

SEDSTAT: A Computer Program for Processing and Presentation of Grain Size Using Sieving Data

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Abstract. SEDSTAT is an interactive computer program for processing and presentation of grain size data. The program utilizes graphic and moment methods for the calculation of grain size statistical parameters. The program has a menu driven format that can be easily understood by anyone with little, or no computer experience. Data storage and retrieval are the major features of SEDSTAT. Another important feature of the program is the built in editor that prompts the user to enter and edit the unprocessed data of weight retained on each sieve and the sieve mesh size in Phi units.

The program starts with receiving data from the keyboard or a disk data file; it then calculates the weight percentage, and cumulative weight percentage retained on each sieve. The gaussian (probability) interpolations and extrapolations are then performed to obtain the requisite critical percentiles that are used to calculate Folk and Ward graphical statistical parameters. Grouped moment statistical parameters are also calculated. Another function of the program is to construct two graphs; the first is a histogram of class weight percentage versus size class interval and the second is a probability plot of cumulative weight percentage versus size class interval. Below both of these graphs the parameters of grain size statistics are printed. A hard copy of the graphs may be obtained using a graphic printer or a screen dumping routine.

Introduction

Grain size is a fundamental physical property of sediments and sedimentary rocks [1;2], grain size distribution has also a great importance in understanding the mechanism of transportation and deposition of clastic sedimentary rocks [3-9]. For these reasons studying grain size analysis is an important aspect of sedimentological research.

The size of clastic grains is measured by several methods [10, pp. 1-248]. The choice of method to be used is controlled by the range of measured grain sizes and the degree of induration of the sediment or sedimentary rock. The most commonly employed methods in grain size analysis are sieving [10; 11], sedimentation [12;13], and automated measurement [14]. Sieving is mainly used for unconsolidated and weakly cemented sandstone. A dry sample is weighed and placed in the uppermost sieve in a set of stacked

sieves, arranged in order so the coarsest sieve is at the top with the finer ones below. The stacked sieves are placed on a shaking machine for 10 to 15 minutes. Each fraction collected in each sieve is then weighed. If more than 5% of the total sample is collected in the pan (*i.e.*, the fraction passed sieve with size 4 Phi), further analysis by sedimentation methods should be employed.

Grain size analyses of sieved material are usually presented in three graphical forms *histogram* in which the different grain sizes are plotted on the horizontal axis (abscissa) and the weight percentage on the vertical axis (ordinate) as shown on Fig. 1; *frequency curve* in which the data is presented as a smooth curve that shows the variation of weight percentage as a continuous function of grain size (Fig. 1); and *cumulative curve* in which the different grain sizes are plotted on the horizontal axis (Fig. 2). Cumulative curves may be drawn using an arithmetic ordinate scale or a probability ordinate scale.

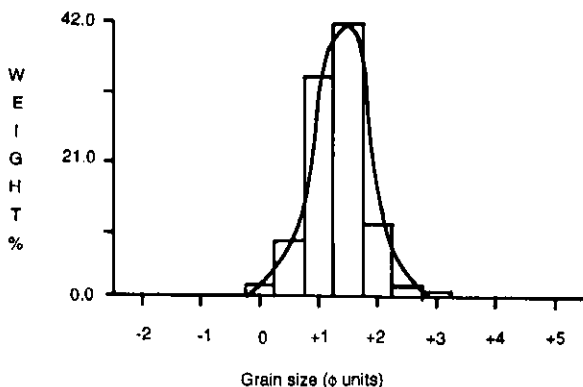


Fig. 1. Hypothetical histogram and frequency curve.

Probability ordinate scale is much superior to the arithmetic scale for the interpolation of critical percentiles [3; 15-17].

Statistical Analysis of Grain Size Data

Since most of grain size distributions approach a normal or gaussian distribution, conventional statistical measures can be used to characterize individual distributions.

The average grain size is defined by three different measures that are *the mode* (the most frequently occurring grain diameter); *the median* (the size for which half of the particles by weight is coarser and the other half is finer) and *the mean* (the arithmetic average of all particle sizes in the sample).

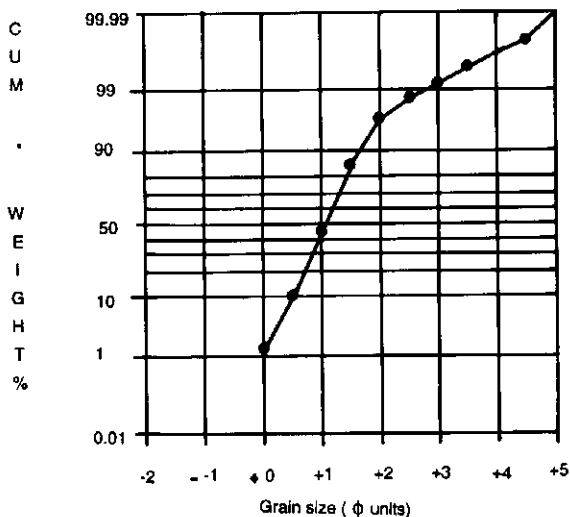


Fig. 2. Hypothetical cumulative curve drawn on probability paper.

Sorting of grain population is the measure of grain size and the magnitude of spread or scatter of these sizes around the mean. Sorting is expressed mathematically by *standard deviation*. In the other hand the normality of grain size distribution is measured by *skewness* (the symmetry of the distribution); and *kurtosis* (the ratio of sorting in the tails and central part of the distribution). SEDSTAT calculates grain size statistics using the moment and graphic methods that are explained briefly below.

Moment Method

Although the moment method is the most reliable method, it has not been used extensively until recently, because of the tedious calculations involved. This method utilizes conventional statistics to characterize grain size distribution.

The computations in moment statistics involve multiplying a weight (weight frequency in percentage) by a distance from the midpoint of each size grade to the arbitrary origin of the abscissa. The formulae for computation of moment statistics are summarized in Table 1 [18].

Graphic Method

This method involves the plotting of a cumulative curve for the sample and reading the grain sizes represented by certain cumulative percentages. The cumulative curve can

Table 1. Formulae for computing moment measures (Source: McBride, 1971)

Mean	$\bar{x}_\phi = \frac{\sum fm}{n}$
Standard deviation	$\sigma_\phi = \sqrt{\frac{\sum f(m - \bar{x}_\phi)^2}{100}}$
Skewness	$Sk_\phi = \frac{\sum f(m - \bar{x}_\phi)^3}{100\sigma_\phi^3}$
Kurtosis	$K_\phi = \frac{\sum f(m - \bar{x}_\phi)^4}{100\sigma_\phi^4}$

Where f = weight percent (frequency) in each grain-size grade present,

m = midpoint of each grain-size grade in ϕ values

n = total number in sample which is 100 when f is in percent.

be plotted on arithmetic or probability paper. Many workers [3;15-17;19] advocate the use of probability paper, which makes the normal curves plotted as straight lines. The critical percentiles needed to compute graphic statistics are read from the cumulative curve. These percentiles are then used in formulae (Table 2) given by Folk and Ward [3] to calculate the graphic statistical parameters.

Table 2. Formulae for computing graphic measures (Source: Folk and Ward, 1957)

Graphic mean	$M_z = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$
Inclusive graphic standard deviation	$\sigma_I = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$
Inclusive graphic skewness	$SK_I = \frac{(\phi_{84} + \phi_{16} - 2\phi_{50})}{2(\phi_{84} - \phi_{16})} + \frac{(\phi_{95} + \phi_5 - 2\phi_{50})}{2(\phi_{95} - \phi_5)}$
Graphic kurtosis	$K_G = \frac{(\phi_{95} - \phi_5)}{2.44 (\phi_{84} - \phi_{25})}$

Statement of the Problem

Several computer programs for calculation of grain size statistical parameters have been written, for example [20-33]. Most, if not all of the above mentioned programs have some drawbacks. The method of interpolation and extrapolation employed by these programs to obtain the required critical percentiles, poses serious problem to the results of the calculated grain size statistics.

Different methods of interpolation and extrapolation were used, such as linear, parabolic, lagrangian, and cubic spline. Although these methods of interpolation and extrapolation are not advocated by Folk and Ward [3], they are commonly used in computer programs to calculate graphic statistical parameters. Swan, *et al.* [17] emphasized in their study of graphic statistical parameter effectiveness, that "gaussian (probability) interpolations between known points on a cumulative curve and extrapolations beyond the end of the distribution are required in the calculation of graphic parameters by computer." They outlined a procedure for gaussian interpolations and extrapolations.

Another serious problem with some of these programs is the omission of graphic presentation of grain size data, especially in the form of histograms and frequency curves. Folk [16] stated that "by not drawing the curve one does not get feel of the data — he does not detect bimodality, or "shoulders" in the curves; fails to catch experimental errors in weighing, or caused by faulty screens." A minor disadvantage is that, some of the above mentioned programs utilize only the graphic method, where others utilize only the moment method.

The main objective of the current study is to build a micro-computer-based expert system for processing and analyzing grain size data. The system will receive raw data in the form of sieve sizes and weights retained on each sieve. From the data received, weight percent and cumulative weight percent will be calculated. Thereafter, the data will be presented graphically in the form of histograms and cumulative curves. The final function of the program is the calculation of moment and graphic statistics.

SEDSTAT Advantages

SEDSTAT has an advantage over all previously written computer programs in that, it computes grain size statistics by both moment method and graphic method. The program utilizes the Gaussian (probability) interpolations and extrapolations to obtain the critical percentiles required for calculation of graphic statistics (Folk and Ward parameters). Many of the earlier programs do not produce graphic outputs (*i.e.* histograms and cumulative curves). Some of the recent programs produce cumulative curves, however, these curves are drawn using arithmetic scale while they should be drawn using probability scale. SEDSTAT redeems all the above mentioned disadvantages. In addition to that some of the earlier programs generate character style output that is sent to a printer which necessitates manual redrafting. SEDSTAT produces high quality graphs on the monitor. These graphs can be easily turned into a hard copy

using a graphic printer and the DOS utility program GRAPHICS.COM or any other screen dumping program.

General Features of SEDSTAT

SEDSTAT code was designed to process and present grain size data obtained by sieving method. The program has a menu driven format that can be easily understood by anyone who has or with little computer experience. Data entry, storage and retrieval is a major feature of the program. SEDSTAT was written to overcome the limitations of the previously published programs. Gaussian interpolation and extrapolation were used to obtain the requisite critical percentiles following the procedure of Swan and others [17]. Grain size statistics are calculated utilizing graphic and moment methods. In addition, grain size distribution is presented graphically in the forms of histogram and cumulative curve plotted on a probability scale. The high quality graphic output of the program can be sent to a printer using a screen dumping commercial software such as PIZZAZPLUS. SEDSTAT was written and compiled using Microsoft QuickBASIC version 4.5 compiler. To run the program the following hardware and software are required: an IBM PC or compatible with at least 512 byte of memory, one disk drive (at least 360 K byte), a graphics card (EGA or VGA) and at least DOS version 2.11.

SEDSTAT Operation

SEDSTAT is built up of three main routines, data entry, calculation, and plotting (Fig. 3). Program SEDSTAT starts with displaying its main menu which offers three options: (1) Input; (2) Read and (3) Exit. The first two options are described next.

Input

This option allows the user to enter grain size data through the keyboard. The entry of a data set consists of sample identification number, initial weight of sample, and sieve size interval. Then the program asks the user to check the correctness of the entries. The user is then asked to enter the weight retained on each sieve. After completion of data entry the program moves to an editor which offers a wide range of editing commands (Fig. 4). By using the editor the user can replace, add, insert, or delete a data set. The edited data is then passed to the calculations routine which first converts retained weights to percentages of the total weight, then further to cumulative weights. The sieve size, and cumulative weight data are then used to calculate grain size statistics by the graphical method [3] and the moment method [18, pp. 109-128].

Read

Data can be also loaded into the program from an ASCII file. The first line represents sample number, sample initial weight, number of sieves; each following line of the file represents sieve size, and weight retained (Table 3). The user is asked to input directory and file name that are containing the data. These entries are checked for errors.

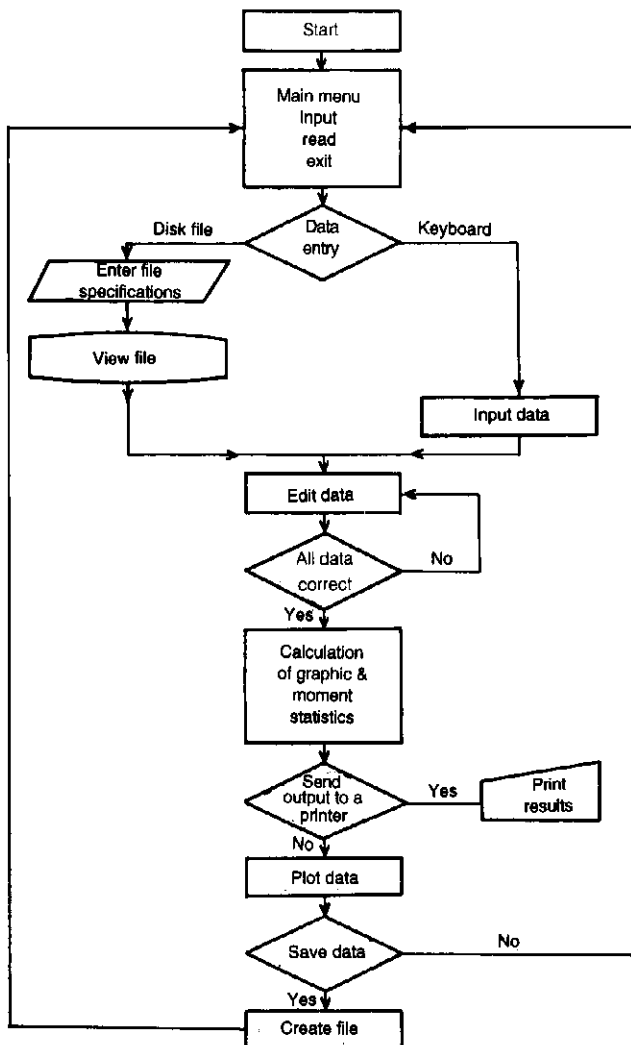


Fig. 3. Flow chart of program SEDSTAT.

Edit Data		
Line#	Size	Weight
1	-1.00	2.08
2	-0.50	3.83
3	0.00	9.92
4	0.50	16.97
5	1.00	19.98
6	1.50	14.71
7	2.00	6.01
8	2.50	1.40
9	3.00	0.40
10	3.50	0.20
11	4.00	0.09
12	4.50	0.11

<<Replace	<<Add	<<Down U	<<Delete	<<Continue
Press: R.O.L.D OR C				

Fig. 4. Editing screen showing a sample data and the editing commands.

Table 3. A sample data file

	Sample no.	Initial wt.	No. of sieves
First line	"PKS 455" ' sieve mesh	76.08 ' wt. retained	12
Second line	-1	2.08	
Third line	-0.05	3.83	
	0	9.92	
	0.5	16.97	
	1	19.98	
	0.5	14.71	
	2	6.01	
	2.5	1.4	
	3	0.40	
	3.5	0.20	
	4	0.09	
Thirteenth line	4.5	0.11	

Once data is read the program moves into the editing mode, and then into the calculation routine.

Following processing, the entered and read data are presented graphically into a histogram and a cumulative curve drawn on a probability paper, then the grain size statistics are printed. A hard copy of the output may be obtained using a graphic printer or a screen dumping routine (Fig. 5).

Conclusions

SEDSTAT is an easy to use menu driven program for processing and graphically representing grain size data. The flexibility in the handling and manipulation of data and the ability to run under DOS on IBM compatible computers, make it a useful tool for research and instructional application. The program performs the gaussian interpolation and extrapolation to obtain the required percentiles for calculating graphic statistics.

SEDSTAT possesses several advantages such as its speed and the fact that it calculated grain size statistics using the graphic methods as well as the method of

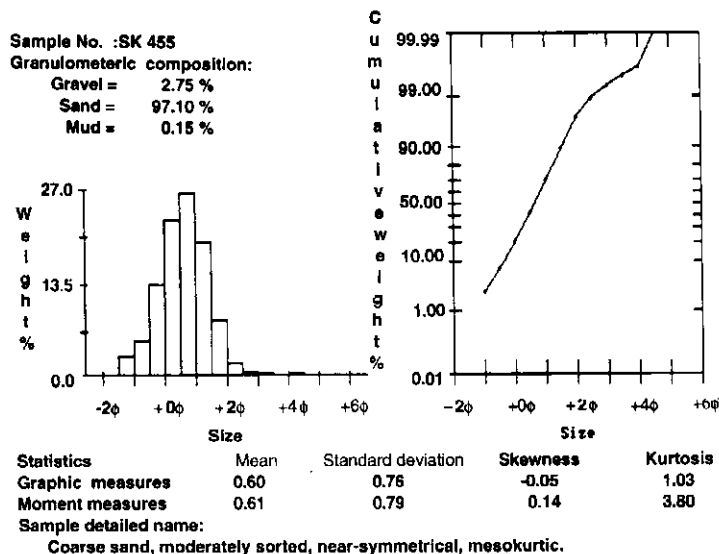


Fig. 5. A screen dump graphic output sample using an IIP-Laser jet printer.

moments. A disadvantage is that the program does not have a built-in screen dumping routine to send the high quality graphic output to a printer. This can be overcome by using a commercial software specially designed for this purpose.

Availability

An executable code copy along with a sample data file can be obtained upon request from H.S. Awad or A.M. Al-bassam in the Geology Department; College of Science; King Saud University, Riyadh, Saudi Arabia.

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سيداتستات: برنامج حاسب آلي يستخدم في المعالجة والتمثيل البياني لمعلومات التحليل الحجمي للحيبيات الرواسب السائبة والمستقاة من عملية النخل

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الرياض ١١٤٥١، المملكة العربية السعودية

(سُلم في ٤ من ذي الحجة ١٤١٥هـ؛ وقبل للنشر في ١٣ شوال ١٤١٦هـ)

ملخص البحث. سيدستات عبارة عن برنامج تفاعلي تمّ تصميمه للمعالجة والتمثيل البياني لمعلومات التحليل الحجمي. يستخدم البرنامج الطريقة الأليانية وطريقة العزوم في حساب المعاملات الإحصائية للتحليل الحجمي، ويعمل من خلال قوائم ذات عدّة خيارات وهي طريقة سهلة الاستعمال لأي شخص لديه خبرة بسيطة في استخدامات الحاسب الألي أو حتى لأي شخص ليست لديه خبرة بالحاسب الألي واستخداماته. يتميّز هذا البرنامج بسهولة تخزين المعلومات واسترجاعها والتي تعتبر من أهم مميّزاته. من المميّزات الأخرى للبرنامج وجود محرر مبني داخله يمكن بواسطته إدخال وتعديل المعلومات الأولية المتمثلة في أحجام المناخل والأوزان المتجمعة عليها وتعديلها.

يبدأ البرنامج بأخذ المعلومات من خلال لوحة المفاتيح في الحاسب الألي أو من خلال ملف خارجي موجود على إحدى وسائل التخزين للحاسب. يتم بعد ذلك حساب النسبة المئوية الوزنية أو النسبة المئوية التراكميّة للأوزان المتجمعة على كل منخل والتي تستخدم فيما بعد في تحديد الأحجام الحبيبية المقابلة للنسب المرحجة. يستخدم البرنامج هذه القيم في حساب المعاملات الإحصائية التي وضعها فولك ووورد كما يقوم البرنامج أيضاً بحساب المعاملات الإحصائية بطريقة العزوم. من الوظائف الأخرى للبرنامج عمل رسمين بيانيين، يوضح الرسم الأول النسب المئوية لفئات الأحجام الحبيبية وذلك باستخدام مقياس رسم مدرّج تكراري frequency curve، أما الرسم الثاني فيوضح المنحنى التراكمي وذلك باستخدام مقياس الاحتمالات probability scale. يقوم بعد ذلك البرنامج بكتابة قيم المعاملات الإحصائية تحت هذه الرسوم البيانية. يمكن الحصول على نسخة من هذه الرسومات إما باستخدام طابعة بيانية أو باستخدام أي برنامج ناسخ للشاشة.