Pitty Pantometer
(aka the Slope Machine)

A collation of pantometer references unearthed to date, along with comments

As undergraduates, we were, if on a field class taken by Alistair, all introduced to the pantometer. It was a useful and cheap way of generating lots of field data that would then feed the growing insatiable demands of quantitative geomorphology.

I used one for my undergrad dissertation, awkwardly taking it on the bus up to the wilds of north Northumberland. I also used it for my PhD. Although, still a little embarrassing, I recall damaging the leather door trim of Roger Arnett's newly acquired car which I think he had been bequeathed by a relative. The ones Alistair provided were made of roughly cut aluminium brackets with sharp corners and I slammed the car door without checking that the pantometer was fully inside!

Hull University geography students getting to grips with an aluminium pantometer

But, the most travelled, at least in the 1970s, went with me to the remote Turkana region on the Ethiopian border of Northern Kenya. A tricky moment was having to put it together in Nairobi airport arrivals where the customs officers were very suspicious as to what it was and wanted a convincing demonstration. You need not know that there was some disbelief that anyone would want to do with it what I told them we were planning!

Professor Ian Reid

Journal of Geology, Vol 76, No.6, Nov 1968, University of Chicago - *an excerpt*

A SIMPLE DEVICE FOR THE FIELD MEASUREMENT OF HILLSLOPES[1]

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ABSTRACT

Many authorities have referred to the need for field measurements of hillslopes. The methods commonly adopted do not necessarily provide the kind and quantity of data that would be most useful in slope analysis. A simple instrument has been designed in an attempt to overcome some of the main limitations of existing methods. The advantages of the new device include its suitability for the surveying of slopes of very different relief scales and its prolific yield of data; the slope surveyor using this instrument does not require specialized training or the aid of a field assistant.

INTRODUCTION

Leopold *et al.* (1964, p. 385) refer to "the dearth of descriptive measurement of both form and process on slopes." One of the major problems which prevent a more rapid progress in meeting the first of these deficiencies is the lack of adequate and universally applicable methods for collecting descriptive data (Zakrzewska, 1967, p. 165).

It seems clear that, for several reasons, a method of slope measurement should be prolific in its yield of data (Pitty, 1967). One

[1] Manuscript received January 8, 1968; revised April 26, 1968.

[JOURNAL OF GEOLOGY, 1968, Vol. 76, p. 717-720]

way of achieving this rapidly is to make ground-surface lengths along a slope profile as short as possible. Measurements are a more faithful representation of the actual form of the ground, the larger the number of points fixed on the slope surface, an advantage for visual inspection of a profile, can be read accurately and quickly to the nearest half-degree. With its aid, and without undue effort, a day's field work can produce 1,500–2,000 measurements. This device has been termed a slope pantometer (Pitty, 1966) and is constructed either from well-seasoned wood or with right-angle gird-

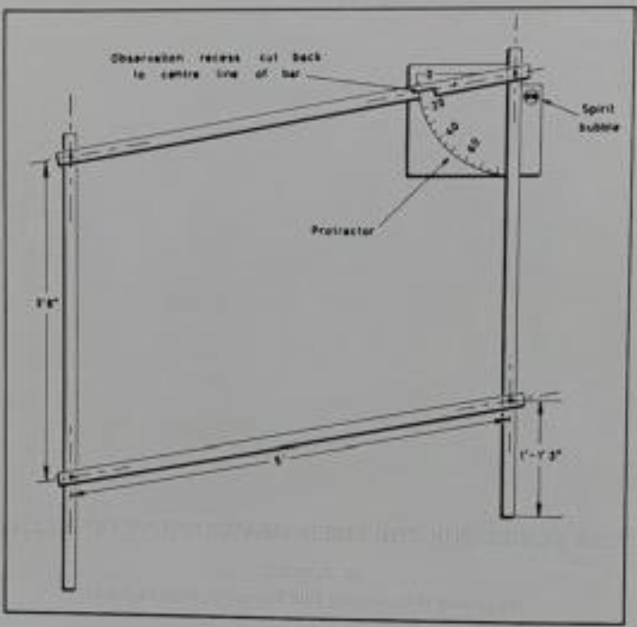
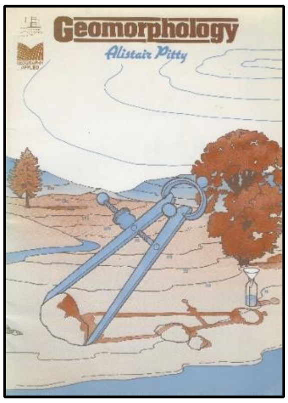


FIG. 1.—The slope pantometer

for curve fitting, and for constructing slope-angle frequency distributions. If, in addition, the ground-surface lengths are equal, the quality of the data increases considerably (Pitty, 1967), and the measuring process speeds up if the fixing of the ground-surface length is an integral part of that process.

DESCRIPTION OF THE SLOPE PANTOMETER

With the above considerations in mind, a simple instrument has been designed which ers of lightweight alloy. It consists of two uprights, each with a bolt near the top and bottom. One of the uprights has a large protractor scale attached, centered on the upper bolt. Two crosspieces, with holes exactly 5 feet apart, lined with metal sleeves if wooden slats are used, complete the parallelogram (fig. 1). The use of spring washers makes the swiveling motion of the device easier to control. Wing nuts are preferable for holding the cross-pieces to the uprights, as it is then easy to set up or dismantle the



Geomorphology (*Geography Applied*)
a slim textbook for geography students,
Blackwells, 1984

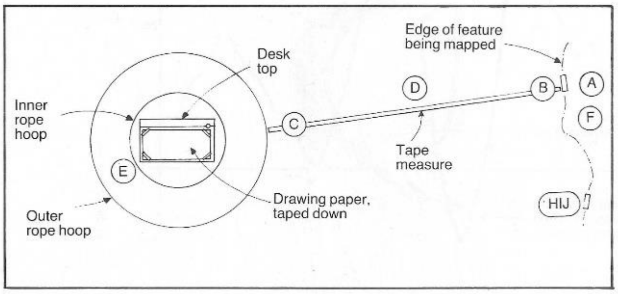


Fig 2.12 Field positions for plane-table survey team

mean gradient or stream size, can be compared as dimensionless graphs. In these diagrams, both horizontal and vertical points are plotted as percentages of the total distance and of the total fall.

EXERCISES

2.14 Select a river known to you, preferably in an area for which geological maps are available, and draw its long profile.
(i) Locate any major changes of profile gradient on the map. Are these related to geological changes? If not, what other explanations could be suggested?
(ii) Record human stream-side activities, past and present, on the profile. Do these change downstream? With passage of time? If so, why?
2.15 How many human activities can you think of which are affected by stream gradient? Select and describe a specific example.

Slope angles and slope profiles are currently the most widely used measurements of landform. Slope angles are basic to geomorphology, simply because landform is made up of an infinite number of slope angles. Slope profiles are important in defining the significance of changes in slope gradient.

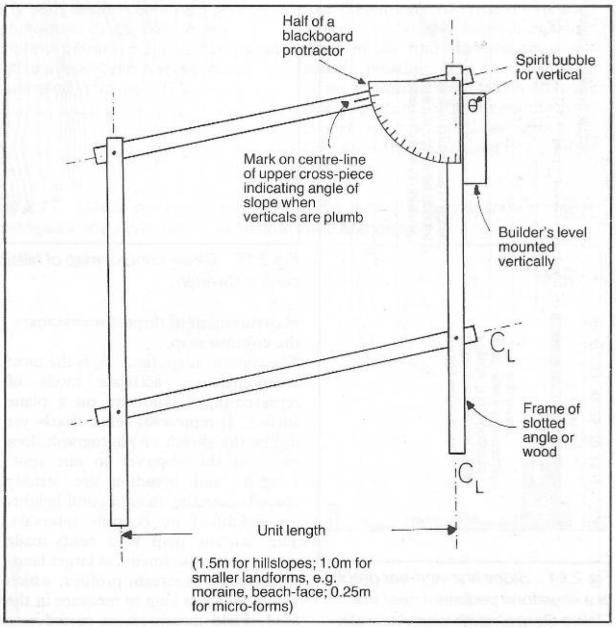
Slope angles in a profile sequence are easily measured in the field by a slope pantometer, a folding parallelogram of slotted alloy angle (fig 2.13). A group of six or more can be involved in a pantometer survey. Tasks include the plotting of angles on graph paper as they are recorded, to produce histograms and line graphs which are then ready for inspection as soon as the profile survey is complete (fig 2.14). However, the advantage of the pantometer survey is that it can be completed single-handed, an advantage where individual project work is required.

Cross-sections describe the width and height or depth of landforms and are commonly used for measuring landform where downvalley or downslope gradients are less important (for example in river channel cross-sections).

EXERCISE

2.16 Select a small, accessible stream and obtain permission to follow its course and wade across.
(i) Make several cross-section measurements (as in fig 4.14 on page 37) with tape measured and metre rule. Calculate width/depth ratios and devise an index of asymmetry.
(ii) Does cross-section shape change as the plan-pattern of the stream changes?
(iii) Can you discover locations where cross-sections can be compared above and below (*a*) a main tributary junction? (*b*) an artificial structure (bridge parapet, weir, dam)? (*c*) a lithological change between contrasted rock types? (*d*) a belt of woodland? (*e*) a zone of accelerated denudation (deforestation, building site)?

Fig 2.13 A slope pantometer

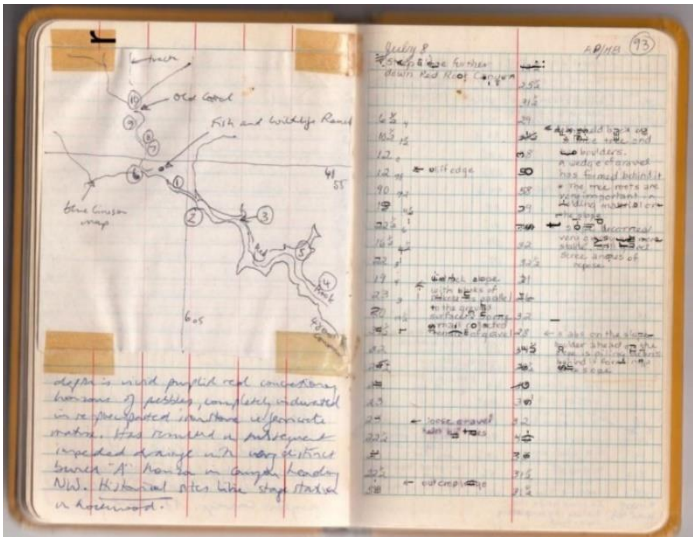


13

Geoarchaeology projects

The Pinon Canyon-Fort Carson project [early ‘80s] is also where the slope machine made its debut. I had known Alistair for about a day and set him up in the field HQ when he proudly took this contraption out of his well-worn suitcase and explained its field application. Several days later he held a meeting with our (very large) team and guided us through its uses and advantages. By that time the rest of our team was riveted by his explanations and saw the relevance to classifying the morphology of the tributary gullies and channels of southeast Colorado. Alistair and I assembled a talk outlining our approach to the National Park Service archaeological Management Team. His delivery was always engaging. In most cases, the archaeologists were initially skeptical, but they eventually bought in.

Dr. Joe Schuldenrein



Alistair’s field notes, Pinon Canyon,
photo courtesy of Joe Schuldenrein

The pantometer was subsequently used on other US geoarchaeology projects.
This photo is from ‘profiles of eroded shores’, Lake Red Rock, Iowa (’84)

ILLUSTRATION OF ANALYSES OF GROUND-SURFACE ROUGHNESS, USING THE EXAMPLE OF PEDIMENT HILLSLOPES IN SOUTHERN COLORADO - PERSONAL COMMUNICATION

A.F.Pitty

INTRODUCTION

1. The significance of ground-surface roughness

Ground-surface roughness is an aspect of terrain microgeometry that is often mentioned briefly in a wide range of environmental studies, yet is not commonly studied in detail. Roughness ranges from the chaos of rockfall debris (Figure 1) to the smoothness of a golf-course putting green. It reflects both the effect of rock type and associated weathered debris sizes, and of the erosional and depositional processes operating on the ground surface. In scale, it falls between the sizes of mineral particles of soil and sediment and those of contour intervals on maps.

2. The field measurement of ground-surface roughness

The present approach depends critically on the use of a surveying instrument designed specifically for acquiring abundant field data in this size range. This device is termed the 'slope pantometer' (Figure 2), a parallelogram of 4 slats which pivot at each corner. When the uprights, with builders' level attached, are set exactly vertical, the inclination of the cross-pieces defines the slope angle for the distance spanned between the two uprights. In measuring a downslope sequence of slope angles, the upslope upright is placed on the point occupied by the downslope upright for the preceding measurement. There is, thus, a random element incorporated into a given measurement, reflecting the chance of an upright landing on a locally high or low point in the terrain microgeometry. This random element is best seen in the scatter on a 'slope-angle line graph' (Figure 3). This diagram plots $\underline{x}$ values, the order of measurements downslope from 1 to $\underline{N}$, where $\underline{N}$ is the last measurement at the base of the hillslope, against $\underline{y}$ values, the slope angle in degrees. The analogy with 'noise' in time-series data is self-evident (Figure 3).

3. Calculation of an Index of Ground-surface Roughness (R.I.)

The 'noise' in Figure 3 is due to the successive differences between pantometer measurements, and this oscillation in the data affords an index for groundsurface roughness. The formula, based on the Mean Square of Successive Differences (M.S.S.D.), is given in Figure 4, together with an illustration of the actual hillslope shape in profile (Figure 4 A), the corresponding line graph (Figure 4 B), and the downslope sequence of the R.I.'s calculated (Figure 4 C). For present purposes, a sequence of 5 slope angles is used in the calculations (Figure 5), 4 successive differences being sufficient to establish a reliable mean figure, but short enough to maximise the number of roughness indices that can be calculated for a given hillslope profile.

The next instalment is perhaps from the late '90s. Pieced together across six large long sheets, the display was aimed at students and other visitors to the Rural Technology Unit, School of Development Studies, University of East Anglia. The panels have been reconstructed with photos, text, graphs and tables.

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A simple index to describe roughness of eroded ground surfaces

Alistair F. Pitty
(Consultant in Applied Geomorphology)

The slope pantometer

Slope pantometer in action on the Wadi Al-Batin alluvial fan, Kuwait

Slope pantometer ready for action on the Erosion Plot on the Experimental Farm of the School of Development Studies, University of East Anglia, Norwich

Exact levelling with easily portable, simple and inexpensive kit

Downslope profiles should be orthogonal to contours. Equally, cross-profiles should be surveyed along traverses with zero gradient overall.

With little expense and physical effort, these conditions can be established adequately and simply.

In a length of water-filled, transparent tubing, water finds its own level to an accuracy of ± 1mm/500m.

Visualizing pantometer profiles

The short step of pantometer measurements means that highly detailed, realistic profiles can be drawn.

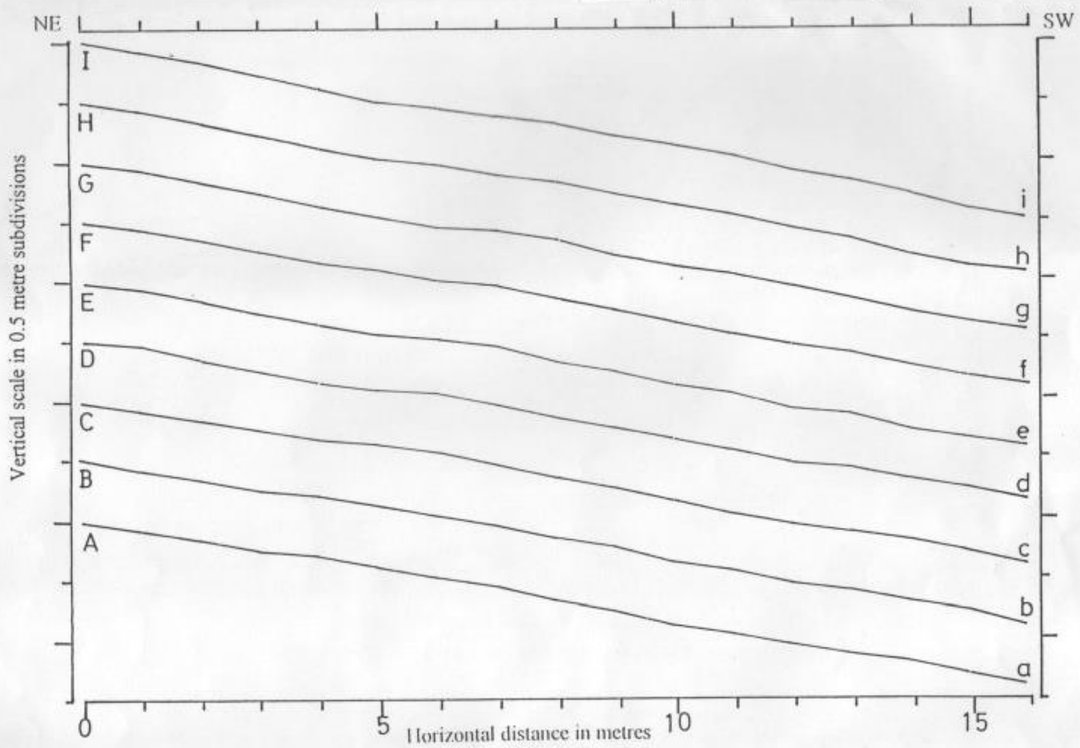


Figure 3. Downplot profiles on the experimental plot (VE x 2).

Profile lines are spaced 1 m apart. In the graph, they are arranged vertically from Aa up to Ii, to give a semi-3D impression. The view is from the NW fence, looking SE, with profile Aa in the foreground.

Visual advantage of line graphs

However, that detail can be represented more precisely, in the form of a line-graph, in which each point can be plotted on x-y co-ordinates.

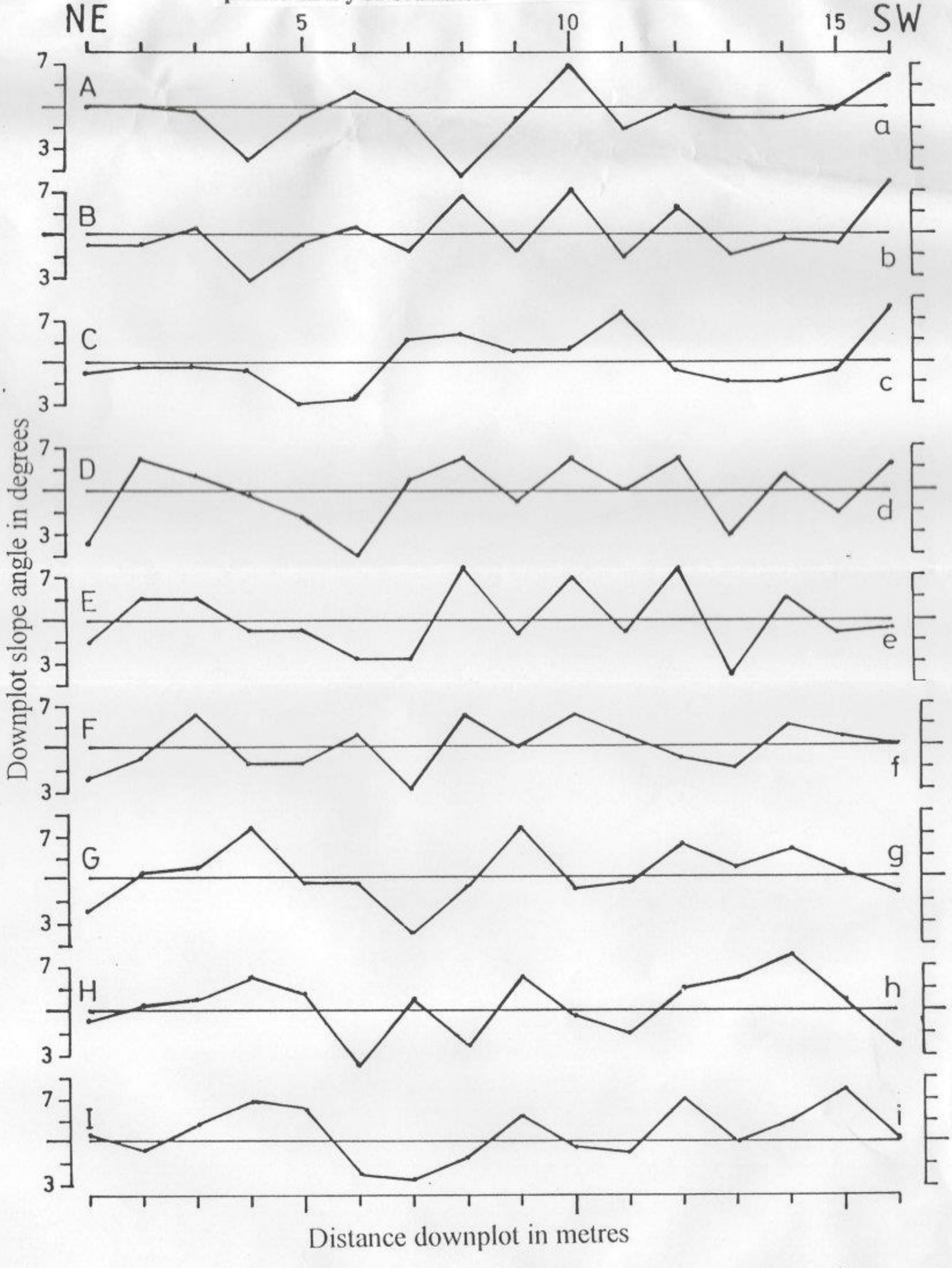


Figure 5. Line graphs showing the downplot sequence of slope angles. The unit length of the measurements is 1 m and the 9 downplot profile lines are spaced 1 m apart.

Further, the scatter of a line-graph, expressing successive differences between a series of measurement, give a visual impression of changes in 'roughness' of the ground surface.

Accuracy of the method

Tables 1. Comparison of methods in the field survey of downslope angles on an experimental plot.

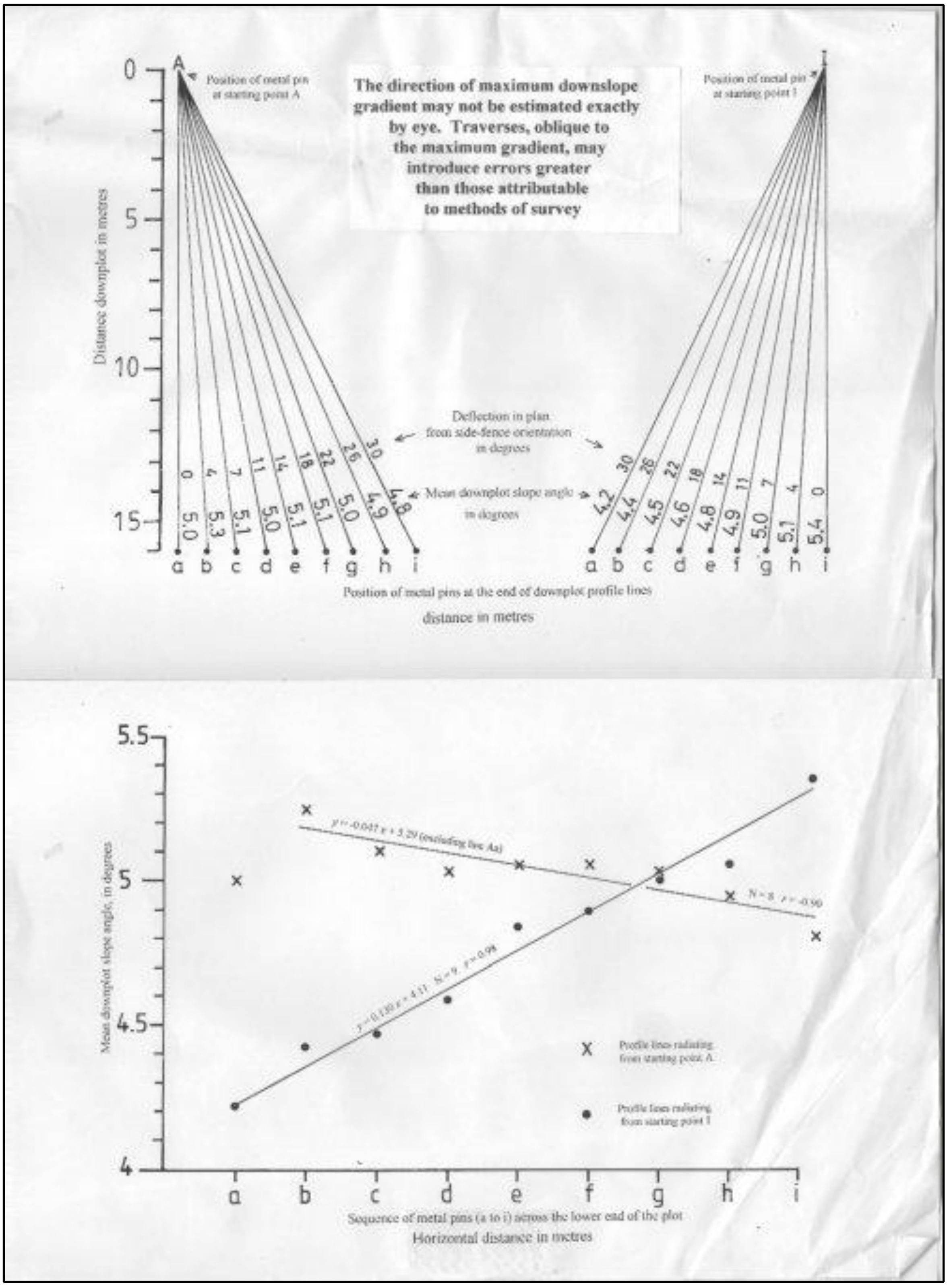
Downplot profile code	levelled	Pantometer means			Abney level
		run 1	run 2	run 3	
Aa	5.052	5.00	5.11	4.98	4.8
Bb	5.088	5.00	5.06	5.08	5.2
Cc	5.027	4.98	4.97	5.00	5.0
Dd	5.074	4.92	5.02	4.95	5.0
Ee	5.164	5.02	5.09	5.09	5.0
Ff	5.146	5.00	5.06	5.13	5.2
Gg	5.259	5.14	5.17	5.23	5.2
Hh	5.203	5.20	5.14	5.17	5.0
Ii	5.268	5.38	5.31	5.28	5.25
mean	5.146	5.07	5.10	5.10	5.07

9 metal pins, A – I, were drived into ground level, at 1m intervals, along the upper perimeter of the erosion plot. 9 corresponding pins, a – i, were positioned similarly, along the lower perimeter. The relative altitudes of the 18 pins were surveyed with an AT-F TOPCON Auto-level and telescopic alloy staff. The 9 pairs of altitudes were converted to slope gradients, for comparison with sequences of 16 pantometer measurements down each profile line. Three devices were used. Both levelling data and pantometer surveys are compared with surverys by Abney Level, a pocket-sized, hand-held instrument.

Downslope view of the experimental plot.

The fact that ‘erosion’ is not apparent does not detract from the purposes and findings of the present, methodological studies.

Importance of orientation of survey lines



The 'Roughness Index', based on pantometer measurements

Table 2. Indices of ground-surface roughness for downplot profiles, based on successive differences of slope angles for 1m ground-surface lengths.

Downplot profile code	up-plot third	middle third	down-plot third	up-plot third means	middle third means	down-plot third means
Aa	1.15	2.35	0.70			
Bb	1.15	2.35	1.70	0.92	1.93	1.25
Cc	0.45	1.10	1.35			
Dd	1.70	2.00	2.35			
Ee	0.95	2.45	2.65	1.32	2.15	1.97
Ff	1.30	2.00	0.90			
Gg	1.25	2.00	1.10			
Hh	1.20	2.10	1.50	1.23	1.70	1.48
Ii	1.25	1.00	1.85			
means	1.16	1.93	1.57			

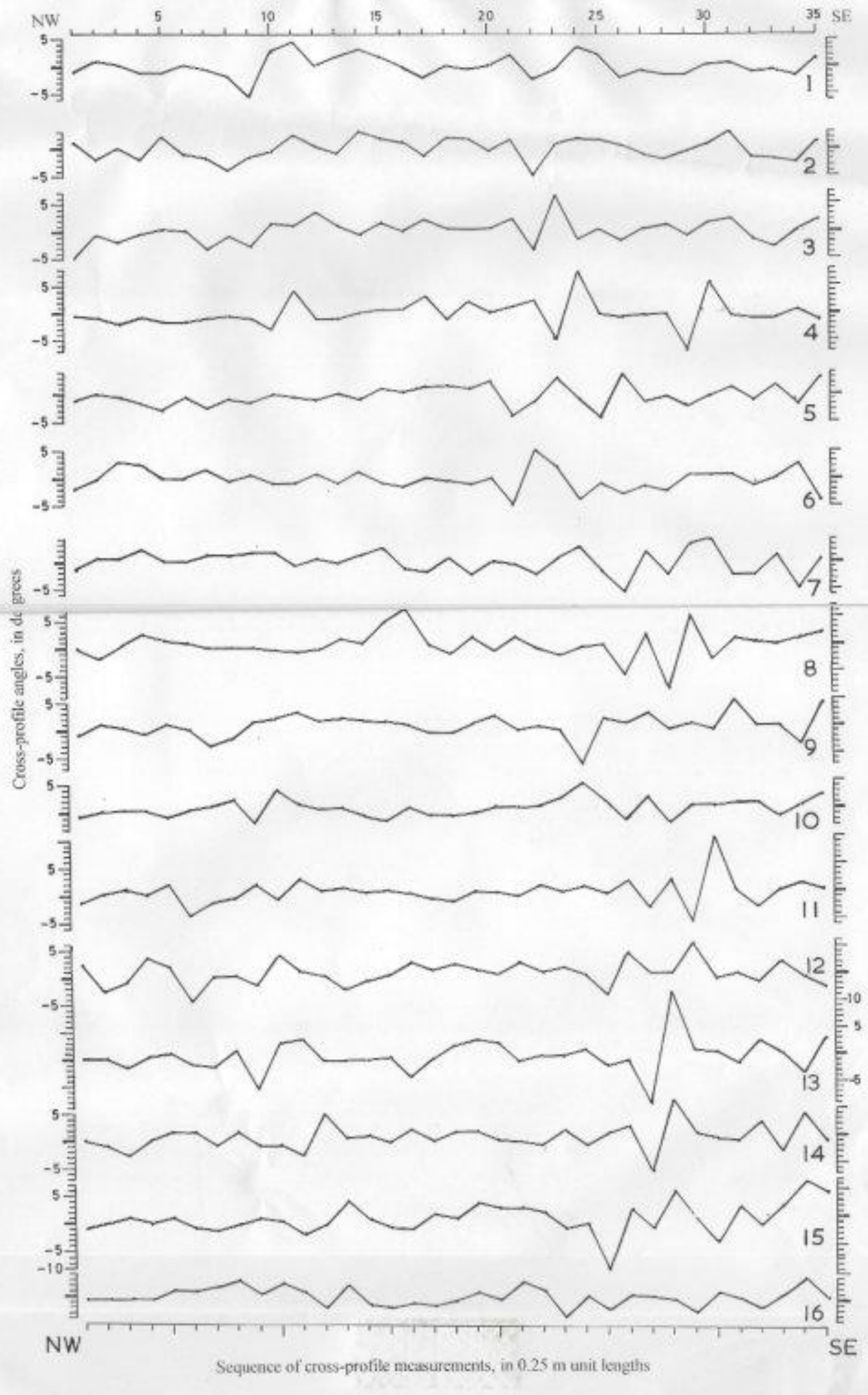
The Roughness Index is a simple calculation. From a selected number (*n*) of measurements, it is the mean of absolute values (*abs*) of successive differences, *n* - 1, between successive pantometer readings:-

$$\text{Roughness Index (R.I.)} = \frac{1}{n-1} \sum_{i=1}^{n-1} abs\,(x_i - x_{i+1})$$

Table 3. Comparison of downplot roughness with that observed on selected natural and semi-natural ground surfaces.

	upper third	middle third	lower third	means	
stony clay experimental plot	1.16	1.93	1.57	1.55	Bluebell Road, Norwich, Norfolk
marginal rangeland vertisol	2.32	1.65	2.44	2.44	Piñon Canyon, S Colorado
sandy gravel plain with calcrete	0.77	0.76	1.03	0.85	Wadi al Batin, N Kuwait
relict sand dune	1.15	0.79	0.71	0.88	Simpson Desert, NW Australia

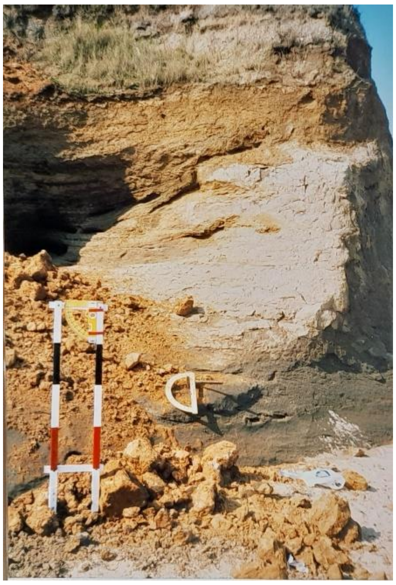
Cross-plot line graphs
(0.25 m units)



Cross-plot Roughness Indices
(0.25m units)

Table 5. Ground-surface roughness indices for cross-plot profiles, grouped into three cross-plot zones.

Cross-profile code	whole profile	Left (NW) flank	Central zone	Right (SE) flank
1	1.88	2.27	1.96	1.41
2	2.27	2.36	2.69	1.70
3	2.40	2.14	3.00	2.00
4	2.73	1.73	2.96	3.48
5	2.17	1.09	2.13	3.32
6	2.09	1.39	2.81	2.00
7	2.38	0.93	1.92	4.32
8	2.71	0.95	2.48	4.70
9	2.08	1.52	1.33	3.45
10	1.60	1.64	0.96	2.25
11	2.64	2.34	0.83	4.91
12	2.65	3.16	1.48	3.41
13	3.19	2.68	1.42	5.64
14	2.82	2.20	1.56	4.82
15	2.74	1.16	1.73	5.41
16	1.85	1.18	2.17	2.18
mean	2.39	1.80	1.96	3.44

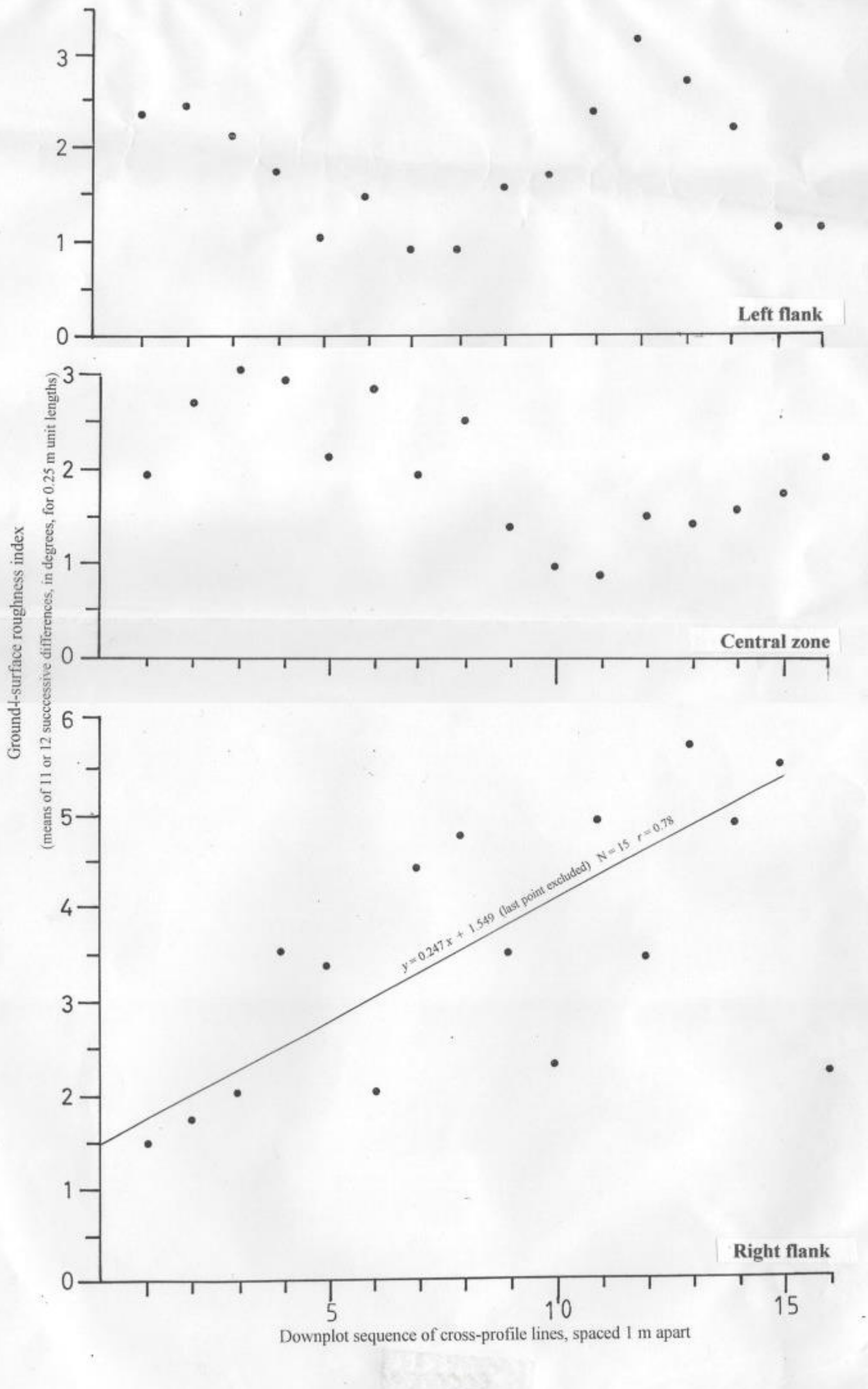


For microforms, like small-scale slumps, or minimal rilling by water erosion, a small pantometer step is preferable.

Thus, for the cross-profiles in the present exercise, a 0.25m version of the device is used.

Note that in cases where incision is greater, a 180° protractor would be fitted to measure the large-scale negative values that would be encountered.

Geographical trends



Further Work

The focus of the present exercise is clearly limited to a methodological enquiry, with an emphasis on a simple, rapid and inexpensive approach. Several tests show that the approach is robust, powerful, and incisive. Characteristics of ground-surface roughness, too subtle to observe by field inspection, are specified by the 'Roughness Index'. Even clear-cut geographical trends are revealed.

Particular acknowledgement is due to Willie Buhler and Don Saunders, Rural Technology Unit, School of Development Studies, University of East Anglia. They both encouraged this exercise and facilitated access to the experimental erosion plot. Their permission to establish semi-permanent survey pins, and to conduct repeated surveys, is much appreciated.

Possibly, their devegetation of one half of the erosion plot may induce accelerated erosion. However, their purpose is essentially a demonstration of basic principles, visiting the Rural Technology Unit.

Further research, applying the pantometer approach to temporal and spatial changes in ground-surface roughness, may be better directed towards locations where there are large-scale changes, such as seasonal changes, following tillage. Clearly, the approach may have greatest potential relevance to areas where portable, simple, and inexpensive equipment is an advantage.

Currently, some on-going research focuses on other types of engineering problems, such as erosion of regularised landslip areas, mine spoil stability, and coastal erosion. In such circumstances, too, an index of ground-surface roughness proves to be a useful descriptive tool.