Morphological imaging techniques and the presentation of large-scale erosional features of the Land's End peninsula

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Introduction

This note reports on the use of terrain digitisation and computer imaging techniques in presenting large-scale erosional features of the Land's End peninsula, Cornwall. These techniques, when combined with an adequate terrain data base, can synthesise aerial views of the landscape and are currently being used by the authors to aid geomorphological field-work in the Land's End area.

Morphological Imaging

The term Morphological Imaging (MI) is used here to describe the mathematical processes and methods used in the presentation of surface data. These include techniques whereby altitudinal data, for example, may be processed to produce a pseudo 3-D perspective image or 'aerial' view of a landscape from any chosen point of observation. The perspective images, or block diagrams, are produced by first taking a set of points defined in Cartesian co-ordinates (x, y, z) with respect to the observer, calculating the angular position of each point in turn, and then connecting the resultant points for successive x and y co-ordinates. The plots have the appearance of a convoluted net and are generally known as 'cheesecloth' images.

Alternatively, the data may be processed to give a cartographic evaluation of particular attributes such as relief (i.e. generalised contours, superimposed profiles etc) or slopes. For this purpose a similar mathematical routine is used to create images of surface morphology as a mosaic of variable tone elements (known individually as 'pixels'). These images are generally photographic in appearance but possess an accuracy and clarity dependent on the data resolution. Although the production of 3-D images is by no means a novel technique, both the cheesecloth and mosaic processes may be used to represent surface morphology with true perspective, as opposed to oblique projection techniques which use simple factoring for depth. The mosaic routine may also be used without perspective in order to create plan representations of topography, where altitude and slopes, for example, may be indicated by pixel intensity.

All the techniques described above were developed by the authors as a suite of computer programs in FORTRAN and BASIC languages.

Terrain Digitisation

As a preliminary exercise a data file of spot heights was compiled by collecting observations from the appropriate O.S. 1:25,000 sheets. Height values were observed at 250m intervals along casting and northing lines and, following conversion to metres, were coded into a computer data file. This file consisted simply of rows and columns (y and x values) of spot heights (z values), where the location of each height in the file matrix inferred its grid reference relative to an assumed origin. This set of altitudinal data was supplemented by spot heights of zero metres at the appropriate locations in order to model the sea around the peninsula. This gave an eventual array size of 10000 (100 x 100) height values representing a geographical area of 625km^2

A finer data resolution was used in some instances. This was obtained by interpolating between spot heights, using a 2nd-order polynomial (quadratic) surface-fit routine, which yielded a second array of spot heights at a resolution of 125m. In the absence of a high resolution data base (i.e.< 10m) it was felt that mathematical interpolation was preferable to measuring additional spot heights manually from the O.S. maps.

A further stage of interpolation was also examined in some cases (i.e. in order to give a 62.5m resolution), although this was done solely as an image enhancement exercise, and of course does not improve the accuracy of the data.

Finally, the locations of granite tors inspected during a field survey of the area were defined in terms of Cartesian co-ordinates and compiled in an additional data file

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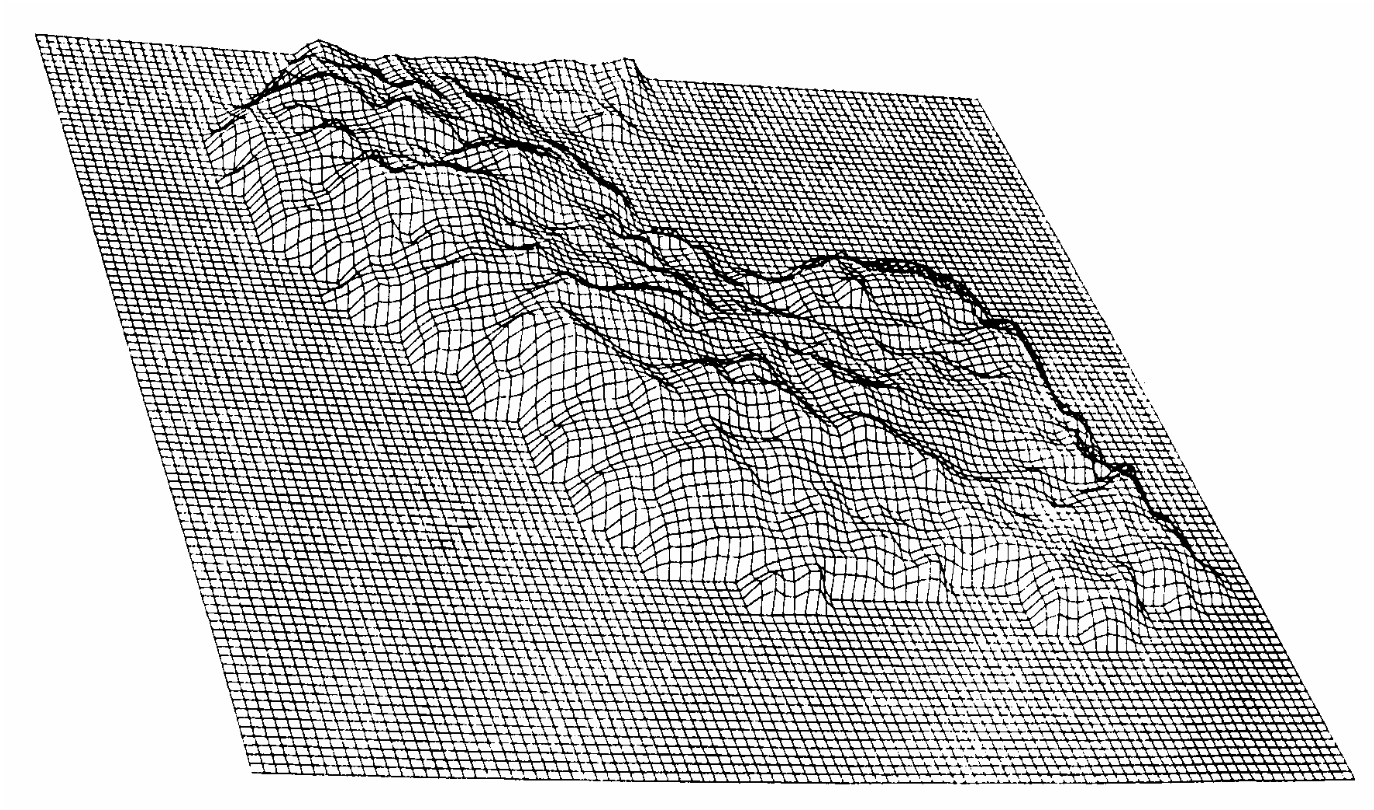

Figure 1. Simulated aerial view of the Land's End peninsula, looking SE.

Results

Cheesecloth Images

The entire peninsula was viewed from various attitudes in order to create a series of 'aerial' pictures of the topography (Fig. 1). Experimentation with a vertical exaggeration facility suggested that z-value magnifications of x 2.5 to 4 produced a satisfactory impression of the main landscape components without undue distortion of the topography. Figure 2 shows a closer view, looking due south, of the coastal stretch near Trendrine Hill, west of St Ives.

Slope Map

Figure 3 illustrates a composite mosaic map of the Penzance area (O.S. 1:25,000 First Series Sheet SW 43), where the pixel elements (at a 62.5m resolution) have been coded according to the maximum slope calculated within each element. The slopes are illustrated on the basis of a linear gradation from light tones (slope = 0 to dark tones (slope ≥ 14°), since at this scale of reproduction individual pixel characters are not discernable. Also shown superimposed on this plot are the positions of granite tors and corestones mapped in the field, as well as examples of computed generalised contours.

Discussion

Presentation of high level surfaces

In the Land’s End peninsula the occurrence of a seaward-dipping platform backed by a bluff at 131m O.D. is now well known. Reid (1890) described these features and attributed them to Pliocene marine erosion. This view was adopted by Gullick (1936), who reported the presence of a platform at 122m O.D., together with surfaces at heights of 55m, 183m and 228m O.D. Robson (1944) documented surfaces at 131m, 183m and 229m O.D., while Balchin (1964) discussed the general topography of the district and identified a break in slope at 122m O.D. More recently, the 131m surface, as it has become known, has been ascribed by Goode and Wilson (1976) to marine planation during the early Pleistocene.

There can be no real substitute for fieldwork in the recognition of these erosion surfaces, and established cartographic or statistical techniques may aid their better definition. However, MI techniques allow a virtually instantaneous perspective or cartographic view of the landscape, and permit flexibility in emphasising or

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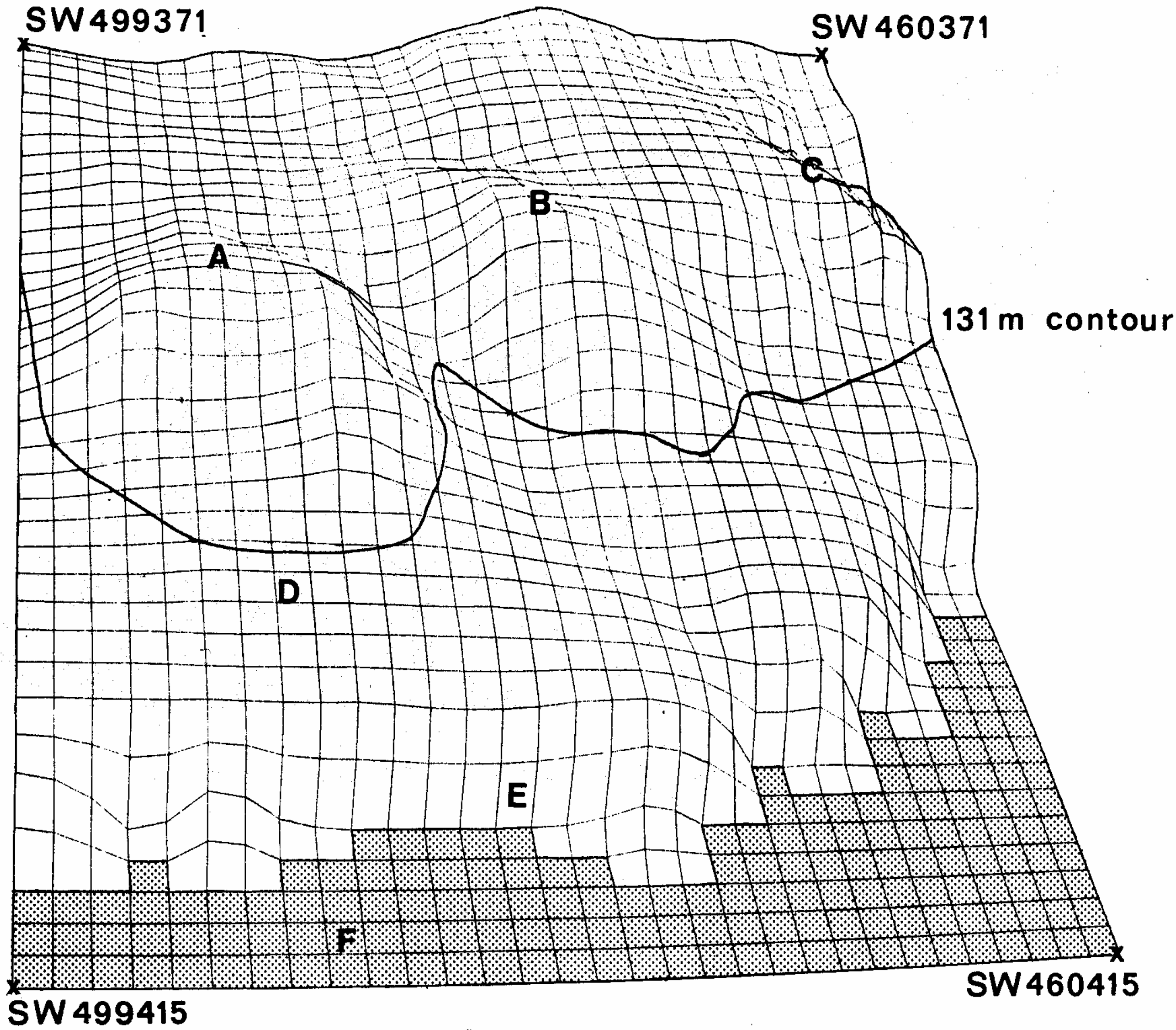

A	Rosewall Hill
B	Trendrine Hill
C	Zennor Hill
D	131m surface
E	modern cliffline
F	sea

Figure 2. Simulated aerial view of the coastal area west of St Ives, showing the salient topographical features. View looking south (125m resolution, X4 vertical exaggeration).

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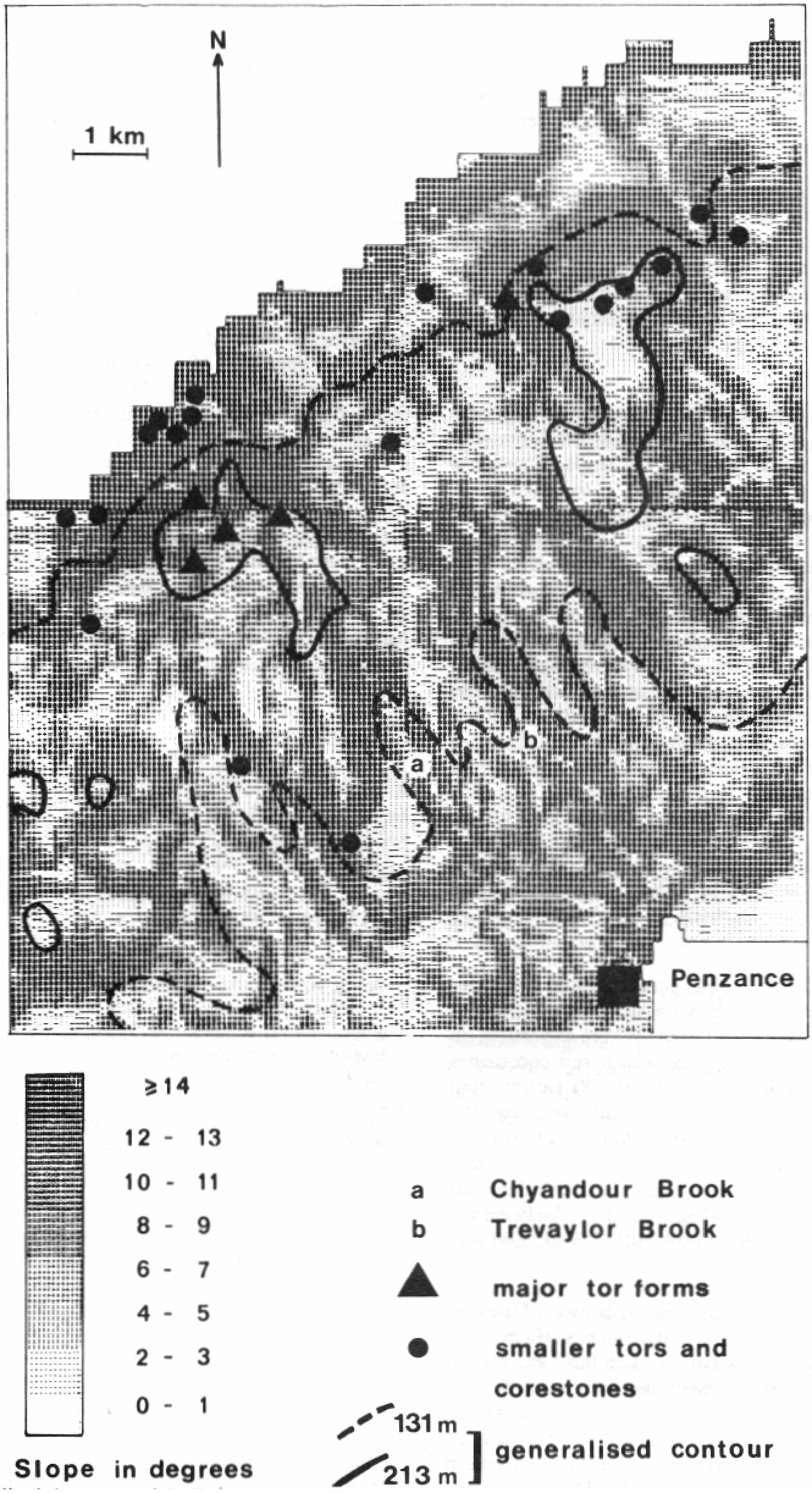

Figure 3. Generalised slope map of the Penzance area, showing the locations of granite exposures (tors and corestones) examined during a field survey. Examples of generalised contours are also illustrated.

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comparing different attributes for the relief. For example, the composite map of the Penzance area (Fig. 3) illustrates that there are relatively level areas in the narrow stretch of the 131m surface paralleling the north coast, and suggests the presence of plateau remnants above the 213m contour.

The 131m platform is also represented in Figure 2, where a narrow section of it is shown in detail. An altimetric frequency subroutine option in the imaging program indicated that 30% of all the terrain spot heights (250m resolution, N=4025) occurred within the height interval 91m to 131m, thereby illustrating the extensive nature of this surface in the landscape.

Slopes

The clinographic mosaic (Fig. 3) indicates the extent and character of the slopes comprising the erosional elements of the landscape. In this example, the areas of steepest slopes (□14°) occur, not surprisingly, along the line of the modern bevelled cliffs, on the incised scarp backing the 13 lm platform, and in the valleys of the SE-trending drainage system (Chyandour, Trevaylor and Rosemorran streams). More level areas are represented by the valley interfluves and the higher plateau remnants over 213m O.D. Some of the valley floors (a and b in Fig. 3) also seem to be characterised by relatively gentle slopes. Although this could reflect infilling by the alluvium or head reported by Goode and Wilson (1976), it should be noted that interpolation produces a 'smoothing' effect and that this could influence any attempt at interpretation.

The usefulness of this technique is again largely a function of the data resolution. In this case a more detailed view was not feasible, although the generalised slope pattern is well represented.

Bedrock Exposure

Recent work (Griffith 1977) has demonstrated that there is a paucity of granite bedrock exposure between 9 lm and 122m O.D. in the Land's End area, Where exposures do occur they take the form of large weathered corestones (such as the Giant's Rock at SW454388) rather than major tor forms. This view is reinforced by the occurrence of tors up to about 90m O.D. on the headlands of the north and west coast, while summit tors and blockfields characterise the silhouette of the bluff backing the 131m platform (Fig. 3), particularly on the dissected scarp between Rosewall Hill (SW495394) and Cam Kenidjack (SW388329).

On this basis it is probable that the distribution of the tors is related to the geometry of the high-level surfaces and, as Goode and Wilson (1976) and others have suggested, the bluff at 131m O.D. represents an ancient cliffline.

Morphological imaging can provide a useful support technique for viewing tors both as individual entities and in the context of the overall landscape. However, imaging of individual tor micro-morphology would only be effectively applied in conjunction with a high-resolution data base.

Conclusion

Essentially, the morphological imaging methods described above comprise a number of terrain modelling techniques, some of which are similar to established cartographic methods, while others have counterparts in the expanding fields of remote sensing and satellite image processing. In this respect MI is intended to supplement rather than replace surveys carried out in the field or from the air.

In general, these techniques allow an overview of the large-scale erosional components in the landscape of the Land's End district. Morphological imaging is flexible and cost-effective, but the efficacy of the techniques is heavily dependent on the data base. For this reason the more extensive erosional features are quite well defined, but detailed forms such as individual tors are virtually undetectable at a 125m or 250m resolution.

References

Balchin, W.G.V. 1964. The denudation chronology of South West England. pp 267-281 *In* 'Present Views and Some Aspects of the Geology of Cornwall and Devon', ed. Hosking, K.F.G. and Shrimpton, G.J. *Roy. geol. Soc. Cornwall,* Penzance.

Goode, A.J.J. and Wilson, A.C. 1976. The Geomorphological Development of the Penzance Area. *Proc. Ussher Soc., 3,* 367-372.

Griffin, M.W. 1977. A Study of Bedrock Micro-morphology in South West England. *Unpublished M. Phil Thesis (2 volumes),* Middlesex Polytechnic, (CNAA, 1977).

Gullick, C.F.W.R. 1936. A Physiographic Survey of West Cornwall. *Trans. Roy. geol. Soc. Cornwall, 16,* 380-399.

Reid, C. 1890. The Pliocene Deposits of Great Britain. *Mem. Geol. Surv. U.K.*

Robson, J. 1944. The Recent Geology of Cornwall. *Trans. Roy. geol. Soc. Cornwall, 17,* 132-163.

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