-0.20818	173.126	4.067
255	3.08	0.11826	0.16449	1.30417	-0.17379	177.302	4.176
256	3.10	0.11663	0.14809	1.31891	-0.13931	181.591	4.289
257	3.12	0.11502	0.13166	1.33371	-0.10473	185.996	4.405
258	3.14	0.11344	0.11521	1.34856	-0.07006	190.519	4.523
259	3.16	0.11188	0.09872	1.36347	-0.03531	195.165	4.646
260	3.18	0.11034	0.08221	1.37843	-0.00046	199.936	4.771
261	3.20	0.10882	0.06568	1.39344	0.03447	204.836	4.900
262	3.22	0.10732	0.04911	1.40850	0.06949	209.869	5.033
263	3.24	0.10584	0.03253	1.42361	0.10459	215.038	5.169
264	3.26	0.10439	0.01591	1.43878	0.13978	220.348	5.309
265	3.28	0.10295	-0.00073	1.45399	0.17505	225.801	5.454
266	3.30	0.10153	-0.01739	1.46926	0.21041	231.403	5.602
267	3.32	0.10013	-0.03408	1.48457	0.24584	237.157	5.754
268	3.34	0.09876	-0.05079	1.49993	0.28136	243.067	5.910
269	3.36	0.09740	-0.06752	1.51534	0.31695	249.139	6.071
270	3.38	0.09605	-0.08428	1.53079	0.35262	255.375	6.237
271	3.40	0.09473	-0.10106	1.54630	0.38836	261.782	6.407
272	3.42	0.09343	-0.11787	1.56184	0.42418	268.363	6.581
273	3.44	0.09214	-0.13469	1.57743	0.46008	275.124	6.761
274	3.46	0.09087	-0.15154	1.59307	0.49605	282.069	6.945
275	3.48	0.08962	-0.16841	1.60874	0.53209	289.204	7.135
276	3.50	0.08839	-0.18530	1.62446	0.56820	296.534	7.330
277	3.52	0.08717	-0.20221	1.64023	0.60438	304.065	7.531
278	3.54	0.08597	-0.21914	1.65603	0.64063	311.802	7.737
279	3.56	0.08479	-0.23610	1.67187	0.67695	319.750	7.949
280	3.58	0.08362	-0.25307	1.68776	0.71333	327.917	8.166
281	3.60	0.08247	-0.27006	1.70368	0.74978	336.307	8.390
282	3.62	0.08133	-0.28708	1.71964	0.78629	344.927	8.620
283	3.64	0.08021	-0.30411	1.73565	0.82287	353.784	8.857
284	3.66	0.07911	-0.32116	1.75168	0.85951	362.884	9.100
285	3.68	0.07802	-0.33823	1.76776	0.89621	372.234	9.350
286	3.70	0.07695	-0.35531	1.78387	0.93297	381.841	9.607
287	3.72	0.07589	-0.37242	1.80002	0.96979	391.712	9.871
288	3.74	0.07484	-0.38954	1.81620	1.00667	401.855	10.143
289	3.76	0.07381	-0.40668	1.83242	1.04361	412.276	10.422
290	3.78	0.07280	-0.42384	1.84868	1.08061	422.985	10.709
291	3.80	0.07179	-0.44101	1.86496	1.11766	433.989	11.004
292	3.82	0.07081	-0.45820	1.88128	1.15476	445.295	11.307
293	3.84	0.06983	-0.47541	1.89763	1.19192	456.914	11.618
294	3.86	0.06887	-0.49263	1.91402	1.22913	468.853	11.939
295	3.88	0.06792	-0.50987	1.93043	1.26640	481.121	12.268
296	3.90	0.06699	-0.52712	1.94688	1.30372	493.728	12.607
297	3.92	0.06606	-0.54439	1.96335	1.34108	506.683	12.955
298	3.94	0.06515	-0.56168	1.97986	1.37850	519.995	13.313
299	3.96	0.06426	-0.57898	1.99640	1.41596	533.676	13.681
300	3.98	0.06337	-0.59629	2.01296	1.45348	547.735	14.059

G	L	R_S	SF'	T
981.0	200.	2.65	1.2	24.0

n	PHI	mm	logRe	$\log C_D$	PSI	T/L	d T/L
301	4.00	0.06250	-0.61362	2.02955	1.49104	562.182	14.447
302	4.02	0.06164	-0.63096	2.04617	1.52864	577.029	14.847
303	4.04	0.06079	-0.64831	2.06282	1.56630	592.287	15.258
304	4.06	0.05995	-0.66568	2.07950	1.60399	607.967	15.680
305	4.08	0.05913	-0.68306	2.09620	1.64173	624.081	16.114
306	4.10	0.05831	-0.70046	2.11293	1.67952	640.641	16.560
307	4.12	0.05751	-0.71787	2.12968	1.71734	657.661	17.019
308	4.14	0.05672	-0.73529	2.14646	1.75521	675.151	17.491
309	4.16	0.05594	-0.75272	2.16326	1.79312	693.127	17.976
310	4.18	0.05517	-0.77016	2.18009	1.83107	711.601	18.474
311	4.20	0.05441	-0.78762	2.19694	1.86906	730.588	18.987
312	4.22	0.05366	-0.80509	2.21381	1.90708	750.101	19.513
313	4.24	0.05292	-0.82257	2.23071	1.94515	770.156	20.055
314	4.26	0.05219	-0.84006	2.24763	1.98325	790.767	20.611
315	4.28	0.05147	-0.85756	2.26457	2.02139	811.951	21.184
316	4.30	0.05077	-0.87507	2.28153	2.05957	833.723	21.772
317	4.32	0.05007	-0.89259	2.29852	2.09778	856.100	22.377
318	4.34	0.04938	-0.91013	2.31552	2.13602	879.098	22.999
319	4.36	0.04870	-0.92767	2.33255	2.17430	902.736	23.638
320	4.38	0.04803	-0.94523	2.34960	2.21262	927.031	24.295
321	4.40	0.04737	-0.96279	2.36666	2.25096	952.002	24.971
322	4.42	0.04671	-0.98036	2.38375	2.28934	977.667	25.665
323	4.44	0.04607	-0.99795	2.40085	2.32775	1004.046	26.379
324	4.46	0.04544	-1.01554	2.41798	2.36619	1031.159	27.113
325	4.48	0.04481	-1.03314	2.43512	2.40467	1059.026	27.867
326	4.50	0.04419	-1.05075	2.45228	2.44317	1087.669	28.643
327	4.52	0.04359	-1.06837	2.46946	2.48170	1117.110	29.441
328	4.54	0.04299	-1.08600	2.48665	2.52026	1147.371	30.261
329	4.56	0.04239	-1.10364	2.50386	2.55885	1178.474	31.103
330	4.58	0.04181	-1.12128	2.52109	2.59746	1210.444	31.970
331	4.60	0.04123	-1.13894	2.53834	2.63611	1243.304	32.861
332	4.62	0.04067	-1.15660	2.55560	2.67478	1277.081	33.776
333	4.64	0.04011	-1.17427	2.57287	2.71347	1311.798	34.718
334	4.66	0.03955	-1.19194	2.59017	2.75220	1347.484	35.686
335	4.68	0.03901	-1.20963	2.60747	2.79094	1384.165	36.681
336	4.70	0.03847	-1.22732	2.62480	2.82972	1421.868	37.704
337	4.72	0.03794	-1.24502	2.64213	2.86851	1460.624	38.755
338	4.74	0.03742	-1.26273	2.65949	2.90733	1500.460	39.836
339	4.76	0.03691	-1.28044	2.67685	2.94618	1541.408	40.948
340	4.78	0.03640	-1.29816	2.69423	2.98504	1583.499	42.091
341	4.80	0.03590	-1.31589	2.71162	3.02393	1626.764	43.265
342	4.82	0.03540	-1.33362	2.72903	3.06284	1671.237	44.473
343	4.84	0.03492	-1.35136	2.74645	3.10178	1716.952	45.715
344	4.86	0.03443	-1.36911	2.76388	3.14073	1763.943	46.991
345	4.88	0.03396	-1.38686	2.78133	3.17971	1812.246	48.303
346	4.90	0.03349	-1.40462	2.79878	3.21870	1861.898	49.652
347	4.92	0.03303	-1.42239	2.81625	3.25772	1912.939	51.039
348	4.94	0.03258	-1.44016	2.83373	3.29675	1965.403	52.465
349	4.96	0.03213	-1.45794	2.85123	3.33581	2019.334	53.931
350	4.98	0.03169	-1.47572	2.86873	3.37488	2074.772	55.438

G	Rs	T
981.0	2.65	24.0

PSI/SF	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-5.00	-1.1065	-1.3562	-1.5929	-1.9198	-2.1329	-2.3924	-2.7149	-3.1271	-3.6776	-4.4747	-5.8613
-4.98	-1.0777	-1.3252	-1.5600	-1.8851	-2.0971	-2.3557	-2.6773	-3.0886	-3.6384	-4.4350	-5.8214
-4.96	-1.0491	-1.2942	-1.5273	-1.8504	-2.0614	-2.3189	-2.6396	-3.0501	-3.5993	-4.3954	-5.7815
-4.94	-1.0206	-1.2635	-1.4947	-1.8158	-2.0257	-2.2823	-2.6020	-3.0116	-3.5602	-4.3558	-5.7416
-4.92	-0.9922	-1.2328	-1.4623	-1.7813	-1.9902	-2.2457	-2.5645	-2.9732	-3.5211	-4.3162	-5.7017
-4.90	-0.9639	-1.2023	-1.4299	-1.7469	-1.9547	-2.2092	-2.5270	-2.9349	-3.4820	-4.2765	-5.6618
-4.88	-0.9358	-1.1719	-1.3977	-1.7126	-1.9194	-2.1728	-2.4896	-2.8966	-3.4429	-4.2369	-5.6218
-4.86	-0.9078	-1.1416	-1.3656	-1.6784	-1.8841	-2.1365	-2.4522	-2.8583	-3.4039	-4.1974	-5.5819
-4.84	-0.8800	-1.1115	-1.3336	-1.6443	-1.8489	-2.1002	-2.4149	-2.8200	-3.3648	-4.1578	-5.5420
-4.82	-0.8523	-1.0815	-1.3017	-1.6103	-1.8138	-2.0640	-2.3776	-2.7818	-3.3258	-4.1182	-5.5021
-4.80	-0.8247	-1.0517	-1.2700	-1.5765	-1.7788	-2.0279	-2.3404	-2.7436	-3.2869	-4.0786	-5.4622
-4.78	-0.7972	-1.0219	-1.2384	-1.5427	-1.7439	-1.9918	-2.3033	-2.7055	-3.2479	-4.0391	-5.4223
-4.76	-0.7699	-0.9923	-1.2069	-1.5091	-1.7091	-1.9559	-2.2662	-2.6674	-3.2090	-3.9996	-5.3824
-4.74	-0.7427	-0.9629	-1.1756	-1.4755	-1.6744	-1.9200	-2.2292	-2.6294	-3.1701	-3.9600	-5.3425
-4.72	-0.7156	-0.9335	-1.1443	-1.4421	-1.6398	-1.8842	-2.1923	-2.5914	-3.1312	-3.9205	-5.3027
-4.70	-0.6887	-0.9043	-1.1132	-1.4088	-1.6054	-1.8485	-2.1554	-2.5535	-3.0924	-3.8810	-5.2628
-4.68	-0.6619	-0.8753	-1.0823	-1.3756	-1.5710	-1.8129	-2.1186	-2.5156	-3.0536	-3.8415	-5.2229
-4.66	-0.6352	-0.8464	-1.0515	-1.3426	-1.5367	-1.7774	-2.0819	-2.4777	-3.0148	-3.8020	-5.1830
-4.64	-0.6086	-0.8176	-1.0208	-1.3096	-1.5025	-1.7420	-2.0452	-2.4399	-2.9760	-3.7626	-5.1431
-4.62	-0.5822	-0.7889	-0.9902	-1.2768	-1.4684	-1.7066	-2.0086	-2.4022	-2.9373	-3.7231	-5.1032
-4.60	-0.5559	-0.7604	-0.9598	-1.2441	-1.4345	-1.6714	-1.9721	-2.3645	-2.8986	-3.6837	-5.0634
-4.58	-0.5298	-0.7320	-0.9295	-1.2115	-1.4006	-1.6362	-1.9356	-2.3268	-2.8599	-3.6442	-5.0235
-4.56	-0.5038	-0.7038	-0.8993	-1.1791	-1.3669	-1.6012	-1.8993	-2.2892	-2.8213	-3.6048	-4.9836
-4.54	-0.4779	-0.6757	-0.8693	-1.1467	-1.3333	-1.5662	-1.8630	-2.2517	-2.7827	-3.5654	-4.9438
-4.52	-0.4521	-0.6477	-0.8395	-1.1145	-1.2998	-1.5314	-1.8268	-2.2142	-2.7441	-3.5260	-4.9039
-4.50	-0.4265	-0.6199	-0.8097	-1.0825	-1.2664	-1.4966	-1.7907	-2.1768	-2.7056	-3.4867	-4.8641
-4.48	-0.4010	-0.5922	-0.7801	-1.0505	-1.2332	-1.4620	-1.7546	-2.1395	-2.6671	-3.4473	-4.8242
-4.46	-0.3756	-0.5647	-0.7507	-1.0187	-1.2000	-1.4274	-1.7187	-2.1022	-2.6286	-3.4080	-4.7843
-4.44	-0.3504	-0.5373	-0.7214	-0.9870	-1.1670	-1.3930	-1.6828	-2.0649	-2.5902	-3.3687	-4.7445
-4.42	-0.3253	-0.5100	-0.6922	-0.9555	-1.1341	-1.3587	-1.6470	-2.0278	-2.5518	-3.3294	-4.7047
-4.40	-0.3003	-0.4829	-0.6632	-0.9241	-1.1014	-1.3245	-1.6114	-1.9906	-2.5135	-3.2901	-4.6648
-4.38	-0.2755	-0.4559	-0.6343	-0.8928	-1.0687	-1.2904	-1.5758	-1.9536	-2.4752	-3.2508	-4.6250
-4.36	-0.2507	-0.4291	-0.6055	-0.8617	-1.0362	-1.2564	-1.5403	-1.9166	-2.4369	-3.2116	-4.5852
-4.34	-0.2261	-0.4024	-0.5770	-0.8307	-1.0038	-1.2225	-1.5048	-1.8797	-2.3987	-3.1723	-4.5453
-4.32	-0.2017	-0.3758	-0.5485	-0.7999	-0.9716	-1.1888	-1.4695	-1.8429	-2.3605	-3.1331	-4.5055
-4.30	-0.1773	-0.3494	-0.5202	-0.7692	-0.9395	-1.1551	-1.4343	-1.8062	-2.3224	-3.0939	-4.4657
-4.28	-0.1531	-0.3231	-0.4920	-0.7386	-0.9075	-1.1216	-1.3992	-1.7695	-2.2843	-3.0547	-4.4259
-4.26	-0.1290	-0.2970	-0.4640	-0.7082	-0.8756	-1.0882	-1.3642	-1.7329	-2.2462	-3.0156	-4.3861
-4.24	-0.1051	-0.2710	-0.4362	-0.6779	-0.8439	-1.0550	-1.3293	-1.6963	-2.2082	-2.9765	-4.3463
-4.22	-0.0812	-0.2451	-0.4084	-0.6478	-0.8124	-1.0218	-1.2945	-1.6599	-2.1703	-2.9374	-4.3065
-4.20	-0.0575	-0.2194	-0.3809	-0.6178	-0.7809	-0.9888	-1.2598	-1.6235	-2.1324	-2.8983	-4.2667

G	Rs	T
981.0	2.65	24.0

PSI/SF	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-4.20	-0.0575	-0.2194	-0.3809	-0.6178	-0.7809	-0.9883	-1.2598	-1.6235	-2.1324	-2.8963	-4.2667
-4.18	-0.0339	-0.1938	-0.3534	-0.5879	-0.7497	-0.9559	-1.2252	-1.5872	-2.0946	-2.8592	-4.2269
-4.16	-0.0105	-0.1684	-0.3261	-0.5582	-0.7185	-0.9232	-1.1908	-1.5510	-2.0568	-2.8202	-4.1871
-4.14	0.0129	-0.1431	-0.2990	-0.5287	-0.6875	-0.8906	-1.1564	-1.5149	-2.0190	-2.7812	-4.1473
-4.12	0.0361	-0.1179	-0.2720	-0.4993	-0.6566	-0.8581	-1.1222	-1.4789	-1.9814	-2.7422	-4.1075
-4.10	0.0592	-0.0929	-0.2452	-0.4700	-0.6259	-0.8257	-1.0880	-1.4429	-1.9437	-2.7032	-4.0678
-4.08	0.0821	-0.0680	-0.2185	-0.4410	-0.5954	-0.7935	-1.0540	-1.4071	-1.9062	-2.6643	-4.0280
-4.06	0.1050	-0.0433	-0.1919	-0.4120	-0.5650	-0.7614	-1.0201	-1.3713	-1.8687	-2.6254	-3.9883
-4.04	0.1277	-0.0187	-0.1656	-0.3832	-0.5347	-0.7295	-0.9864	-1.3357	-1.8312	-2.5865	-3.9485
-4.02	0.1503	0.0058	-0.1393	-0.3546	-0.5046	-0.6977	-0.9527	-1.3001	-1.7938	-2.5477	-3.9088
-4.00	0.1728	0.0301	-0.1132	-0.3261	-0.4746	-0.6660	-0.9192	-1.2646	-1.7565	-2.5088	-3.8690
-3.98	0.1952	0.0544	-0.0872	-0.2978	-0.4448	-0.6345	-0.8853	-1.2293	-1.7193	-2.4700	-3.8293
-3.96	0.2174	0.0784	-0.0614	-0.2696	-0.4151	-0.6032	-0.8526	-1.1940	-1.6821	-2.4313	-3.7896
-3.94	0.2396	0.1024	-0.0358	-0.2416	-0.3856	-0.5719	-0.8194	-1.1589	-1.6450	-2.3926	-3.7499
-3.92	0.2616	0.1262	-0.0103	-0.2137	-0.3562	-0.5409	-0.7864	-1.1238	-1.6079	-2.3539	-3.7102
-3.90	0.2835	0.1498	0.0151	-0.1860	-0.3271	-0.5099	-0.7536	-1.0889	-1.5710	-2.3152	-3.6705
-3.88	0.3053	0.1733	0.0403	-0.1584	-0.2980	-0.4792	-0.7208	-1.0540	-1.5341	-2.2766	-3.6308
-3.86	0.3269	0.1967	0.0654	-0.1310	-0.2691	-0.4486	-0.6882	-1.0193	-1.4972	-2.2380	-3.5911
-3.84	0.3485	0.2200	0.0903	-0.1038	-0.2404	-0.4181	-0.6558	-0.9847	-1.4605	-2.1995	-3.5514
-3.82	0.3699	0.2431	0.1151	-0.0767	-0.2118	-0.3878	-0.6235	-0.9502	-1.4238	-2.1609	-3.5118
-3.80	0.3913	0.2662	0.1398	-0.0497	-0.1834	-0.3576	-0.5913	-0.9159	-1.3872	-2.1225	-3.4721
-3.78	0.4125	0.2890	0.1643	-0.0230	-0.1551	-0.3276	-0.5593	-0.8816	-1.3507	-2.0840	-3.4325
-3.76	0.4336	0.3118	0.1886	0.0037	-0.1270	-0.2978	-0.5274	-0.8475	-1.3143	-2.0457	-3.3928
-3.74	0.4546	0.3344	0.2128	0.0301	-0.0991	-0.2681	-0.4957	-0.8135	-1.2780	-2.0073	-3.3532
-3.72	0.4755	0.3569	0.2369	0.0564	-0.0713	-0.2386	-0.4641	-0.7796	-1.2417	-1.9690	-3.3136
-3.70	0.4963	0.3792	0.2608	0.0826	-0.0437	-0.2092	-0.4327	-0.7458	-1.2056	-1.9307	-3.2740
-3.68	0.5169	0.4015	0.2846	0.1086	-0.0163	-0.1800	-0.4014	-0.7122	-1.1695	-1.8925	-3.2344
-3.66	0.5375	0.4236	0.3082	0.1344	0.0110	-0.1509	-0.3703	-0.6787	-1.1336	-1.8544	-3.1948
-3.64	0.5579	0.4455	0.3317	0.1601	0.0382	-0.1220	-0.3393	-0.6454	-1.0977	-1.8163	-3.1552
-3.62	0.5783	0.4674	0.3551	0.1857	0.0651	-0.0933	-0.3085	-0.6121	-1.0619	-1.7782	-3.1156
-3.60	0.5985	0.4891	0.3783	0.2110	0.0920	-0.0648	-0.2779	-0.5791	-1.0263	-1.7402	-3.0761
-3.58	0.6187	0.5107	0.4014	0.2362	0.1186	-0.0364	-0.2474	-0.5461	-0.9907	-1.7022	-3.0365
-3.56	0.6387	0.5322	0.4243	0.2613	0.1451	-0.0081	-0.2170	-0.5133	-0.9552	-1.6643	-2.9970
-3.54	0.6587	0.5536	0.4472	0.2862	0.1714	0.0199	-0.1868	-0.4807	-0.9199	-1.6264	-2.9575
-3.52	0.6785	0.5748	0.4698	0.3110	0.1976	0.0478	-0.1568	-0.4482	-0.8846	-1.5887	-2.9180
-3.50	0.6982	0.5960	0.4924	0.3356	0.2236	0.0755	-0.1270	-0.4158	-0.8495	-1.5509	-2.8785
-3.48	0.7178	0.6170	0.5148	0.3600	0.2494	0.1031	-0.0973	-0.3836	-0.8144	-1.5132	-2.8390
-3.46	0.7374	0.6379	0.5370	0.3843	0.2751	0.1305	-0.0678	-0.3515	-0.7795	-1.4756	-2.7996
-3.44	0.7568	0.6586	0.5592	0.4085	0.3006	0.1577	-0.0384	-0.3196	-0.7447	-1.4381	-2.7601
-3.42	0.7761	0.6793	0.5812	0.4325	0.3260	0.1848	-0.0092	-0.2878	-0.7101	-1.4006	-2.7207
-3.40	0.7954	0.6998	0.6030	0.4563	0.3512	0.2117	0.0198	-0.2562	-0.6755	-1.3632	-2.6813

G	Rs	T
981.0	2.65	24.0

PSI/SF	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-3.40	0.7954	0.6998	0.6030	0.4563	0.3512	0.2117	0.0198	-0.2562	-0.6755	-1.3632	-2.6813
-3.38	0.8145	0.7203	0.6248	0.4800	0.3762	0.2384	0.0486	-0.2248	-0.6411	-1.3258	-2.6419
-3.36	0.8336	0.7406	0.6464	0.5036	0.4011	0.2650	0.0773	-0.1935	-0.6068	-1.2885	-2.6025
-3.34	0.8525	0.7608	0.6679	0.5270	0.4259	0.2914	0.1058	-0.1624	-0.5726	-1.2513	-2.5632
-3.32	0.8714	0.7809	0.6892	0.5502	0.4504	0.3176	0.1341	-0.1314	-0.5386	-1.2142	-2.5238
-3.30	0.8901	0.8008	0.7104	0.5733	0.4748	0.3437	0.1623	-0.1006	-0.5047	-1.1771	-2.4845
-3.28	0.9088	0.8207	0.7316	0.5963	0.4991	0.3696	0.1903	-0.0700	-0.4709	-1.1401	-2.4452
-3.26	0.9274	0.8405	0.7525	0.6191	0.5231	0.3953	0.2181	-0.0395	-0.4373	-1.1032	-2.4059
-3.24	0.9459	0.8601	0.7734	0.6417	0.5471	0.4209	0.2458	-0.0092	-0.4038	-1.0664	-2.3667
-3.22	0.9643	0.8797	0.7941	0.6643	0.5709	0.4463	0.2732	0.0209	-0.3704	-1.0297	-2.3274
-3.20	0.9826	0.8991	0.8147	0.6866	0.5945	0.4715	0.3006	0.0509	-0.3372	-0.9930	-2.2882
-3.18	1.0008	0.9184	0.8352	0.7089	0.6180	0.4965	0.3277	0.0807	-0.3041	-0.9565	-2.2490
-3.16	1.0190	0.9377	0.8556	0.7310	0.6413	0.5214	0.3546	0.1103	-0.2712	-0.9200	-2.2098
-3.14	1.0370	0.9568	0.8758	0.7529	0.6644	0.5462	0.3814	0.1398	-0.2384	-0.8836	-2.1707
-3.12	1.0550	0.9758	0.8959	0.7747	0.6875	0.5707	0.4080	0.1690	-0.2058	-0.8473	-2.1315
-3.10	1.0728	0.9947	0.9159	0.7964	0.7103	0.5951	0.4345	0.1981	-0.1733	-0.8111	-2.0924
-3.08	1.0906	1.0136	0.9358	0.8180	0.7330	0.6194	0.4607	0.2271	-0.1410	-0.7751	-2.0534
-3.06	1.1083	1.0323	0.9556	0.8394	0.7556	0.6435	0.4868	0.2558	-0.1089	-0.7391	-2.0143
-3.04	1.1260	1.0509	0.9753	0.8606	0.7780	0.6674	0.5127	0.2844	-0.0769	-0.7032	-1.9753
-3.02	1.1435	1.0694	0.9948	0.8818	0.8003	0.6911	0.5384	0.3127	-0.0451	-0.6674	-1.9363
-3.00	1.1610	1.0878	1.0143	0.9028	0.8224	0.7147	0.5640	0.3410	-0.0134	-0.6317	-1.8973
-2.98	1.1784	1.1062	1.0336	0.9236	0.8444	0.7382	0.5894	0.3690	0.0181	-0.5962	-1.8584
-2.96	1.1957	1.1244	1.0528	0.9444	0.8662	0.7615	0.6146	0.3968	0.0494	-0.5607	-1.8195
-2.94	1.2129	1.1426	1.0719	0.9650	0.8879	0.7846	0.6397	0.4245	0.0806	-0.5254	-1.7806
-2.92	1.2300	1.1606	1.0909	0.9855	0.9095	0.8075	0.6645	0.4520	0.1116	-0.4902	-1.7418
-2.90	1.2471	1.1786	1.1098	1.0058	0.9309	0.8304	0.6892	0.4793	0.1424	-0.4551	-1.7030
-2.88	1.2641	1.1964	1.1286	1.0261	0.9522	0.8530	0.7138	0.5064	0.1731	-0.4201	-1.6642
-2.86	1.2810	1.2142	1.1473	1.0462	0.9733	0.8755	0.7381	0.5334	0.2035	-0.3852	-1.6255
-2.84	1.2979	1.2319	1.1659	1.0661	0.9943	0.8979	0.7623	0.5601	0.2338	-0.3505	-1.5868
-2.82	1.3146	1.2495	1.1844	1.0860	1.0151	0.9201	0.7864	0.5867	0.2640	-0.3159	-1.5482
-2.80	1.3313	1.2670	1.2027	1.1057	1.0359	0.9421	0.8102	0.6131	0.2939	-0.2814	-1.5096
-2.78	1.3480	1.2844	1.2210	1.1253	1.0565	0.9640	0.8339	0.6393	0.3237	-0.2471	-1.4710
-2.76	1.3645	1.3018	1.2392	1.1448	1.0769	0.9858	0.8575	0.6654	0.3532	-0.2129	-1.4325
-2.74	1.3810	1.3190	1.2573	1.1642	1.0972	1.0074	0.8808	0.6912	0.3826	-0.1789	-1.3940
-2.72	1.3974	1.3362	1.2752	1.1835	1.1174	1.0288	0.9040	0.7169	0.4118	-0.1450	-1.3556
-2.70	1.4137	1.3533	1.2931	1.2026	1.1375	1.0501	0.9271	0.7424	0.4409	-0.1112	-1.3172
-2.68	1.4300	1.3703	1.3109	1.2216	1.1574	1.0713	0.9499	0.7677	0.4697	-0.0776	-1.2788
-2.66	1.4462	1.3872	1.3286	1.2405	1.1773	1.0923	0.9726	0.7928	0.4984	-0.0441	-1.2405
-2.64	1.4623	1.4040	1.3462	1.2593	1.1969	1.1132	0.9952	0.8178	0.5268	-0.0108	-1.2023
-2.62	1.4784	1.4208	1.3637	1.2780	1.2165	1.1339	1.0176	0.8426	0.5551	0.0224	-1.1641
-2.60	1.4944	1.4375	1.3811	1.2966	1.2359	1.1545	1.0338	0.8672	0.5832	0.0554	-1.1260

G	R_S	T
981.0	2.65	24.0

PSI/SP	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-2.60	1.4944	1.4375	1.3811	1.2966	1.2359	1.1545	1.0398	0.8672	0.5832	0.0554	-1.1260
-2.58	1.5103	1.4541	1.3985	1.3151	1.2553	1.1750	1.0619	0.8916	0.6111	0.0882	-1.0879
-2.56	1.5262	1.4706	1.4157	1.3335	1.2745	1.1953	1.0838	0.9158	0.6388	0.1209	-1.0499
-2.54	1.5420	1.4871	1.4328	1.3517	1.2935	1.2155	1.1056	0.9399	0.6663	0.1534	-1.0119
-2.52	1.5577	1.5034	1.4499	1.3699	1.3125	1.2356	1.1272	0.9638	0.6937	0.1858	-0.9740
-2.50	1.5734	1.5198	1.4669	1.3879	1.3313	1.2555	1.1487	0.9875	0.7208	0.2180	-0.9362
-2.48	1.5890	1.5360	1.4838	1.4058	1.3501	1.2753	1.1700	1.0111	0.7478	0.2500	-0.8984
-2.46	1.6046	1.5521	1.5006	1.4237	1.3687	1.2950	1.1912	1.0344	0.7745	0.2818	-0.8607
-2.44	1.6201	1.5682	1.5173	1.4414	1.3872	1.3145	1.2122	1.0576	0.8011	0.3135	-0.8231
-2.42	1.6355	1.5842	1.5339	1.4591	1.4056	1.3340	1.2330	1.0807	0.8275	0.3450	-0.7855
-2.40	1.6509	1.6002	1.5505	1.4766	1.4239	1.3532	1.2538	1.1035	0.8537	0.3763	-0.7480
-2.38	1.6662	1.6160	1.5670	1.4941	1.4420	1.3724	1.2743	1.1262	0.8797	0.4074	-0.7106
-2.36	1.6815	1.6319	1.5834	1.5114	1.4601	1.3915	1.2948	1.1488	0.9055	0.4384	-0.6733
-2.34	1.6967	1.6476	1.5997	1.5287	1.4780	1.4104	1.3151	1.1711	0.9311	0.4692	-0.6360
-2.32	1.7118	1.6633	1.6159	1.5458	1.4959	1.4292	1.3352	1.1933	0.9565	0.4998	-0.5989
-2.30	1.7269	1.6789	1.6321	1.5629	1.5136	1.4478	1.3553	1.2154	0.9818	0.5302	-0.5618
-2.28	1.7419	1.6944	1.6482	1.5799	1.5313	1.4664	1.3751	1.2373	1.0068	0.5604	-0.5248
-2.26	1.7569	1.7099	1.6642	1.5968	1.5488	1.4849	1.3949	1.2590	1.0317	0.5904	-0.4878
-2.24	1.7718	1.7253	1.6801	1.6136	1.5663	1.5032	1.4145	1.2805	1.0564	0.6202	-0.4510
-2.22	1.7867	1.7406	1.6960	1.6303	1.5836	1.5214	1.4340	1.3019	1.0809	0.6499	-0.4143
-2.20	1.8015	1.7559	1.7118	1.6469	1.6009	1.5395	1.4533	1.3232	1.1052	0.6793	-0.3776
-2.18	1.8162	1.7711	1.7275	1.6634	1.6180	1.5575	1.4726	1.3443	1.1293	0.7086	-0.3411
-2.16	1.8309	1.7863	1.7432	1.6799	1.6351	1.5754	1.4916	1.3652	1.1533	0.7376	-0.3046
-2.14	1.8456	1.8014	1.7587	1.6962	1.6520	1.5932	1.5106	1.3860	1.1770	0.7665	-0.2683
-2.12	1.8602	1.8164	1.7743	1.7125	1.6689	1.6108	1.5294	1.4066	1.2006	0.7951	-0.2321
-2.10	1.8747	1.8314	1.7897	1.7287	1.6856	1.6284	1.5482	1.4271	1.2240	0.8236	-0.1959
-2.08	1.8892	1.8463	1.8051	1.7448	1.7023	1.6459	1.5668	1.4474	1.2472	0.8519	-0.1599
-2.06	1.9037	1.8612	1.8204	1.7609	1.7189	1.6632	1.5852	1.4676	1.2702	0.8799	-0.1240
-2.04	1.9181	1.8760	1.8356	1.7768	1.7354	1.6805	1.6036	1.4877	1.2931	0.9078	-0.0882
-2.02	1.9324	1.8907	1.8508	1.7927	1.7518	1.6976	1.6218	1.5076	1.3158	0.9355	-0.0526
-2.00	1.9467	1.9054	1.8659	1.8085	1.7682	1.7147	1.6399	1.5273	1.3383	0.9629	-0.0170
-1.98	1.9610	1.9200	1.8810	1.8242	1.7844	1.7316	1.6579	1.5470	1.3607	0.9902	0.0184
-1.96	1.9752	1.9346	1.8960	1.8399	1.8006	1.7485	1.6758	1.5664	1.3828	1.0173	0.0537
-1.94	1.9894	1.9492	1.9109	1.8555	1.8166	1.7653	1.6936	1.5858	1.4048	1.0441	0.0888
-1.92	2.0035	1.9636	1.9258	1.8710	1.8326	1.7819	1.7113	1.6050	1.4267	1.0708	0.1239
-1.90	2.0176	1.9780	1.9406	1.8864	1.8485	1.7985	1.7288	1.6241	1.4483	1.0972	0.1587
-1.88	2.0316	1.9924	1.9553	1.9018	1.8644	1.8150	1.7463	1.6430	1.4698	1.1235	0.1935
-1.86	2.0456	2.0067	1.9700	1.9171	1.8801	1.8314	1.7636	1.6618	1.4911	1.1495	0.2281
-1.84	2.0595	2.0210	1.9846	1.9323	1.8958	1.8477	1.7808	1.6805	1.5123	1.1754	0.2626
-1.82	2.0734	2.0352	1.9992	1.9475	1.9114	1.8639	1.7980	1.6991	1.5333	1.2010	0.2969
-1.80	2.0873	2.0494	2.0137	1.9625	1.9263	1.8801	1.8150	1.7175	1.5542	1.2265	0.3311

G	Rs	T
981.0	2.65	24.0

PSI/SP	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-1.80	2.0873	2.0494	2.0137	1.9625	1.9269	1.8801	1.8150	1.7175	1.5542	1.2265	0.3311
-1.78	2.1011	2.0635	2.0282	1.9776	1.9424	1.8961	1.8319	1.7358	1.5749	1.2518	0.3651
-1.76	2.1148	2.0776	2.0426	1.9925	1.9577	1.9121	1.8487	1.7540	1.5954	1.2768	0.3989
-1.74	2.1286	2.0916	2.0569	2.0074	1.9730	1.9280	1.8655	1.7721	1.6158	1.3017	0.4326
-1.72	2.1423	2.1056	2.0712	2.0222	1.9883	1.9437	1.8821	1.7900	1.6360	1.3263	0.4662
-1.70	2.1559	2.1195	2.0855	2.0370	2.0034	1.9595	1.8986	1.8079	1.6561	1.3508	0.4995
-1.68	2.1695	2.1334	2.0997	2.0517	2.0185	1.9751	1.9151	1.8256	1.6760	1.3751	0.5327
-1.66	2.1831	2.1472	2.1138	2.0663	2.0335	1.9907	1.9314	1.8432	1.6958	1.3991	0.5658
-1.64	2.1966	2.1610	2.1279	2.0809	2.0485	2.0061	1.9477	1.8607	1.7154	1.4230	0.5986
-1.62	2.2101	2.1748	2.1420	2.0954	2.0634	2.0215	1.9638	1.8780	1.7349	1.4467	0.6313
-1.60	2.2235	2.1885	2.1559	2.1099	2.0782	2.0369	1.9799	1.8953	1.7542	1.4702	0.6638
-1.58	2.2369	2.2021	2.1699	2.1243	2.0930	2.0521	1.9959	1.9125	1.7734	1.4935	0.6962
-1.56	2.2503	2.2158	2.1838	2.1386	2.1076	2.0673	2.0118	1.9295	1.7925	1.5166	0.7283
-1.54	2.2637	2.2293	2.1976	2.1529	2.1223	2.0824	2.0276	1.9465	1.8114	1.5396	0.7603
-1.52	2.2770	2.2429	2.2114	2.1671	2.1369	2.0974	2.0434	1.9633	1.8302	1.5623	0.7921
-1.50	2.2902	2.2564	2.2252	2.1813	2.1513	2.1124	2.0590	1.9800	1.8489	1.5849	0.8237
-1.48	2.3034	2.2698	2.2389	2.1954	2.1658	2.1273	2.0746	1.9967	1.8674	1.6073	0.8551
-1.46	2.3166	2.2832	2.2525	2.2095	2.1802	2.1421	2.0900	2.0132	1.8858	1.6295	0.8863
-1.44	2.3298	2.2966	2.2661	2.2235	2.1945	2.1569	2.1054	2.0296	1.9040	1.6515	0.9173
-1.42	2.3429	2.3099	2.2797	2.2375	2.2087	2.1715	2.1208	2.0460	1.9222	1.6733	0.9481
-1.40	2.3560	2.3232	2.2932	2.2514	2.2229	2.1862	2.1360	2.0622	1.9402	1.6950	0.9787
-1.38	2.3691	2.3365	2.3067	2.2653	2.2371	2.2007	2.1512	2.0783	1.9581	1.7165	1.0091
-1.36	2.3821	2.3497	2.3202	2.2791	2.2512	2.2152	2.1663	2.0944	1.9758	1.7378	1.0393
-1.34	2.3951	2.3629	2.3336	2.2928	2.2652	2.2297	2.1813	2.1104	1.9935	1.7590	1.0693
-1.32	2.4080	2.3760	2.3469	2.3065	2.2792	2.2440	2.1962	2.1262	2.0110	1.7800	1.0991
-1.30	2.4209	2.3891	2.3602	2.3202	2.2931	2.2583	2.2111	2.1420	2.0284	1.8008	1.1287
-1.28	2.4338	2.4022	2.3735	2.3338	2.3070	2.2726	2.2259	2.1577	2.0457	1.8214	1.1581
-1.26	2.4467	2.4152	2.3867	2.3474	2.3208	2.2868	2.2407	2.1733	2.0628	1.8419	1.1872
-1.24	2.4595	2.4282	2.3999	2.3609	2.3346	2.3009	2.2553	2.1888	2.0799	1.8622	1.2162
-1.22	2.4723	2.4412	2.4131	2.3744	2.3483	2.3150	2.2699	2.2043	2.0968	1.8824	1.2449
-1.20	2.4851	2.4541	2.4262	2.3878	2.3620	2.3290	2.2844	2.2196	2.1137	1.9024	1.2735
-1.18	2.4978	2.4670	2.4393	2.4012	2.3756	2.3430	2.2989	2.2349	2.1304	1.9222	1.3018
-1.16	2.5105	2.4799	2.4523	2.4145	2.3892	2.3569	2.3133	2.2501	2.1470	1.9419	1.3299
-1.14	2.5232	2.4927	2.4653	2.4278	2.4027	2.3707	2.3276	2.2652	2.1636	1.9614	1.3578
-1.12	2.5358	2.5055	2.4783	2.4411	2.4162	2.3845	2.3419	2.2803	2.1800	1.9808	1.3855
-1.10	2.5484	2.5183	2.4912	2.4543	2.4297	2.3983	2.3561	2.2952	2.1963	2.0000	1.4129
-1.08	2.5610	2.5310	2.5041	2.4675	2.4430	2.4119	2.3703	2.3101	2.2125	2.0191	1.4402
-1.06	2.5736	2.5437	2.5170	2.4806	2.4564	2.4256	2.3844	2.3249	2.2286	2.0381	1.4672
-1.04	2.5861	2.5564	2.5298	2.4937	2.4697	2.4392	2.3984	2.3397	2.2447	2.0569	1.4940
-1.02	2.5986	2.5690	2.5426	2.5068	2.4829	2.4527	2.4124	2.3543	2.2606	2.0755	1.5206
-1.00	2.6111	2.5816	2.5554	2.5198	2.4961	2.4662	2.4263	2.3689	2.2764	2.0940	1.5470

G	Rs	T
981.0	2.65	24.0

PSI/SF	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-1.00	2.6111	2.5816	2.5554	2.5198	2.4961	2.4662	2.4263	2.3689	2.2764	2.0940	1.5470
-0.98	2.6236	2.5942	2.5681	2.5327	2.5093	2.4797	2.4401	2.3834	2.2921	2.1124	1.5732
-0.96	2.6360	2.6068	2.5808	2.5457	2.5224	2.4931	2.4539	2.3979	2.3078	2.1307	1.5992
-0.94	2.6484	2.6193	2.5935	2.5586	2.5355	2.5064	2.4677	2.4123	2.3234	2.1488	1.6249
-0.92	2.6607	2.6318	2.6061	2.5714	2.5486	2.5197	2.4814	2.4266	2.3388	2.1668	1.6504
-0.90	2.6731	2.6442	2.6187	2.5843	2.5616	2.5330	2.4950	2.4409	2.3542	2.1846	1.6757
-0.88	2.6854	2.6567	2.6312	2.5970	2.5745	2.5462	2.5086	2.4551	2.3695	2.2023	1.7008
-0.86	2.6977	2.6691	2.6438	2.6098	2.5875	2.5593	2.5221	2.4692	2.3847	2.2199	1.7257
-0.84	2.7100	2.6814	2.6563	2.6225	2.6003	2.5725	2.5356	2.4833	2.3998	2.2374	1.7504
-0.82	2.7222	2.6938	2.6688	2.6352	2.6132	2.5855	2.5490	2.4973	2.4149	2.2547	1.7749
-0.80	2.7344	2.7061	2.6812	2.6479	2.6260	2.5986	2.5624	2.5112	2.4298	2.2719	1.7992
-0.78	2.7466	2.7184	2.6936	2.6605	2.6388	2.6116	2.5758	2.5251	2.4447	2.2890	1.8232
-0.76	2.7588	2.7307	2.7060	2.6731	2.6515	2.6245	2.5891	2.5389	2.4595	2.3060	1.8471
-0.74	2.7709	2.7429	2.7184	2.6856	2.6642	2.6374	2.6023	2.5527	2.4743	2.3229	1.8707
-0.72	2.7831	2.7552	2.7307	2.6981	2.6769	2.6503	2.6155	2.5664	2.4889	2.3396	1.8942
-0.70	2.7952	2.7673	2.7430	2.7106	2.6895	2.6632	2.6286	2.5800	2.5035	2.3563	1.9174
-0.68	2.8072	2.7795	2.7553	2.7231	2.7021	2.6760	2.6417	2.5936	2.5180	2.3728	1.9404
-0.66	2.8193	2.7917	2.7675	2.7355	2.7147	2.6887	2.6548	2.6072	2.5325	2.3892	1.9633
-0.64	2.8313	2.8038	2.7797	2.7479	2.7272	2.7014	2.6678	2.6207	2.5468	2.4056	1.9859
-0.62	2.8433	2.8159	2.7919	2.7602	2.7397	2.7141	2.6808	2.6341	2.5611	2.4218	2.0084
-0.60	2.8553	2.8279	2.8041	2.7726	2.7521	2.7268	2.6937	2.6475	2.5754	2.4379	2.0307
-0.58	2.8673	2.8400	2.8162	2.7849	2.7646	2.7394	2.7066	2.6608	2.5895	2.4539	2.0527
-0.56	2.8792	2.8520	2.8284	2.7971	2.7770	2.7520	2.7194	2.6741	2.6036	2.4698	2.0746
-0.54	2.8912	2.8640	2.8404	2.8094	2.7893	2.7645	2.7322	2.6874	2.6176	2.4856	2.0963
-0.52	2.9031	2.8760	2.8525	2.8216	2.8017	2.7770	2.7450	2.7006	2.6316	2.5013	2.1178
-0.50	2.9150	2.8879	2.8646	2.8338	2.8140	2.7895	2.7577	2.7137	2.6455	2.5169	2.1391
-0.48	2.9268	2.8999	2.8766	2.8460	2.8263	2.8019	2.7704	2.7268	2.6593	2.5324	2.1602
-0.46	2.9387	2.9118	2.8886	2.8581	2.8385	2.8143	2.7831	2.7398	2.6731	2.5478	2.1812
-0.44	2.9505	2.9237	2.9005	2.8702	2.8507	2.8267	2.7957	2.7528	2.6868	2.5632	2.2020
-0.42	2.9623	2.9356	2.9125	2.8823	2.8629	2.8390	2.8083	2.7658	2.7005	2.5784	2.2226
-0.40	2.9741	2.9474	2.9244	2.8943	2.8751	2.8513	2.8208	2.7787	2.7141	2.5936	2.2430
-0.38	2.9858	2.9592	2.9363	2.9064	2.8872	2.8636	2.8333	2.7916	2.7276	2.6086	2.2633
-0.36	2.9976	2.9710	2.9482	2.9184	2.8993	2.8759	2.8458	2.8044	2.7411	2.6236	2.2834
-0.34	3.0093	2.9828	2.9600	2.9303	2.9114	2.8881	2.8582	2.8172	2.7546	2.6385	2.3033
-0.32	3.0210	2.9946	2.9719	2.9423	2.9234	2.9003	2.8706	2.8299	2.7679	2.6533	2.3230
-0.30	3.0327	3.0063	2.9837	2.9542	2.9355	2.9124	2.8830	2.8426	2.7813	2.6681	2.3426
-0.28	3.0444	3.0181	2.9955	2.9661	2.9475	2.9246	2.8953	2.8553	2.7945	2.6827	2.3620
-0.26	3.0560	3.0298	3.0072	2.9780	2.9594	2.9367	2.9076	2.8679	2.8078	2.6973	2.3813
-0.24	3.0677	3.0414	3.0190	2.9899	2.9714	2.9487	2.9199	2.8805	2.8209	2.7118	2.4004
-0.22	3.0793	3.0531	3.0307	3.0017	2.9833	2.9608	2.9321	2.8930	2.8341	2.7262	2.4194
-0.20	3.0909	3.0648	3.0424	3.0135	2.9952	2.9728	2.9443	2.9056	2.8471	2.7406	2.4382

G	Rs	T
981.0	2.65	24.0

PSI/SF	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-0.20	3.0909	3.0648	3.0424	3.0135	2.9952	2.9728	2.9443	2.9056	2.8471	2.7406	2.4382
-0.18	3.1025	3.0764	3.0541	3.0253	3.0071	2.9848	2.9565	2.9180	2.8602	2.7549	2.4568
-0.16	3.1140	3.0880	3.0658	3.0371	3.0189	2.9968	2.9686	2.9305	2.8731	2.7691	2.4753
-0.14	3.1256	3.0996	3.0774	3.0488	3.0307	3.0087	2.9807	2.9429	2.8861	2.7832	2.4937
-0.12	3.1371	3.1112	3.0891	3.0606	3.0425	3.0206	2.9928	2.9552	2.8989	2.7973	2.5119
-0.10	3.1486	3.1227	3.1007	3.0723	3.0543	3.0325	3.0049	2.9675	2.9118	2.8112	2.5300
-0.08	3.1601	3.1343	3.1123	3.0840	3.0661	3.0444	3.0169	2.9798	2.9246	2.8252	2.5479
-0.06	3.1716	3.1458	3.1238	3.0956	3.0778	3.0562	3.0289	2.9921	2.9373	2.8390	2.5657
-0.04	3.1831	3.1573	3.1354	3.1073	3.0895	3.0680	3.0409	3.0043	2.9500	2.8528	2.5834
-0.02	3.1945	3.1688	3.1469	3.1189	3.1012	3.0798	3.0528	3.0165	2.9627	2.8666	2.6009
0.00	3.2060	3.1803	3.1585	3.1305	3.1129	3.0916	3.0647	3.0287	2.9753	2.8802	2.6183
0.02	3.2174	3.1917	3.1700	3.1421	3.1245	3.1033	3.0766	3.0408	2.9879	2.8938	2.6355
0.04	3.2288	3.2032	3.1814	3.1536	3.1362	3.1151	3.0885	3.0529	3.0004	2.9074	2.6527
0.06	3.2402	3.2146	3.1929	3.1652	3.1478	3.1268	3.1003	3.0650	3.0129	2.9209	2.6697
0.08	3.2515	3.2260	3.2044	3.1767	3.1594	3.1384	3.1121	3.0770	3.0254	2.9343	2.6865
0.10	3.2629	3.2374	3.2158	3.1882	3.1709	3.1501	3.1239	3.0890	3.0378	2.9477	2.7033
0.12	3.2743	3.2488	3.2272	3.1997	3.1825	3.1617	3.1357	3.1010	3.0502	2.9610	2.7200
0.14	3.2856	3.2601	3.2386	3.2112	3.1940	3.1733	3.1474	3.1130	3.0626	2.9742	2.7365
0.16	3.2969	3.2715	3.2500	3.2226	3.2055	3.1849	3.1591	3.1249	3.0749	2.9874	2.7529
0.18	3.3082	3.2828	3.2614	3.2341	3.2170	3.1965	3.1708	3.1368	3.0871	3.0006	2.7692
0.20	3.3195	3.2941	3.2727	3.2455	3.2285	3.2080	3.1825	3.1487	3.0994	3.0137	2.7854
0.22	3.3308	3.3054	3.2841	3.2569	3.2399	3.2196	3.1941	3.1605	3.1116	3.0267	2.8014
0.24	3.3420	3.3167	3.2954	3.2683	3.2514	3.2311	3.2058	3.1723	3.1238	3.0397	2.8174
0.26	3.3533	3.3280	3.3067	3.2796	3.2628	3.2426	3.2174	3.1841	3.1359	3.0527	2.8333
0.28	3.3645	3.3392	3.3180	3.2910	3.2742	3.2540	3.2290	3.1959	3.1480	3.0656	2.8490
0.30	3.3757	3.3505	3.3293	3.3023	3.2856	3.2655	3.2405	3.2076	3.1601	3.0784	2.8647
0.32	3.3869	3.3617	3.3405	3.3136	3.2969	3.2769	3.2521	3.2193	3.1721	3.0912	2.8802
0.34	3.3981	3.3729	3.3518	3.3249	3.3083	3.2883	3.2636	3.2310	3.1841	3.1040	2.8956
0.36	3.4093	3.3841	3.3630	3.3362	3.3196	3.2997	3.2751	3.2427	3.1961	3.1167	2.9110
0.38	3.4205	3.3953	3.3742	3.3475	3.3309	3.3111	3.2865	3.2543	3.2081	3.1293	2.9262
0.40	3.4316	3.4065	3.3854	3.3588	3.3422	3.3225	3.2980	3.2659	3.2200	3.1420	2.9414
0.42	3.4428	3.4177	3.3966	3.3700	3.3535	3.3338	3.3094	3.2775	3.2319	3.1545	2.9565
0.44	3.4539	3.4288	3.4078	3.3812	3.3648	3.3451	3.3209	3.2891	3.2437	3.1671	2.9714
0.46	3.4650	3.4400	3.4190	3.3924	3.3760	3.3565	3.3323	3.3007	3.2556	3.1796	2.9863
0.48	3.4761	3.4511	3.4301	3.4036	3.3873	3.3677	3.3436	3.3122	3.2674	3.1920	3.0011
0.50	3.4872	3.4622	3.4412	3.4148	3.3985	3.3790	3.3550	3.3237	3.2792	3.2044	3.0158
0.52	3.4983	3.4733	3.4524	3.4260	3.4097	3.3903	3.3663	3.3352	3.2909	3.2168	3.0305
0.54	3.5094	3.4844	3.4635	3.4371	3.4209	3.4015	3.3777	3.3467	3.3026	3.2291	3.0450
0.56	3.5205	3.4955	3.4746	3.4483	3.4320	3.4128	3.3890	3.3581	3.3143	3.2414	3.0595
0.58	3.5315	3.5065	3.4857	3.4594	3.4432	3.4240	3.4003	3.3695	3.3260	3.2537	3.0738
0.60	3.5425	3.5176	3.4967	3.4705	3.4544	3.4352	3.4115	3.3809	3.3377	3.2659	3.0881

G	R_S	T
981.0	2.65	24.0

PSI/SF	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
0.60	3.5425	3.5176	3.4967	3.4705	3.4544	3.4352	3.4115	3.3809	3.3377	3.2659	3.0881
0.62	3.5536	3.5286	3.5078	3.4816	3.4655	3.4463	3.4228	3.3923	3.3493	3.2780	3.1024
0.64	3.5646	3.5397	3.5189	3.4927	3.4766	3.4575	3.4340	3.4037	3.3609	3.2902	3.1165
0.66	3.5756	3.5507	3.5299	3.5038	3.4877	3.4687	3.4453	3.4150	3.3725	3.3023	3.1306
0.68	3.5866	3.5617	3.5409	3.5148	3.4988	3.4798	3.4565	3.4263	3.3840	3.3144	3.1446
0.70	3.5976	3.5727	3.5519	3.5259	3.5099	3.4909	3.4677	3.4377	3.3955	3.3264	3.1585
0.72	3.6085	3.5837	3.5629	3.5369	3.5210	3.5020	3.4788	3.4489	3.4071	3.3384	3.1724
0.74	3.6195	3.5946	3.5739	3.5480	3.5320	3.5131	3.4900	3.4602	3.4185	3.3504	3.1862
0.76	3.6305	3.6056	3.5849	3.5590	3.5431	3.5242	3.5012	3.4715	3.4300	3.3623	3.1999
0.78	3.6414	3.6166	3.5959	3.5700	3.5541	3.5353	3.5123	3.4827	3.4414	3.3742	3.2135
0.80	3.6523	3.6275	3.6068	3.5810	3.5651	3.5463	3.5234	3.4939	3.4529	3.3861	3.2271
0.82	3.6633	3.6384	3.6178	3.5919	3.5761	3.5574	3.5345	3.5051	3.4643	3.3980	3.2406
0.84	3.6742	3.6494	3.6287	3.6029	3.5871	3.5684	3.5456	3.5163	3.4756	3.4098	3.2541
0.86	3.6851	3.6603	3.6396	3.6139	3.5981	3.5794	3.5567	3.5275	3.4870	3.4216	3.2675
0.88	3.6960	3.6712	3.6506	3.6248	3.6090	3.5904	3.5677	3.5386	3.4983	3.4333	3.2808
0.90	3.7069	3.6821	3.6615	3.6357	3.6200	3.6014	3.5788	3.5498	3.5096	3.4451	3.2941
0.92	3.7177	3.6929	3.6724	3.6467	3.6309	3.6124	3.5898	3.5609	3.5209	3.4568	3.3073
0.94	3.7286	3.7038	3.6833	3.6576	3.6419	3.6234	3.6008	3.5720	3.5322	3.4684	3.3204
0.96	3.7395	3.7147	3.6941	3.6685	3.6528	3.6343	3.6118	3.5831	3.5435	3.4801	3.3335
0.98	3.7503	3.7255	3.7050	3.6794	3.6637	3.6453	3.6228	3.5942	3.5547	3.4917	3.3466
1.00	3.7611	3.7364	3.7159	3.6902	3.6746	3.6562	3.6338	3.6053	3.5659	3.5033	3.3596
1.02	3.7720	3.7472	3.7267	3.7011	3.6855	3.6671	3.6448	3.6163	3.5771	3.5149	3.3725
1.04	3.7828	3.7580	3.7375	3.7120	3.6964	3.6780	3.6557	3.6273	3.5883	3.5264	3.3854
1.06	3.7936	3.7689	3.7484	3.7229	3.7072	3.6889	3.6667	3.6384	3.5995	3.5379	3.3982
1.08	3.8044	3.7797	3.7592	3.7337	3.7181	3.6998	3.6776	3.6494	3.6106	3.5494	3.4110
1.10	3.8152	3.7905	3.7700	3.7445	3.7289	3.7107	3.6885	3.6604	3.6218	3.5609	3.4237
1.12	3.8260	3.8013	3.7808	3.7553	3.7398	3.7215	3.6994	3.6713	3.6329	3.5723	3.4364
1.14	3.8368	3.8120	3.7916	3.7661	3.7506	3.7324	3.7103	3.6823	3.6440	3.5838	3.4490
1.16	3.8475	3.8228	3.8024	3.7769	3.7614	3.7432	3.7212	3.6933	3.6551	3.5952	3.4616
1.18	3.8583	3.8336	3.8131	3.7877	3.7722	3.7541	3.7321	3.7042	3.6662	3.6066	3.4741
1.20	3.8691	3.8443	3.8239	3.7985	3.7830	3.7649	3.7429	3.7151	3.6772	3.6179	3.4866
1.22	3.8798	3.8551	3.8347	3.8093	3.7939	3.7757	3.7538	3.7260	3.6883	3.6292	3.4991
1.24	3.8905	3.8658	3.8454	3.8200	3.8046	3.7865	3.7646	3.7369	3.6993	3.6406	3.5115
1.26	3.9013	3.8766	3.8562	3.8308	3.8154	3.7973	3.7755	3.7478	3.7103	3.6519	3.5238
1.28	3.9120	3.8873	3.8669	3.8415	3.8261	3.8081	3.7863	3.7587	3.7213	3.6631	3.5361
1.30	3.9227	3.8980	3.8776	3.8523	3.8369	3.8189	3.7971	3.7696	3.7323	3.6744	3.5484
1.32	3.9334	3.9087	3.8883	3.8630	3.8476	3.8296	3.8079	3.7804	3.7432	3.6856	3.5606
1.34	3.9441	3.9194	3.8990	3.8737	3.8584	3.8404	3.8187	3.7913	3.7542	3.6968	3.5728
1.36	3.9548	3.9301	3.9097	3.8844	3.8691	3.8511	3.8294	3.8021	3.7651	3.7080	3.5850
1.38	3.9655	3.9408	3.9204	3.8952	3.8798	3.8619	3.8402	3.8129	3.7761	3.7192	3.5971
1.40	3.9762	3.9515	3.9311	3.9059	3.8905	3.8726	3.8510	3.8238	3.7870	3.7304	3.6092

G	Rs	T
981.0	2.65	24.0

PSI/SF	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
1.40	3.9762	3.9515	3.9311	3.9059	3.8905	3.8726	3.8510	3.8238	3.7870	3.7304	3.6092
1.42	3.9868	3.9622	3.9418	3.9165	3.9012	3.8833	3.8617	3.8346	3.7979	3.7415	3.6212
1.44	3.9975	3.9728	3.9525	3.9272	3.9119	3.8940	3.8725	3.8453	3.8088	3.7526	3.6332
1.46	4.0082	3.9835	3.9631	3.9379	3.9226	3.9047	3.8832	3.8561	3.8196	3.7637	3.6452
1.48	4.0188	3.9941	3.9738	3.9486	3.9333	3.9154	3.8939	3.8669	3.8305	3.7748	3.6571
1.50	4.0294	4.0048	3.9844	3.9592	3.9440	3.9261	3.9046	3.8777	3.8414	3.7859	3.6690
1.52	4.0401	4.0154	3.9951	3.9699	3.9546	3.9368	3.9153	3.8884	3.8522	3.7969	3.6809
1.54	4.0507	4.0260	4.0057	3.9805	3.9653	3.9475	3.9260	3.8991	3.8630	3.8080	3.6927
1.56	4.0613	4.0367	4.0163	3.9912	3.9759	3.9581	3.9367	3.9099	3.8738	3.8190	3.7045
1.58	4.0720	4.0473	4.0269	4.0018	3.9866	3.9688	3.9474	3.9206	3.8847	3.8300	3.7163
1.60	4.0826	4.0579	4.0376	4.0124	3.9972	3.9794	3.9581	3.9313	3.8954	3.8410	3.7280
1.62	4.0932	4.0685	4.0482	4.0230	4.0078	3.9901	3.9687	3.9420	3.9062	3.8520	3.7397
1.64	4.1038	4.0791	4.0588	4.0336	4.0184	4.0007	3.9794	3.9527	3.9170	3.8629	3.7514
1.66	4.1143	4.0897	4.0693	4.0442	4.0290	4.0113	3.9900	3.9634	3.9278	3.8739	3.7631
1.68	4.1249	4.1003	4.0799	4.0548	4.0396	4.0219	4.0007	3.9741	3.9385	3.8848	3.7747
1.70	4.1355	4.1108	4.0905	4.0654	4.0502	4.0325	4.0113	3.9847	3.9492	3.8957	3.7863
1.72	4.1461	4.1214	4.1011	4.0760	4.0608	4.0431	4.0219	3.9954	3.9600	3.9066	3.7978
1.74	4.1566	4.1320	4.1117	4.0866	4.0714	4.0537	4.0325	4.0060	3.9707	3.9175	3.8094
1.76	4.1672	4.1425	4.1222	4.0971	4.0820	4.0643	4.0431	4.0167	3.9814	3.9284	3.8209
1.78	4.1778	4.1531	4.1328	4.1077	4.0925	4.0749	4.0537	4.0273	3.9921	3.9392	3.8324
1.80	4.1883	4.1636	4.1433	4.1183	4.1031	4.0855	4.0643	4.0379	4.0028	3.9501	3.8438
1.82	4.1989	4.1742	4.1539	4.1288	4.1137	4.0960	4.0749	4.0485	4.0135	3.9609	3.8552
1.84	4.2094	4.1847	4.1644	4.1393	4.1242	4.1066	4.0855	4.0592	4.0242	3.9718	3.8667
1.86	4.2199	4.1952	4.1749	4.1499	4.1348	4.1171	4.0960	4.0698	4.0348	3.9826	3.8780
1.88	4.2304	4.2058	4.1855	4.1604	4.1453	4.1277	4.1066	4.0804	4.0455	3.9934	3.8894
1.90	4.2410	4.2163	4.1960	4.1709	4.1558	4.1382	4.1172	4.0909	4.0561	4.0042	3.9007
1.92	4.2515	4.2268	4.2065	4.1815	4.1663	4.1488	4.1277	4.1015	4.0667	4.0149	3.9120
1.94	4.2620	4.2373	4.2170	4.1920	4.1769	4.1593	4.1383	4.1121	4.0774	4.0257	3.9233
1.96	4.2725	4.2478	4.2275	4.2025	4.1874	4.1698	4.1488	4.1227	4.0880	4.0364	3.9346
1.98	4.2830	4.2583	4.2380	4.2130	4.1979	4.1803	4.1593	4.1332	4.0986	4.0472	3.9458
2.00	4.2935	4.2688	4.2485	4.2235	4.2084	4.1908	4.1699	4.1438	4.1092	4.0579	3.9570
2.02	4.3040	4.2793	4.2590	4.2340	4.2189	4.2013	4.1804	4.1543	4.1198	4.0686	3.9682
2.04	4.3145	4.2898	4.2695	4.2444	4.2294	4.2118	4.1909	4.1648	4.1304	4.0793	3.9794
2.06	4.3249	4.3002	4.2799	4.2549	4.2399	4.2223	4.2014	4.1754	4.1410	4.0900	3.9906
2.08	4.3354	4.3107	4.2904	4.2654	4.2503	4.2328	4.2119	4.1859	4.1515	4.1007	4.0017
2.10	4.3459	4.3212	4.3009	4.2759	4.2608	4.2433	4.2224	4.1964	4.1621	4.1114	4.0128
2.12	4.3563	4.3316	4.3113	4.2863	4.2713	4.2538	4.2329	4.2069	4.1726	4.1221	4.0239
2.14	4.3668	4.3421	4.3218	4.2968	4.2817	4.2642	4.2433	4.2174	4.1832	4.1327	4.0350
2.16	4.3772	4.3525	4.3322	4.3072	4.2922	4.2747	4.2538	4.2279	4.1937	4.1434	4.0461
2.18	4.3877	4.3630	4.3427	4.3177	4.3026	4.2852	4.2643	4.2384	4.2043	4.1540	4.0571
2.20	4.3981	4.3734	4.3531	4.3281	4.3131	4.2956	4.2748	4.2489	4.2148	4.1646	4.0681

MACROGRANOMETER APPLICATION NOTE:

OIL AND GAS PROSPECTION

Increasing petroleum demand makes the search for this fossil fuel dramatically valuable for mankind. Growing efforts, such as immense borehole prices, dictate that costly samples from a great depth must be evaluated with exceptional care.

Most oil and gas is found in sandy rock. Its basic textural feature - grain size distribution - defines porosity which is the prerequisite for accumulation of oil and gas in geological traps. Maps, profiles and three-dimensional block diagrams of grain size distribution data disclose trends of the fossil sedimentary environment, enable its reconstruction,and paleocurrent and basin analyses.

It was not by chance, that the petroleum geologists introduced the settling tube for grain size analysis of sandy rock (Shell, Amsterdam, 1936). This way, they improved considerably the analysis method which used sieves. Most of the later development of the sedimentation technique has been accomplished for the purpose of the petroleum prospection (eg Preussag AG, W. Germany, 1965). This purpose guided our research since 1961 towards the development of the Macrogranometer. In addition to the above mentioned application of the grain size distribution data, the Macrogranometer results have been succesfully used in stratigraphic correlation

Here is a *BRIEF SURVEY of OUR RESEARCH, DEVELOPMENT AND SIGNIFICANT ACTIVITIES:*

1961 to 1970 Studies in mathematical statistics of grain size distribution, research and experiments in hydrodynamics of laminar and turbulent sedimentation, related problems in mechanical and chemical engineering such as sieving, and development of sediment sensing methods by pressure and weight.

1971 Demonstration of the Macrogranometer using electronic underwater balance, electronic time base of own construction, and XY-recorder output, during the 7th International Sedimentological Congress at Heidelberg, W. Germany; construction of this Macrogranometer type for the Geological and Paleontological Institute of the University Marburg, W Germany.

1972 German Patent (Nr. 22 51 838) precision electronic balance; introduction of a real time computer for sedimentation data fetching, their processing, and operation control of the Macrogranometer (Varian, Model 620).

1973 Installation of computer controlled Macrogranometer at the Sedimentological Laboratory of AGIP SpA, Milano, Italy, and others.

1974 to 1978 Development of the improved sample introduction device: Venetian blind with hydraulically shaped and eccentrically tilting lamellae; steadily improving Assembler programs for computers from Computer Automation Inc. (LSI-2 family) and Hewlett-Packard (21MX family), supply to various institutions (eg Federal Geological Survey of W. Germany, Hannover), demonstration at the Department of Mining Engineering of the Technical University of Delft, Netherland, and at the Institute of Hydraulic Research, University of Iowa,USA

1979 Development of a new equation which defines relationship among drag coefficient, Reynolds' number and shape factor of sedimenting irregular particles, as well as their size and settling rate. Easy calibration of the Macrogranometer to any grain size analysis standard, eg. ASTM- or DIN-sieving, by calculation of shape values of all particle size grades from a standard grain size analysis and the Macrogranometer settling rate distribution analysis of the same sample; this is accomplished automatically by the Fortran segment SHAPE including: multicomponental Gaussian regression, finding inverse settling rate distribution function of each grain size distribution value, and calculation of the shape to each particle size grade; the shape values can be used for Macrogranometer size analyses of similar material. Software for Digital Equipment Corporation real time computers, family 11 (PDP-11 and LSI-11).