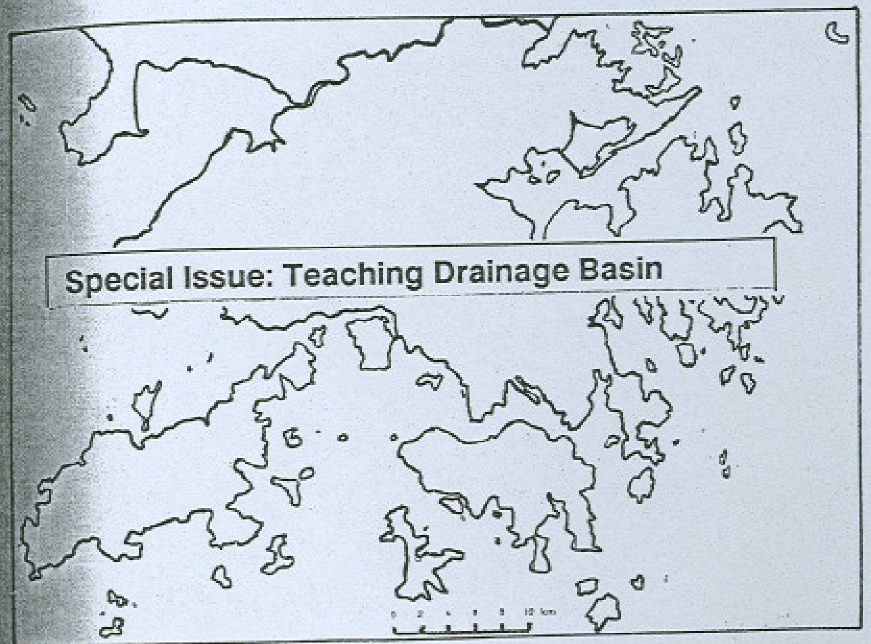
Hong Kong Geographical Association 香港地理學會

THE HONG KONG GEOGRAPHER

VOL.7 NO.3
MAY 1989



Special Issue: Teaching Drainage Basin

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Words from the Editor

In this issue of the Hong Kong Geographer, a number of articles and worksheets were prepared on the teaching of Drainage Basins which is considered by Geography teachers as one of the most difficult topics to teach. Dr. Peart from the Hong Kong University has contributed on the Drainage Evolution and Hillslope Systems. He discussed the key concepts and suggested fieldworks that are practical to all geography teachers. In addition, part of the worksheets prepared by fellow teachers in the Field Study Camp held early this year in the Kadoorie Agricultural Research Centre were included in this issue. We hope members will find these worksheets together with Dr. Peart's article useful in teaching the drainage basin. Other worksheets prepared at the Field Study Camp will be published in the coming issues together with other articles by Dr. Peart on teaching fluvial processes and weathering systems.

Mr. To Ka Yan, a computer nut in the teaching of Geography, has written on the use of content free software to test the Manning's equation. Mr. To has also kindly agreed to share his data file with other users. Anyone interested in his exercise can send me a stamped and strong envelope with a diskette for a data file.*

This is the first time I write an editorial foreward. Without the kind permission and support of Dr. S.M. Li and the contributors to this issue, it would have not been possible. Besides, assistance given by the members of the editorial board is very much appreciated. To all of them, I should express my deepest gratitude.

K.M. Yeung

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The Teaching of Drainage Basin
I. Drainage Evolution and Hillslope System

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INTRODUCTION

Chorley (l969) proposes that the drainage basin is the fundamental unit within which to examine hydrologic and geomorphic systems. There are many topics suitable for teaching in schools involving the drainage basin. This discussion paper is, therefore, forced to select some topics of interest to the teachers. Discussion will be made of the geomorphic unity of the drainage basin and hence the functional link between slope and channel systems. Hillslope erosion and hydrology will be examined.

HYDROLOGY AND DRAINAGE BASIN EVOLUTION

The association between weathering, slope erosion and rivers is shown diagramatically in Figure 1. This tells us that there is a relationship between slopes and streams. We can regard the slope and river systems as part of a continuum. The action of the river may influence slope process and form, while slope processes, through the supply of debris, may govern stream activity.

Students can get much benefit from investigating the relationship between slope and channel gradients. A number of examples show the link between slope processes and stream activity. Slaymaker (l972), working in mid-Wales, UK, monitored sediment supply to the channel system. He found that in six basins sediment supply matched removal and this may indicate adjustment of form to process. The stream would neither erode nor deposit. In three basins removal exceeded supply and degradation of the stream occurred while in one catchment aggradation resulted from an excess of sediment reaching the stream.

An additional piece of evidence that can be used to examine the association between slopes and streams is to examine slope form as represented by slope angle and stream gradient at the base. Strahler (l950) reports that mean valley side slope and mean channel gradient can be related by an empirical equation which implies a balance between

the rates of debris transport in the two systems resultant upon a mutual adjustment of valley side slope and channel gradients. This relationshipis shown in Figure 2 and indicates that as slope angle increases the channel gradient steepens. However, there is some evidence that the positive association between slope and channel gradients may not apply everywhere. For example, the studies of Carter and Chorley (l96l) and Arnett (l97l) suggest a negative relationship between slope and channel gradients. Moreover, Summerfield (l976) was not able to find a correlation between slope angle and channel gradient. These, at first, disparate findings need to be placed in perspective.

However, as Richards (l977) states the relationship between slope angle and stream gradient must be investigated under conditions of constant discharge. The association between stream and slope angles should be carried out for individual order or magnitude streams. We should note that Strahlers (l950) work refers to second order basins. Furthermore, Richards (l977) reports a strong positive association between slope and channel gradients for first order streams but fails to find a significant correlation in fourth order stream segments. This Richards (l977) suggests may be due to a less sensitive association between slope and stream for higher order valleys which, in part, results from floodplain development. Summerfields (l976) failure to find an association between stream and slope gradients may result from his inclusion of observations from streams of several orders. It should also be remembered that as Richards (l977) points out the lack of correlation between slope and channel gradients may result from the ability of a stream to adjust cross-section form in addition to gradient. Moreover, the development of flood plains may cause the link between slope and channel to become obscured (e.g. Richards, l977). Therefore, if students fail to find a correlation between the two variables these alternative explanations may be cited. Richards (l977) also indicates that different processes delivering sediment to the channel system may complicate the identification of slope angle-basal stream gradient relationships.

Additional evidence of the functional relationship between slopes and streams is provided by Strahler (l950) who reports that undercut slopes have a greater angles than those not being actively eroded. This is shown diagramatically in Figure 3. Moreover, we can use these findings to comment upon slope decline, as opposed to parallel retreat, as theories of slope evolution. Where sediment supply from the slope is in excess of the basal streams capacity to remove it, or floodplain construction prevents the material reaching the stream, colluvium develops at the base and ultimately decline results. In contrast if basal stream action ensures removal of the sediment supplied from the slope parallel retreat may occur if one ignores the possible rock cliff at the slope base. These two situations are shown diagramatically in Figure 4.

Figure 1: The association between weathering, slope processes and rivers

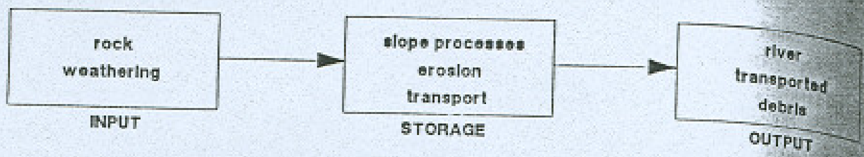


Figure 2: The relationship between slope and channel gradient as found by Strahler (1950)

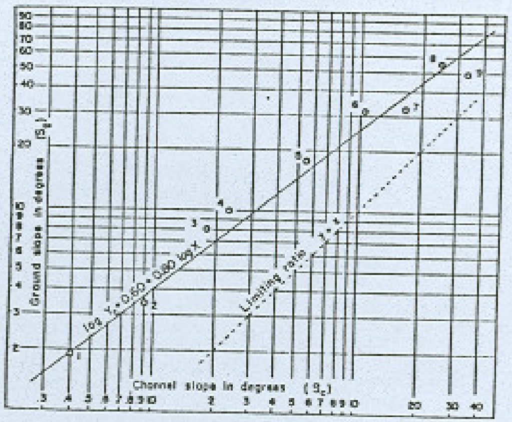


Figure 3: The relationship between slope angle and basal process

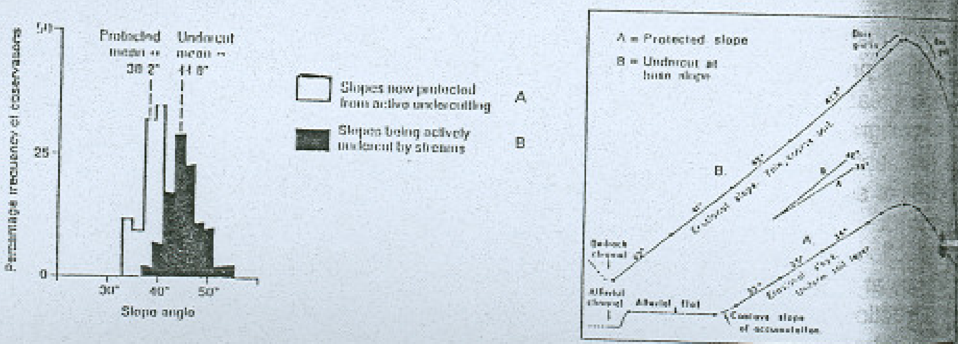


Figure 4: Slope evolution and basal stream action

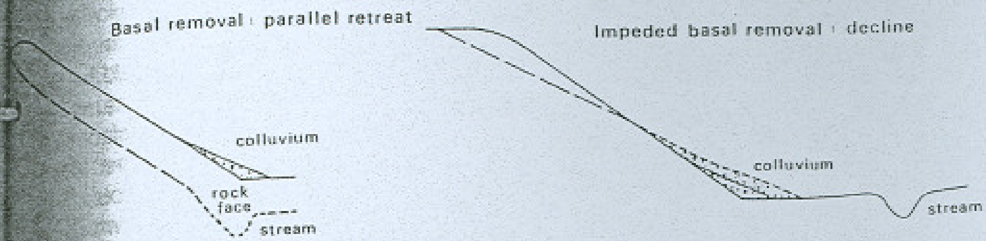
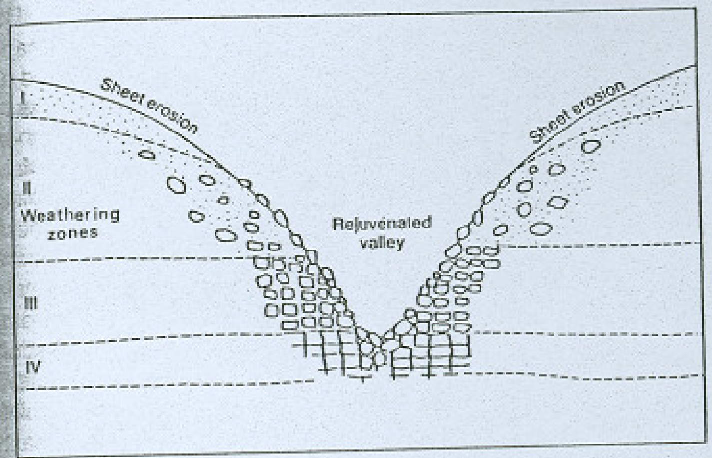


Figure 5: Slope evolution on deeply weathered granite in Hong Kong. After Ruxton and Berry (1957)



We can use the relationship between stream action and slope processes to explain some of our landscape. For example, Ruxton and Berry (1957) present a model of slope development on well weathered granite which has been heavily dissected. The model, shown in Figure 5, explains why we often find boulders to be more prevelant on the lower segments of hillslopes. The heavy weathering associated with the upper horizons prevents boulders occurring in the upper reaches of the slopes. However, stream incision and slope erosion near the stream exposes boulders (in reality, corestones) associated with weathering zones III and IV. In such terrain weathering, stream erosion and slope processes are all involved in the development of the landscape.

The preceding discussion has indicated a number of ways of illustrating the association between slopes and basal stream channels. Three projects suitable for student investigation emerge. These are firstly: investigation of the relationship between slope and channel gradient for streams of a given order. Secondly: comparison could be made of slope angles for slopes which are protected at their base as compared to those where basal erosion by the stream is taking place. Data for all two studies can be collected from the field but the first is amenable to data obtained from maps. For example, Luk (1971) found that mean slope angles obtained from 1:10,000 topographic maps were comparable to those derived from field measurement. Strahler (1950) and Richards (1977) successfully used data obtained from 1:25,000 scale maps to investigate stream-slope gradient relationships.

THE HILLSLOPE SYSTEM

Erosion of slopes by water is an important process of landscape evolution in many regions. The process of erosion can be considered as consisting of the following sequence of events: weathering---detachment---transport---deposition. With respect to fluvial processes operating on hillslopes the following affect detachment: rainsplash; the tractive effect of sheet flow; the tractive effect of concentrated flow in rills and gullies; and pipeflow. Transportation may also be consequent upon these processes.

It is suggested that these processes are not amenable to group fieldwork exercises. Process measurement involves repeat observation at one or more sites over a considerable period of time which may not be practical. However, surface lowering may be measured by erosion pins while sediment traps can be used to examine wash erosion. Splash erosion may be quantified using splash traps/boards or cups. These processes may be suitable topics for individual projects. Furthermore, sediment transport in gullies or streams may also be quantified. Students wishing to undertake individual projects involving the study of erosion should be referred to either Goudie et. al. (1981) or Trudgill (1983) for outlines of suitable methodologies. With respect to examining the spatial and temporal development of erosion. Hansen and Nash (1985) indicate that in Hong Kong aerial photographs may be a valuable source of data. They also suggest that they may enable gully erosion to be quantified.

With respect to group fieldwork it may be necessary to use form to comment upon process. For example, Lam (1969) working on the granite badlands of Hong Kong identifies four lateral belts, which are illustrated in Figure 6, on the hillslope each with a number of differing processes. Moreover, Lam (1969) shows how these belts may evolve with time. Students upon visiting a badland site could be asked to assess the reality of this model. This could be achieved by conducting a simple survey of the hillslope. Alternatively, measurement could be made of the extent of gully development on a hillslope. The objective of each exercise should be to demonstrate the reality of erosion and deposition on the hillslope. However, more benefit could be obtained from a field visit if measurement is made of infiltration, a hydrological parameter which affects erosion by water on hillslopes. If rain is applied to the surface in excess of the infiltration rate, once the surface storage has been filled, overlandflow (sheetwash) may occur. When the infiltration capacity is in excess of the applied rainfall overlandflow will not happen.

Infiltration is a relatively simple measurement to make in the field, however, one or two hours will be needed to obtain one measurement. The reason for this can be ascertained by considering the typical infiltration curve presented for two sites in Hong Kong presented in Figure 7. Figure 7 tells us that infiltration rates typically decline with time and eventually reach a relatively constant rate. It is important to ascertain steady state infiltration because, for much of a rainfall event, this will be the infiltration rate which governs runoff development. The method for the field determination of infiltration rates are given by Burt (1987). Alternatively, Smith and Stopp (1978) or Goudie et al (1981) can be consulted.

Some data on infiltration for Hong Kong is available from the literature and this is presented in Table 1. Field measurement of infiltration capacity can be compared to observed rainfall intensities published by the Royal Observatory and the possibility of rainfall exceeding the infiltration capacity, and hence, forming overlandflow assessed. If rainfall intensity does not exceed infiltration capacity we are not likely to get overlandflow and, therefore, no sheetwash, rill or gully erosion.

Figure 6: Zones of erosion on granitic badlands and their development with time (after Lam 1969)

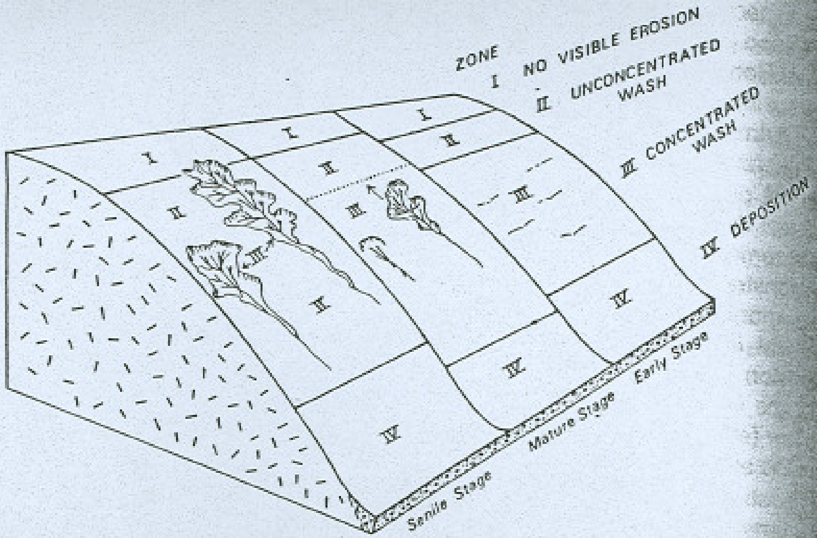


Figure 7: Infiltration rates for three sites in Hong Kong. After Lam (1974)

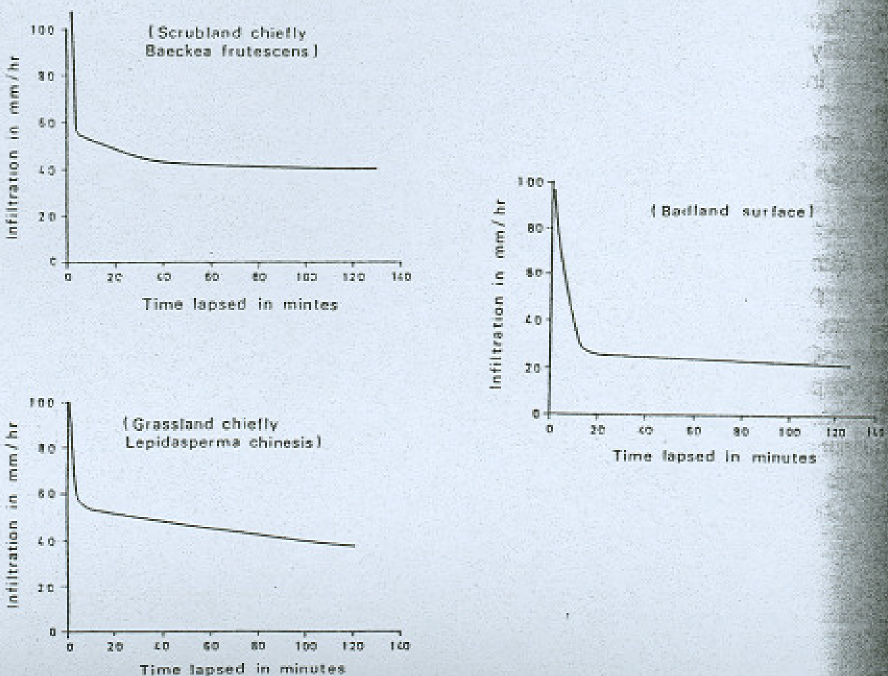


Table 1: Observed infiltration rates in Hong Kong (Lam, 1974)

Site Description	Initial Infiltration Rate mm/hr mm/hr	Steady State Infiltration mm/hr
Vegetated Slope 68% sand	58.1	40.42
Badland Slope 70%sand	40.82	19.87

It is possible to utilise a field visit to some of the badland areas of Hong Kong to illustrate the significance of infiltration in soil and slope erosion.[1] This may be achieved by showing that the measured or published infiltration rates are well below rainfall intensity. Therefore, overlandflow may develop, and hence, with it, rill and gully erosion. This model can be expanded to account for the fact that the gullies do not develop at the divide but only at some point downslope. The explanation for this according to R.E. Horton, upon whose classical model of runoff generation this work is based, may be that at the hillcrest, although rainfall may exceed infiltration capacity, it forms a sheet which has little capacity for erosion. However, at some point downslope Horton argues that sufficient overlandflow accumulates to overcome the resistance of the soil to erosion.

The point at which erosion starts may also see the development of rill erosion. The area of hillslope where wash is ineffective as an agent of erosion because of its inability to overcome the resistance of the soil is called the belt of no erosion. Horton's model of hillslope erosion is shown in Figure 8. Figure 8 also tells us that if slope angle declines we will get deposition of eroded sediment.[2] The Hjulstrom curve is shown in Figure 9 and it relates erosion, transport and deposition to the velocity of flow for specific particle size ranges. If we reduce slope angle we may decrease the velocity of overlandflow. If the velocity of overlandflow is reduced sufficiently the Hjulstrom curve tells us that deposition will occur. Moreover, it also indicates that the coarse material will be deposited first followed by the finer sediments. At the base of some gullies where deposition occurs it may be possible to detect a lateral gradation in particle size and this may form a useful additional exercise.

Figure 8: The Horton model of slope erosion

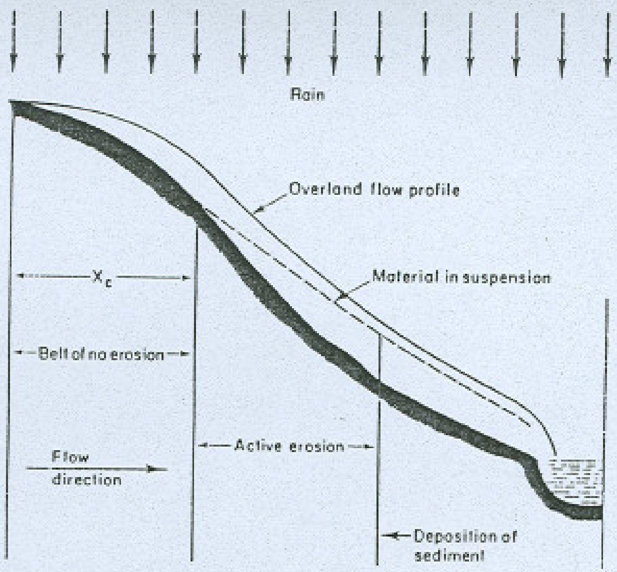
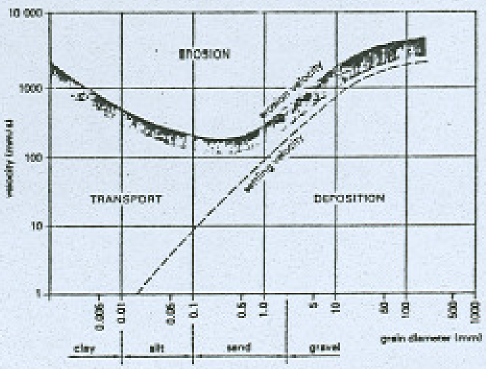


Figure 9: The Hjulstrom curve which relates erosion, transport and deposition to velocity



The students attention should be brought to the fact that the completely vegetated slopes exhibit little sign of erosion. For example, no well developed gullies are present. This may be explained as follows. On the exposed badland slopes rainbeat can cause a surface crust to develop which lowers the infiltration capacity thereby promoting erosion.

In contrast vegetated slopes are likely to have high infiltration rates which do not so readily promote overlandflow. Vegetated slopes have high infiltration rates in part because the organic content of the soil promotes a better structure. Furthermore, the sealing effect of splash erosion is likely to be absent under a vegetative cover. Vegetation is also likely to reduce the velocity of overlandflow which reduces the erosive capacity of the water. Moreover, because of interception there is likely to be less water reaching the ground surface which may act to reduce the volume of water for overlandflow which in turn decreases the potential for erosion. However, field measurements of infiltration, or those from Table 1, for vegetated slopes reveal that overlandflow is likely to develop. Therefore, the reason for reduced erosion on these slopes lies in the protective effects of vegetation against splash detachment which aids entrainment. The less evident erosion may also be attributed to the lower runoff velocities which hinder entrainment by overlandflow. The reduced volume of runoff in comparison to bare slopes also serves to reduce the opportunity for erosion.

It may prove possible to relate infiltration to slope form. It can be argued that where overlandflow becomes an effective agent of erosion the removal of material from the slope will act to increase slope angle. Slopes with high infiltration capacities will generate little overlandflow and hence it requires a greater length of slope to develop sufficient surface runoff to overcome the resistance of the soil and initiate erosion. In contrast slopes with low infiltration rates will soon generate sufficient overlandflow to cause erosion and the upper straight slope and convexity become reduced in importance. These contrasts may be reflected in slope form and this is shown diagramatically in Figure 10. Chorley (1978) suggests that the point at which overlandflow achieves sufficient depth to cause erosion may coincide with rill development. It may be possible to use rill development to define the belt of no erosion. Furthermore, rill development may also coincide with an increase in slope angle.

This consideration of erosion has focussed upon the badlands and neighbouring slopes. The argument can be widened. It has been suggested earlier that erosion might be expected to be greater on bare slopes in comparison to those covered with vegetation. The literature supports such observations. For example, Lam (1978) reports a much lower sediment yield for the basin containing no badland in comparison to two other basins. It should be noted that the basins are similar in all aspects except vegetation cover. The data is presented in Table 2 and it might make a useful exercise for the students to account for the variation in sediment yield between basins.

It is also possible to widen the spatial coverage of slope erosion in Hong Kong which has so far concentrated upon the badland areas. Luk (1971) presents a model of slope morphology in the western New Territories which is presented in Figure 11. As Luk (1971) comments all the slope elements may not be present. He also describes the characteristic slope processes of each of these elements. This may be useful teaching material and is presented in Table 3. Table 3 reveals that for the mid-straight slope transportation of material by mass movement and including soil slips and shallow slumps.

Table 2: Sediment yield and catchment characteristics for three small basins in Hong Kong. After Lam (1978)

Characteristics	Basin A	Basin B	Basin C
Area (km^2)	0.282	0.267	0.240
Badland as % of area	40	24	0
Relative relief (m)	107	183	168
Relief length ratio	0.134	0.227	0.192
Characteristic slope angle	27	25	29
Estimated sediment yield m ton	2,422	1,082	55

Table 3: Slope units and contemporary process. After Luk (1971)

Unit	Dominant contemporary processes	Unit	Process
upper straight slope	vertical soil water movement and lateral seepage	lower concave slope	accumulation and/or removal of colluvial materials & other wash materials
upper convex slope	'soil creep' by unconcentrated flow	lower convex slope	accumulation and/or removal of colluvium
upper rock face	rock fall, mechanical disintegration & ground water seepage	lower rock face	rock fall, ground water seepage & mechanical disintegration
mid-straight slope	transportation of materials by mass movement: soil slips & shallow slumps		

Figure 10: The effect of infiltration capacity upon slope form

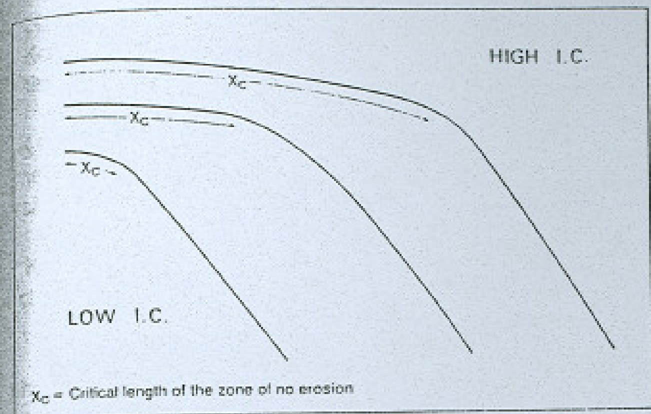
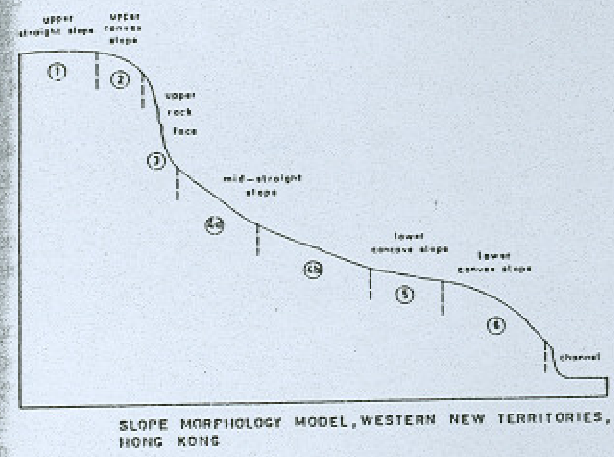


Figure 11: Model of slope morphology in the Western New Territories. After Luk (1971).



Conclusion

Thus far attention has focussed upon water at the surface but we should remember that hillslope hydrology is also concerned with water in the soil. Indeed it is the water content of the soil mantle or colluvium that may result in slope failure. For example, Ruxton (1980) in his examination of hillslopes in Hong Kong reports the following types of failure: firstly, infiltration slips which may be due to infiltration causing saturation of the colluvium or residual debris giving rise to failure especially on steep slopes. Secondly, seepage slips which may develop when water flow in the soil becomes concentrated. Finally, arcuate soil slips develop when an impermeable layer in the soil prevents infiltration giving rise to a saturated layer. This may cause seepage, undermining and failure.

Water may also flow through the soil in pipes or natural tunnels and their development may result in significant volumes of erosion. Nash and Dale (1984) indicate that the superficial and residual soils of Hong Kong provide good localities for pipe development. They identify two major types of natural tunnels in Hong Kong. Firstly, there exist small diameter pipes confined to the A or B horizons up to about I m depth in the soil column. These pipes seem to develop at textural boundaries and their origin is ascribed to root holes and animal and insect tunnels. Finally, pipes may develop deeper within the soil profile, often at a major discontinuity such as that of the residual soil/weathered bedrock interface. Some of these natural tunnels may owe their origin to the piping of groundwater and Nash and Dale (l984) report that some may be 2 m wide. The pipe systems may develop by groundwater flow exploiting and expanding small voids or gaps between corestones and colluvium. Relict joints often govern groundwater movement and pipe development. If pipes are sufficiently developed Nash and Dale (l984) suggest that collapse may result thereby producing gullies. They also indicate that piping may result in slope failure. Therefore, in addition to the erosion associated with their development pipes may also result in gullying and mass movement, features which have been discussed previously. Nash and Dale (l984) also indicate that the development of piping may dewater a slope. This will increase slope stability.

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Hong Kong Geographer 7(3), 15-28(1989)

Using Spreadsheets to Teach the Concepts of River Velocity

by
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INTRODUCTION

In Hong Kong, one of the obstacles to the use of microcomputers in teaching is the lack of software. This is not only a problem of availability but also an issue of suitability. Besides, the majority of the educational software available are subject-specific or content-specific which are not so cost effective since they cannot serve to work for wider purposes. In view of this, some educationists are beginning to look for the potential of content-free or generic software, like word processing, spreadsheet and database.

The advantages of using content-free software can be summarized as follows:

a) To use these programs requires little programming knowledge on the part of the teachers or the students.

b) They are easier to get from the commercial world and are cheaper since many of them are shareware or public domain software.

c) They are more cost effective to purchase than subject-specific software and can be customized to suit many different applications.

d) Different software versions of similar functions are available to fit with the diversity of machines.

e) They are open-ended programs. Teachers may easily insert their own content to suit the needs and ability levels of their students.

Various attempts have been made by geographers to develop teaching programs by using content-free software, such as spreadsheets (Goble 1988, Lee & Soper 1987, Wiegand 1987), database (Worster & Morrison, 1986) and the CELLULAR MODELLING SYSTEM and DYNAMIC MODELLING SYSTEM (Longman 1988).

Considering the degree of prevalence, ease of operation, and suitability to geographical studies, spreadsheets have considerable potential for geographical analysis. This article attempts to illustrate how spreadsheets have been applied to teaching the concepts of river velocity to Secondary Six students in Hong Kong.

THE USE OF SPREADSHEET IN GEOGRAPHY TEACHING

A spreadsheet resembles a large sheet of paper consisting of columns and rows forming a matrix of cells. These cells can contain numeric data, text, formulae and commands. It is possible to develop templates in which some cells have been prepared for data entry while other cells are configured for calculations using those data. When the content of any cell is altered, any values calculated from this cell can be immediately recalculated. Thus, the user can make changes to the data in the template so that predictions of "what if?" nature can be produced.

Spreadsheet programs share similar benefits possessed by other content-free software. In particular, they are relevant to such geographical studies involving simulation, decision making, statistical analysis and data manipulation. Using spreadsheets for the simulation of geographical models enables the student to concentrate on the geographical significance and to explore the relationships of the variables in the model, so that they would not be distracted by arithmetic consideration.

There is a wide range of areas in geography to which spreadsheets can be applied. These may include simulation games, river channel and flow characteristics, industrial location, land rent, population growth, statistical analysis, etc. In general, quantitative models are more easily handled by spreadsheet programs.

There are different types of spreadsheets available for different machines. Some of the more common ones are ViciCalc for Apple II, Viewsheet for BBC and Lotus 1-2-3 for IBM PC. For the latter machine, clones of 1-2-3, such as PC-Calc, are also available at a price much lower than its original. The functions of a spreadsheet can be enhanced by using more advanced spreadsheet programs which incorporate database, word-processing and graphic facilities.

AN EXAMPLE OF SPREADSHEET APPLICATION

a) The idea

In the study of the downstream changes in river flow and channel characteristics, students often find it difficult to appreciate the downstream increase in river velocity because they are concerned solely with the impact of one factor, i.e. stream gradient, on river velocity. In reality, river velocity is dependent on channel gradient, channel form (represented by hydraulic radius), channel roughness and discharge. To express quantitatively the interrelationship between these variables, the Manning equation, which estimates river velocity at bankfull stage, can be used.

The equation is as follows:

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

where :
V is stream velocity (m/sec)
R is channel hydraulic radius (m) defined as channel*cross-sectional area divided by wetted perimeter of the channel
S is channel slope expressed as a decimal (i.e. 1 in 100 =0.01)
n is channel roughness (Manning's roughness coefficient, (see Note 1)

This equation provides a useful theoretical basis for understanding hydrological relationships. Referring to the above equation, the following relationships could be envisaged :

Variables	Relationship
Gradient and Velocity	Positive
Hydraulic radius and Velocity	Positive
Channel roughness and velocity	Negative

The situation is complicated when one adds the "downstream change" element into the investigation, since downstream change in velocity is also related to downstream change in the variables which affect velocity. Based on theoretical and field research, the following general patterns are established with regard to downstream changes in channel characteristics.

Downstream increase in hydraulic radius.
Downstream decrease in channel gradient.
Downstream decrease in channel roughness.
Downstream increase in river velocity.

The above mentioned interrelationships can best be studied by using a spreadsheet which allows the student to explore the factors affecting river velocity one by one and to observe the influence of an individual factor, as well as the cumulative effect of all factors on river velocity changes. Bearing this in mind, a spreadsheet template has been designed to help students understand the complex relationships involved in the downstream change of river velocity and channel form characteristics. The idea of this program is adopted from Goble's work (1988) and modified by the author.

b) <u>The program</u>

The spreadsheet used is VisiCalc of Apple II DOS version which runs on any 48K Apple II machines. This particular version is chosen because Apple IIe is the type of microcomputers available in the school in which the author works. Transferring similar design to other powerful spreadsheets is not difficult. Templates of PC-Calc and Lotus 1-2-3 on the same topic are also available from the author. The explanation given below will refer to VisiCalc version only. But the terms used, the layout and the structure of the templates are basically similar for different versions of spreadsheet programs.

<u>Fig. 1</u>

	A	B	C	D	E	F
1	CHANNEL VELOCITY					
2	GRADIENT					.4
3	CHANGE IN GRADIENT					0
4	HYDRAULIC RADIUS					.8
5	CHANGE IN HYDRAULIC RADIUS					0
6	ROUGHNESS					.08
7	CHANGE IN ROUGHNESS					0
8						
9	STATIO	GRADI	HYDRA	ROUGH		VELOCI
10	1	.4	.8	.08		6.813
11	2	.4	.8	.08		6.813
12	3	.4	.8	.08		6.813
13	4	.4	.8	.08		6.813
14	5	.4	.8	.08		6.813
15	6	.4	.8	.08		6.813
16	7	.4	.8	.08		6.813
17	8	.4	.8	.08		6.813
18	9	.4	.8	.08		6.813
19	10	.4	.8	.08		6.813
20	%CHANG	0	0	0		0

The screen layout of the template as shown in the monitor screen is shown in Fig. 1. Limited by the screen display of Apple IIe which shows only 40 characters in a line at a time, the labels of the variables have to be shortened. STATIO in cell A9 stands for station number along the river. It is assumed that station 1 is near the river head, while station 10 near the river mouth. All the data in the template are hypothetical. Rows 2, 4 and 6 show respectively the channel gradient, hydraulic radius and channel roughness of station 1. Their values are linked to the contents in cells B10, C10 and D10. Rows 3, 5, and 7 display respectively the values of the incremental change of each of the three variables between one station and another. For instance, when -0.03 is input in cell F3, the content in B11 (station 2) will be immediately changed to 0.37 (i.e. 0.4+(-0.03)) and the content in B12 to 0.34.(Fig. 2) Students are allowed to change ithe contents of the cells in column F from rows 2 to 7. Once altered, the values of the cells in columns B to F from rows 10 to 20 will change automatically since recalculations based on the formulae "hidden" in these cells take place.

Fig. 2

	A	B	C	D	E	F
1	CHANNEL VELOCITY					
2	GRADIENT					.4
3	CHANGE IN GRADIENT					-.03
4	HYDRAULIC RADIUS					.8
5	CHANGE IN HYDRAULIC RADIUS					0
6	ROUGHNESS					.08
7	CHANGE IN ROUGHNESS					0
8						
9	STATIO	GRADI	HYDRA	ROUGH		VELOCI
10	1	.4	.8	.08		6.813
11	2	.37	.8	.08		6.552
12	3	.34	.8	.08		6.281
13	4	.31	.8	.08		5.998
14	5	.28	.8	.08		5.700
15	6	.25	.8	.08		5.386
16	7	.22	.8	.08		5.053
17	8	.19	.8	.08		4.695
18	9	.16	.8	.08		4.309
19	10	.13	.8	.08		3.884
20	%CHANG	67.5	0	0		-43.0

The formulae used to obtain the values in the range of cells from B10 to F19 are given in Fig. 3. All formulae that have been typed into the cells are "opaque" to the student. Manning equation is used to calculate the values in the cells of Column F from rows 10 to 19. The values of the cells in columns B to D from rows 11 to 19 are linked to the contents of rows 3, 5 and 7. Row 19 indicates the total percentage of change (%CHANG) of the variables from Station 1 to Station 10.

Fig.3 Formulae used in the template

Row	Column B	C	D	F
10	F2	F4	F6	((B10^(1/2))*(C10^(2/3)))/D10
11	(B10+F3)	(C10+F5)	(D10+F7)	((B11^(1/2))*(C11^(2/3)))/D11
12	(B11+F3)	(C11+F5)	(D11+F7)	((B12^(1/2))*(C12^(2/3)))/D12
13	(B12+F3)	(C12+F5)	(D12+F7)	((B13^(1/2))*(C13^(2/3)))/D13
14	(B13+F3)	(C13+F5)	(D13+F7)	((B14^(1/2))*(C14^(2/3)))/D14
15	(B14+F3)	(C14+F5)	(D14+F7)	((B15^(1/2))*(C15^(2/3)))/D15
16	(B15+F3)	(C15+F5)	(D15+F7)	((B16^(1/2))*(C16^(2/3)))/D16
17	(B16+F3)	(C16+F5)	(D16+F7)	((B17^(1/2))*(C17^(2/3)))/D17
18	(B17+F3)	(C17+F5)	(D17+F7)	((B18^(1/2))*(C18^(2/3)))/D18
19	(B18+F3)	(C18+F5)	(D18+F7)	((B19^(1/2))*(C19^(2/3)))/D19
20	(B19-B10)*100/B10	(C19-C10)*100/C10	(D19-D10)*100/D10	(F19-F10)*100/F10

c) The classroom experience

The spreadsheet program described in this article has been used in the teaching of a Secondary Six class in the computer room during a double-period geography lesson. There were altogether 12 students and each could have access to an Apple IIe machine. No prior experience of computer use by the students was expected. Terms like channel gradient, roughness and hydraulic radius had been explained to them in the previous lessons. It took about 15 minutes to explain briefly the use of the keyboard and the principal ideas behind a spreadsheet. Only the essential points relevant to the use of spreadsheets were mentioned.

The spreadsheet template together with the VisiCalc main program had been loaded into the computer before the lesson started. The monitor displayed the screen layout as depicted in Fig. 1. Students were asked to follow the questions in a worksheet provided (Note 2) and were reminded to alter only the contents of the cells from F2 to F7 in the spreadsheet.

At first, to demonstrate the influence of channel gradient on river velocity, the values of channel hydraulic radius and roughness in all stations had to be kept constant Student were asked to change the initial gradient in cell F2 only and to observe the change in velocity in column F. It should be noted that the gradient value must not exceed 1. Then, they had to change the content in cell F3, i.e. the rate of change in gradient between stations. Before doing this, they had to determine the trend of change. Input of a negative value assumed downstream decrease, whereas a positive value downstream increase. Fig.2 shows the result when -.03 was inserted in cell F3. If a negative value was input in cell F3, the magnitude of change should not be too great because it might result in negative gradient values in the stations in the "lower course". (Fig. 4) Similar procedures and decisions had to be made when data for hydraulic radius and roughness were input into cells F5 and F7.

Fig. 4

	A	B	C	D	E	F
1	CHANNEL VELOCITY					
2	GRADIENT					.4
3	CHANGE IN GRADIENT					-.06
4	HYDRAULIC RADIUS					.8
5	CHANGE IN HYDRAULIC RADIUS					0
6	ROUGHNESS					.08
7	CHANGE IN ROUGHNESS					0
8						
9	STATIO	GRADI	HYDRA	ROUGH		VELOCI
10	1	.4	.8	.08		6.813
11	2	.34	.8	.08		6.281
12	3	.28	.8	.08		5.700
13	4	.22	.8	.08		5.053
14	5	.16	.8	.08		4.309
15	6	.1	.8	.08		3.406
16	7	.04	.8	.08		2.154
17	8	-.02	.8	.08		ERROR
18	9	-.08	.8	.08		ERROR
19	10	-.14	.8	.08		ERROR
20	%CHANG	-135	0	0		ERROR

It appeared that a possible range of values provided by the teacher might be of help to students. For example, the following had been suggested to students :

Variables	Cell	Possible range of values
Channel gradient	F2	0.01 - 0.9
Hydraulic radius	F4	0.01 - 5
Channel roughness	F6	0.025 - 0.1

This is to ensure that a more "sensible" pattern of changes would be observed, and to avoid from having extreme values that would distort the general pattern. Another approach is to allow students to input any value they like, be it sensible or not, and to let them explore the relationships by trial and error. In this case, many curious results may occur and the teacher may be preoccupied with answering student's questions during the whole course of study.

The effects of hydraulic radius and channel roughness on river velocity were examined separately, and the results are given in Figs. 5 to 6. (Refer to questions 4 and 5 in the worksheet) Finally, the students were left to work through the tasks. When the content of the cells F2 to F7 had been altered, river velocity was found to increase downstream. (Fig. 7) The final results of the work of each student were printed out and used for comparison and discussion.

Fig.5

	A	B	C	D	E	F
1	CHANNEL VELOCITY					
2	GRADIENT					.4
3	CHANGE IN GRADIENT					0
4	HYDRAULIC RADIUS					.8
5	CHANGE IN HYDRAULIC RADIUS					.05
6	ROUGHNESS					.08
7	CHANGE IN ROUGHNESS					0
8						
9	INTERV	GRADI	HYDRA	ROUGH		VELOCI
10	1	.4	.8	.08		6.813
11	2	.4	.85	.08		7.278
12	3	.4	.9	.08		7.765
13	4	.4	.95	.08		8.278
14	5	.4	1	.08		8.819
15	6	.4	1.05	.08		9.391
16	7	.4	1.1	.08		9.996
17	8	.4	1.15	.08		10.63
18	9	.4	1.2	.08		11.63
19	10	.4	1.25	.08		11.95
20	%CHANG	0	56.25	0		75.46

Fig.6

	A	B	C	D	E	F
1	CHANNEL VELOCITY					
2	GRADIENT					.4
3	CHANGE IN GRADIENT					0
4	HYDRAULIC RADIUS					.8
5	CHANGE IN HYDRAULIC RADIUS					0
6	ROUGHNESS					.08
7	CHANGE IN ROUGHNESS					-.005
8						
9	INTERV	GRADI	HYDRA	ROUGH		VELOCI
10	1	.4	.8	.08		6.813
11	2	.4	.8	.075		7.267
12	3	.4	.8	.07		7.786
13	4	.4	.8	.065		8.385
14	5	.4	.8	.06		9.084
15	6	.4	.8	.055		9.910
16	7	.4	.8	.05		10.901
17	8	.4	.8	.045		12.112
18	9	.4	.8	.04		13.626
19	10	.4	.8	.035		15.572
20	%CHANG			-56.3		128.56

Fig.7

	A	B	C	D	E	F
1	CHANNEL VELOCITY					
2	GRADIENT					.4
3	CHANGE IN GRADIENT					-.03
4	HYDRAULIC RADIUS					.8
5	CHANGE IN HYDRAULIC RADIUS					.05
6	ROUGHNESS					.08
7	CHANGE IN ROUGHNESS					-.005
8						
9	INTERV	GRADI	HYDRA	ROUGH		VELOCI
10	1	.4	.8	.08		6.813
11	2	.37	.85	.075		7.278
12	3	.34	.9	.07		7.765
13	4	.31	.95	.065		8.275
14	5	.28	1	.06		8.819
15	6	.25	1.05	.055		9.391
16	7	.22	1.1	.05		9.996
17	8	.19	1.15	.045		10.63
18	9	.16	1.2	.04		11.29
19	10	.13	1.25	.035		11.95
20	%CHANG	-67.5	56.25	-56.3		75.46

During the lesson, students had been stimulated by the program to think and ask questions. Originally each student was expected to work individually with a computer. Later it was found that some students preferred to work in pairs so as to facilitate discussion. For the more brilliant students, they discovered that if the percentage of change (%CHANG) of a variable was much larger than that of the other variables, the influence of other variables on river velocity might be suppressed. Fig. 8 shows how dominance of gradient over other variables could have led to a downstream decrease in river velocity.

None of the students was unable to produce correct answers to the worksheet. They found no difficulty in understanding the interrelationships involved in the downstream change of river velocity. They were also particularly interested in inputting extreme values and guessing the resultant changes in velocity. A few male students seemed to enjoy the activity and asked for permission to run the template again in the computer room after school.

Fig.8

	A	B	C	D	E	F
1	CHANNEL VELOCITY					
2	GRADIENT					.5
3	CHANGE IN GRADIENT					-.055
4	HYDRAULIC RADIUS					.8
5	CHANGE IN HYDRAULIC RADIUS					.05
6	ROUGHNESS					.08
7	CHANGE IN ROUGHNESS					-.005
8						
9	INTERV	GRADI	HYDRA	ROUGH		VELOCI
10	1	.5	.8	.08		7.617
11	2	.445	.85	.075		7.981
12	3	.39	.9	.07		8.316
13	4	.335	.95	.065		8.605
14	5	.28	1	.06		8.819
15	6	.225	1.05	.055		8.910
16	7	.17	1.1	.05		8.787
17	8	.115	1.15	.045		8.272
18	9	.060	1.2	.04		6.915
19	10	.005	1.25	.035		2.344
20	%CHANG	-99	56.25	-56.3		-69.22

d) Limitations and further modifications

There are a number of limitations associated with the use of VisiCalc templates on Apple IIe. They include slow speed of computation, 40 column screen display, inconvenience in changing the movement direction of the cursor, lack of graphics, etc. These would be eliminated if a more powerful spreadsheet program run on IBM compatible machines is used. Fig. 9 shows the template layout of the screen using the PC-Calc spreadsheet program. Obviously, this layout gives a better visual impression to the user. But, using an advanced spreadsheet implies the need for more money to purchase spreadsheet programs and machines.

Fig. 9

	A	B	C	D	E	F
1	Relationship between stream velocity and channel characteristics					
2						
3	Channel	Change in	Hydraulic	Change in	Channel	Change in
4	gradient	channel	radius	Hydraulic	roughness	channel
5		gradient		radius		roughness
6	.050	-.004	.800	.50	.080	-.005
7	----------	----------	----------	----------	----------	----------
8	Interval	Channel	Hydraulic	Channel		Velocity
9		gradient	radius	roughness		(m/sec)
10	1	.050	.800	.080		2.409
11	2	.046	.850	.075		2.566
12	3	.042	.900	.070		2.729
13	4	.038	.950	.065		2.898
14	5	.034	1.000	.060		3.073
15	6	.030	1.050	.055		3.253
16	7	.026	1.100	.050		3.436
17	8	.022	1.150	.045		3.618
18	9	.018	1.200	.040		3.788
19	10	.014	1.250	.035		3.923
20	Total----------	----------	----------	----------	----------	----------
21	change %	-72.000	56.250	-56.250		62.848

The spreadsheet template could be modified by fitting fieldwork data into the cells so that a more realistic picture could be obtained. Also, the learning experience of using spreadsheets could be further enhanced by asking students to setting up their own templates. This certainly could not be carried out in the class, but could be achieved through the Geography Society under the guidance of the teacher.

Perhaps, the best way to appreciate the use of the template mentioned in this article is to actually run it on the computer. This spreadsheet application represents an initial attempt in exploring the possibilities of using spreadsheets to assist teaching or learning of a geographical concept. The author is by no means an expert in this field. Indeed, one of the purpose of this article is just to arouse the interest of the readers in certain aspects of computer use in teaching. There may be pitfalls both in the design of the templates and in the teaching strategy adopted. Moreover, the effectiveness of the program in assisting learning has not been seriously assessed and evaluated. This requires the feedback from both the students and the teachers who have used the template. Effective use of a program also relies on the availablity of comprehensive guidelines, instructions and worksheets to both teachers and students. All these require the cooperation of and the support from the teachers as well as members of academic societies/institutions. Perhaps it is now time for "somebody", be it the Geographical Association or the Geography Section of the Advisory Inspectorates, to consider organising teachers with some knowledge of computing into groups to make use of the available spreadsheets to design templates and their associated documents for geography teaching.

CONCLUSION

The spreadsheet template described above is applied to river velocity changes, but the principles underlying its construction are relevant to many other geographical analysis. In view of the fact that it is unlikely that more subject-specific educational software will be developed in the near future, it is time for teachers to explore the use of spreadsheets in geographical teaching.

References

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Wiegand, P.(1987) "Teaching geography with spreadsheets", Teaching Geography, 195-197.

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Note 1 : Values of Manning's roughness coefficient (n) for different stream channel sections

Stream description	Bad	Channel state Fair	Good	Best
Minor streams (<30 m wide at bank-full)				
Lowland				
Clean, straight, no rifts or deep pools	.033	.03	.0275	.025
Some weeds or stones	.004	.035	.033	.03
Clean winding, some pools or shoals	.045	.04	.035	.033
More stones	.06	.055	.05	.045
Sluggish reaches, weedy, deep pools	.08	.07	.06	.05
Upland (no vegetation in channel except at bank-full; banks steep)				
Gravel, cobbles and some boulders on bed	.05	.04	.035	.03
Cobbles and large boulders on bed	.07	.06	.05	.04
Major streams (>30 m wide at bank-full)				
Regular reach with no boulders or weed	.06	.05	.035	.025
Irregular and rough section	.1	.08	.05	.035

Note 2 : Worksheet

Exercise on stream velocity based on Manning's Equation

1) It is assumed that station 1 is nearest to the source of the stream (headwater), and the last station is nearest to the river mouth.

2) You can adjust the initial units for channel gradient (F2), hydraulic radius (F4) and channel roughness (F6), as well as their respective rates of change.(F3, F5, F7)

3) Keep roughness and hydraulic radius constant, change the units for gradient. See what happens to stream velocity.
<Insert data into cells F2 and F3. Make sure that cells F5 and F7 show a 0 value.> ---> Other factors being constant,velocity ________(decreases/increases) with ________(decreasing/increasing) gradient ________ (downstream/ upstream).

4) Keep roughness and gradient constant, change the untis for hydraulic radius. See what happens to stream velocity.
<Insert data into cells F4 and F5. Make sure that cells F3 and F7 show a 0 value.>
---> Other factors being constant, velocity ________(decreases/increases) with ________(decreasing/increasing) hydraulic radius________(downstream/ upstream).

5) Keep gradient and hydraulic radius constant, change the untis for roughness. See what happens to stream velocity.
<Insert data into cells F6 and F7. Make sure that cells F3 and F5 show a 0 value.>
--->Other factors being constant, velocity ________(decreases/increases) with ________ (decreasing/increasing) roughness________(downstream/ upstream).

6) Change all the units of gradient, roughness and hydraulic radius, what happens to the change in velocity downstream ?
<Alter the data in cells F2 to F7.>

In general, stream velocity ________ (decreases/ increases) with increasing distance away from the headwater.

Worksheet 1 Hydrological Processes in the Drainage Basin*

1.Objectives

a. To illustrate the effects of vegetation on infiltration rate.
b. To study the relationships between infiltration rate and slope form.

2.Study Method

a. Select two slopes, one is vegetated and the other is bare which shows signs of gullying and extensive erosion.
b. Measure the infiltration rates of both sites using the infiltrometer.
c. Draw sketches of both sites showing slope angles and erosion features.
d. Make tape and abney measurement of the slopes.

3.Questions for Discussion

a. What kind of surface has a higher infiltration?
b. What are the hydrological consequences if the rainfall intensity exceeds infiltration rates?
c. What are the differences in runoff between vegetated and eroded slopes?
d. The following diagrams show 2 slopes with same slope angle but different slope development. Using information from a to c, give an explanatory account.

e. What does the difference in runoff tell about the rate of erosion?
f. Why the badland slope exhibits severe gully erosion?

*Modified from a worksheet prepared by Mr. C.L. Yeung et al (1989) during the Geography Field Camp held at Kadoorie Agricultural Research Centre

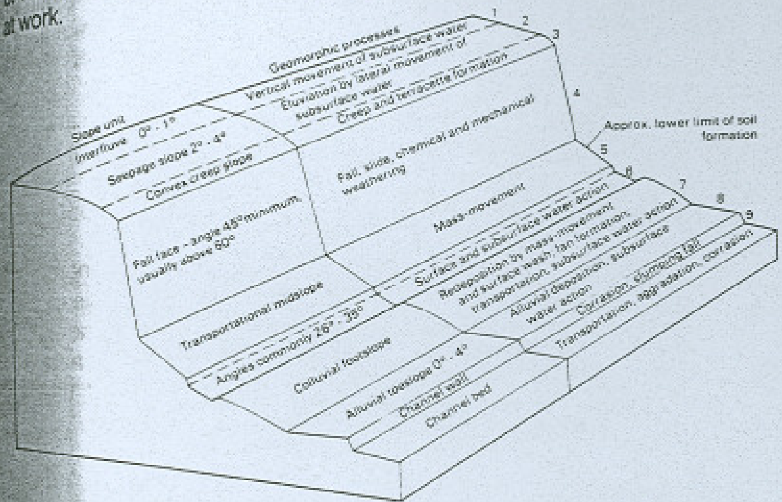
Worksheet 2 Slope Forms and Slope Processes**

1.Objectives

a. To identify the major components and processes of a slope subsystem.
b. To determine the critical length of the zone of no erosion.
c. To study the major factors influencing the form of a slope.

2.Study Method

a. Identify the major components of two slopes selected for study.
b. With the use of the following diagram, identify the major processes at work.



c. Compare the slope forms and processes of the selected slopes.
d. Based on information on O.S. maps, measure the critical length of the zone of no erosion.

3.Questions for Discussion

a. By referring to the following factors, account for the differences in the critical length of the zone of no erosion:
i. geology
ii. hydrological factor
iii. vegetation cover
b. With reference to the slopes examined, discuss the main factors influencing the forms of slopes.

**Modified from a Worksheet prepared by Miss L. Cheng et al (1989) during the Geography Field Camp held at Kadoorie Agricultural Research Centre

News of the Hong Kong Geographical Association

1. Geography of China and Tourism Exhibition

The Geography of China and Tourism Exhibition was successfully held on April 28-30, 1989 at the Shatin Town Hall. A total of more than ten schools took part in the activity. This was joined by map exhibits brought by colleagues from Beijing. Dr. Daniel Tse, President of Hong Kong Baptist College and member of the Legislative and Executive Council, gave the opening speech. The opening ceremony was also officiated by Profs. C.K. Leung, Y.M. Yeung and D.F. Fitzgerald of HKU, CUHK and Baptist College, respectively, Dr. Anthony Yeh, Chairman of Hong Kong Geographical Association and Mr. C.W. Yuen, Chairman of the Organization Committee.

2. Hong Kong Geography Day, AGM and EGM

The Hong Kong Geography Day, 1989, and the year's annual general meeting (which was immediately followed by an extraordinary general meeting) were held on March 11, 1989 at the Rayson Huang Theatre, HKU. Some 100 people took part in the event. A new executive committee was elected at the AGM. Members of the current exco are:

Dr. Anthony Yeh (Chairman)
Mr. Yeung Chi Ling (Hon. Secretary)
Mr. Yeung Pui Ming (Hon. Treasurer)
Mr. Y. W. Fung
Mrs. K. K. Wan
Mr. Chan Tat On
Mr. Yuen Ching Wai
Dr. C. M. Luk
Dr. Li Si Ming

3. Land Information System Course

A course on the land information system consisting of a series of 5 lectures, jointly offered by Hong Kong Geographical Association and the Extramural Studies Department of the Chinese University will commence on June 24, 1989. Drs. A. Yeh, T. Fung and S. Cheung will lecture in this course. The medium of instruction is Cantonese. Admission fee is set at HK$ 300.00. Members who are interested in the course should register at the Extramural Studies Department, Chinese University, Oriental Centre, 14/F, 67 Chatham Road, Kowloon.

4. University of Bristol Association of Alumni

The University of Bristol Association of Alumni was recently formed and would like to draw attention of HKGA's members who are graduates of Bristol to this matter. For further information please contact Alastair Scott (Tel: 5-264475, evenings; 5-610221, daytime).