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22. Programmed calculation of Folk and Ward sediment parameters.

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Folk and Ward (1957) have discussed the theory behind the parameters derived from sieve analysis data. The validity of the theory is open to question, but until a considerable amount of data are processed and analysed it is not possible to confirm or deny the views of Folk and Ward nor establish better criteria.

The four parameters may be quoted as:

$$\text{Mean size} = \frac{\phi_{16}+\phi_{50}+\phi_{84}}{3}$$

$$\text{Deviation} = \frac{\phi_{84}-\phi_{16}}{4} + \frac{\phi_{95}-\phi_{5}}{6.6}$$

$$\text{Skewness} = \frac{\phi_{16}+\phi_{84}-2\phi_{50}}{2(\phi_{84}-\phi_{16})} + \frac{\phi_{5}+\phi_{95}-2\phi_{50}}{2(\phi_{95}-\phi_{5})}$$

$$\text{Kurtosis} = \frac{\phi_{95}-\phi_{5}}{2.44(\phi_{75}-\phi_{25})}$$

The bulk of the analyses available are expressed as retained percentages on screens with phi scale values of -1.27, -0.27, 0.73, 1.73, 2.73, 3.73; although some analyses incorporate screen size variants. The percentage of material passing all screens is also stated.

METHOD OF CALCULATION

In hand calculation the percentage values are converted to pass percentages and these percentages are plotted against phi on a log graph. The appropriate phi values are taken from the graph and the parameters calculated. The process may be repeated after conversion of pass percentages to 100%, ignoring any material which passes all screens. Many of the analyses show losses of up to 50% indicating a broad range of composition. By hand, the process is tedious and because the phi values are read from the graph the consistency of the results is doubtful.

PROGRAMMED METHOD OF CALCULATION

The introduction of the programme, which was developed for the Wang 700B desk computer, includes the six standard phi values. These can be altered manually should the need arise. The six associated retained percentage values are then introduced. These are converted to pass percentages and 'adjusted to 100' pass percentages.

Either or both sets of pass percentages can be entered to memory. Instead of plotting the information, a Lagrange five point interpolation (to produce a fourth order curve) is undertaken. Phi value -1.27 is the only data piece not used (a valid condition). The Lagrange interpolation may be stated as follows:

$$y = \frac{y_0+y_1+y_2+y_3+y_4}{r_0+r_1+r_2+r_3+r_4}$$

$$\text{where } r_0 = \frac{(x_0-x_1)(x_0-x_1)(x_0-x_3)(x_0-x_4)}{(x-x_1)(x-x_2)(x-x_3)(x-x_4)}$$

$$r_1 = \frac{(x_1-x_0)(x_1-x_2)(x_1-x_3)(x_1-x_4)}{(x-x_0)(x-x_2)(x-x_3)(x-x_4)}$$

$$r_2 = \frac{(x_2-x_0)(x_2-x_1)(x_2-x_3)(x_2-x_4)}{(x-x_0)(x-x_1)(x-x_3)(x-x_4)}$$

$$r_3 = \frac{(x_3-x_0)(x_3-x_1)(x_3-x_2)(x_3-x_4)}{(x-x_0)(x-x_1)(x-x_2)(x-x_4)}$$

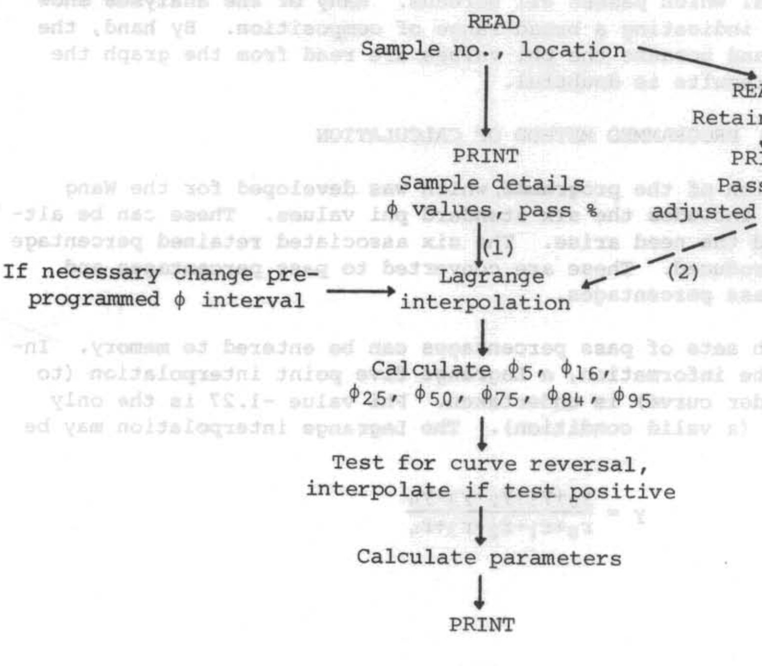
$$r_4 = \frac{(x_4-x_0)(x_4-x_1)(x_4-x_2)(x_4-x_3)}{(x-x_0)(x-x_1)(x-x_2)(x-x_3)}$$

The expression in this form is readily calculated and the five point interpolation has the advantage of fitting a curve across most of the data although it requires a rather special fourth order curve. The interpolation is valid provided that there are no large intervals between the percentage values. Where this occurs the curve may inflect backward which is an unreal situation. A special test is inserted to overcome this and a direct interpolation of the last valid values taken.

In the above equations, $x = \%$, $y = \phi$. The required percentage values are programmed and the appropriate phi values calculated and stored. The phi values are then substituted in the parameter equations.

The success of the above method depends on the suitability of the data to a Lagrange interpolation, noting that such an interpolation will be more accurate and consistent than any other form. While the overall form may resemble third order curves it is not simply possible to calculate these reliably on moderate intervals with limited data.

Programme flow



Example of print-out

SAMPLE : 27 (- 6)

CUM. %	.2	2.2	7.7	27.5	83.7	96.9
PASS %	99.8	97.8	92.3	72.5	16.3	3.1
ADJ. P. %	99.7	97.7	92.0	71.6	13.6	.0

SEDIMENT .. ANALYSIS

SAMPLE	PHI	PASS %	MEAN	DEVIATION	SKEWNESS	KURTOSIS
27(-6)	-1.27	99.8				
	- .27	97.8				
	.73	92.3				
	1.73	72.5				
	2.73	16.3				
	3.73	3.1	2.06	- .80	- .20	4.10
	-1.27	99.7				
	.27	97.7				
	.73	92.0				
	1.73	71.6				
	2.73	13.6				
	3.73	.0	1.95	- .73	- .17	6.98

CONCLUSION

The above example shows the form of print-out and the nature of variations possible in the parameters. Hand calculation of the unadjusted percentages gave results of 1.97, -.79, 0.22, 1.24 respectively. The wide variations in skewness and kurtosis are largely due to poor interpolation by eye across the tails of the curve, although the ϕ_{50} value is also strongly at variance. Tests on data show that the parameters deviation, skewness and kurtosis are subject to wide fluctuations with small changes in curve form. Kurtosis is the most sensitive parameter, due to its direct dependence on ϕ_{95}, ϕ_5 in the tails of the grain distribution graph. It is in the ϕ_{95}-ϕ_{100} and ϕ_0-ϕ_5 ranges that the Lagrange interpolation is most likely to fail, but then only if one screen interval retains most of the sediment, *i.e.* a well sorted strongly leptokurtic material. It is essential however that the data presented cover the extreme values and it may be necessary in odd examples to add a coarse phi value and related % of 99.9 or 100.0. Where there is an adequate range of values the interpolation is not susceptible to failure. Use should be freely made of the capacity to alter phi values for particular conditions and not to rely on the standard intervals for all cases.

Thus in conclusion the process detailed is found to be consistent and reliable provided that appropriate screen distributions are used in each analysis although the latter condition is only critical in very well sorted materials.

REFERENCE

FOLK, P.L.; WARD, W.C. 1957. Brazos river bar - a study in the significance of grain size parameters. *J.sediment.Petrology* 27:3-26.