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Graphicacy Through Landscape Models

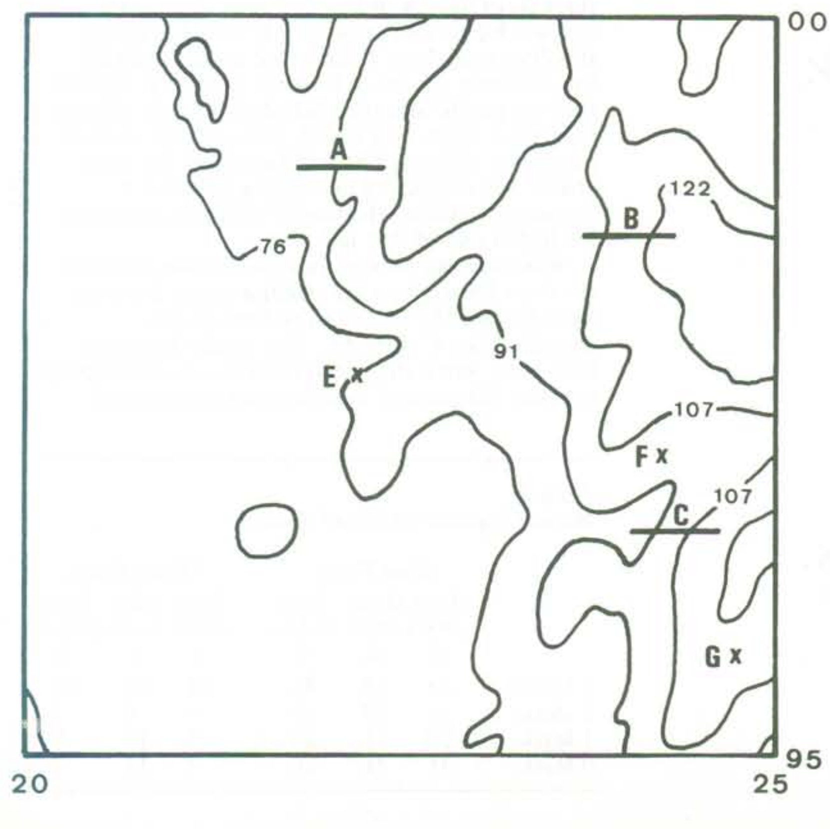
Introduction

Graphicacy is now recognised as the strong and distinctive contribution of geography to the school curriculum. This is reaffirmed in a recent leaflet published by the Geographical Association (1981) as a response to the current debate about the school curriculum and distributed to all LEAs in England and Wales for circulation to head teachers. Here it is pointed out that only in geography are pupils taught systematically to read and use maps and the understanding and communication of spatial information through maps is a crucially important contribution of geography to the curriculum. A new handbook on geographical work in primary and middle schools (Mills, 1981) also emphasises the importance of graphicacy and development of map skills in younger children.

The concept of graphicacy was first proposed in an influential article by Balchin and Coleman (1965) who defined it as 'the communication of relationships that cannot be successfully communicated by words or mathematical notation alone'. Graphicacy became part of every geography teacher's vocabulary after Professor Balchin used it as the title of his presidential address to the Geographical Association in 1972. On this occasion he incorporated the word 'spatial' into the definition, so that graphicacy came to be defined as 'the communication of spatial information that cannot be conveyed adequately by verbal or numerical means' (Balchin, 1972). This communication can take place through maps, photographs, sketches and models. Graphicacy embraces a number of spatial skills including those used in craft, design and technology, art graphics, architecture and surveying. Brazil (1975) has stressed the need for a major contribution to graphicacy from art teachers as those who are largely responsible for teaching visual language. Barrett (1979) has discussed graphicacy as one of the six rationales of art education.

Graphicacy develops in children alongside literacy, numeracy and oracy. Boardman (1976) has urged geography teachers to share with their colleagues in other subjects, notably English and Mathematics, responsibility for ensuring that pupils acquire competence in graphicacy before they leave school. It is the purpose of the present article to show that in at least one aspect of graphicacy, the transformation of the two-dimensional map into three-dimensional form, there is much to be gained from collaboration with craft, design and technology teachers. This is in accordance with the recommendation of Eggleston (1976) that practical activities with materials should have a place in most subjects of the curriculum and that inter-departmental collaboration can help to elevate the status of design education in schools. Similar inter-disciplinary cooperation has also been advocated in the recent Design Council report (1980), especially where it develops pupils' understanding of and responsibility for the environment in which they live.

Fig. 1 Contour map.

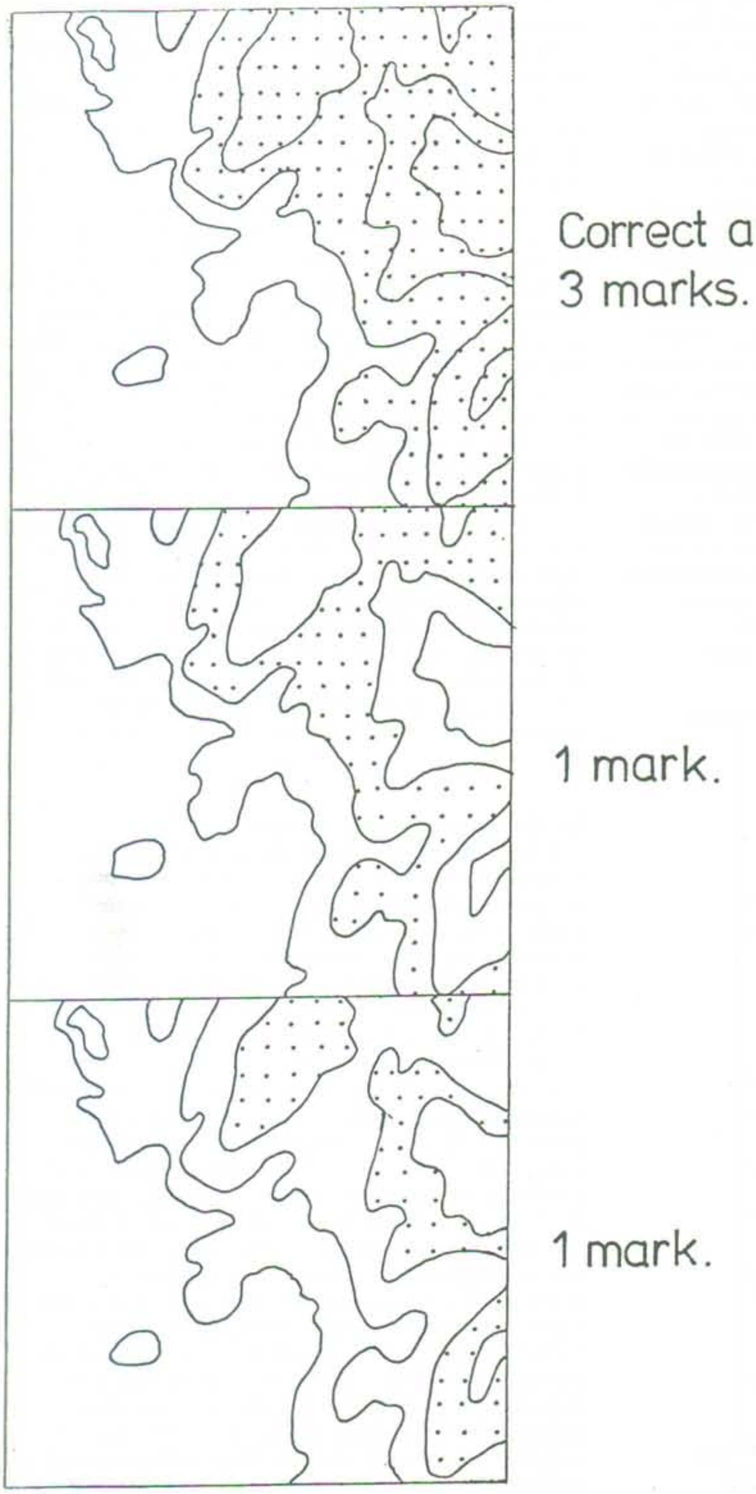


Misconceptions about Contours

The third dimension of the physical landscape is represented on Ordnance Survey maps by means of contour lines. These are usually introduced to pupils at an early stage of map reading in the secondary school. Learning the definition of contours as 'lines joining all points which are the same height above sea level', however, does not by itself ensure comprehension of the concept, as the following study shows.

A test was given to 336 pupils who had completed map reading courses in six comprehensive schools in the West Midlands. 166 (80 boys and 86 girls) were pupils aged 11-12 in six first-form classes and 170 (81 boys and 89 girls) were pupils aged 13-14 in six third-form classes. In the three schools in which first-form classes were tested, the pupils had followed map reading courses upon entry to the school. Of the three schools in which third-year classes were tested, one admitted pupils at age 11 but taught a combined humanities course in the first two years, leaving map reading until the third year. Another admitted pupils at age 12 but did not teach map reading until the following year. The other school admitted pupils at 13 and gave them a map reading course upon entry to the school.

Fig. 2
Scoring Schedule
(Sheet 1).



The test was based on a small part of the 1:50,000 scale Ordnance Survey map showing an area of gentle relief near Kingsbury to the north-east of Birmingham. The contours were traced on to a map on the same scale measuring 10cm by 10cm representing an area of 5km by 5km (Fig. 1). All pupils had copies of the Ordnance Survey map extract to refer to during the test if they wished to do so.

The pupils were first asked to shade on the contour map all land above 91m in height. A maximum of three marks were allocated for this question and the results are shown in Table 1. It will be seen that only 36% of the first-form pupils performed this apparently straightforward task with complete accuracy, whilst a quarter obtained only one mark and another quarter no marks at all. Third-form pupils performed rather better, three-quarters obtaining full marks. The scoring schedule is shown in Fig. 2 and the errors made by pupils deserve study. A common mistake was to shade only the land between 91 and 107m. Apparently these pupils did not realise that land above 107m was also above 91m. Other pupils shaded only the land above 107m. They appear to have chosen the first contour bearing a number greater than 91m, indicating that they failed to appreciate the continuous rise in the height of the land between one contour and the next. Some pupils left unshaded land above 122m or an area enclosed by an unnumbered contour.

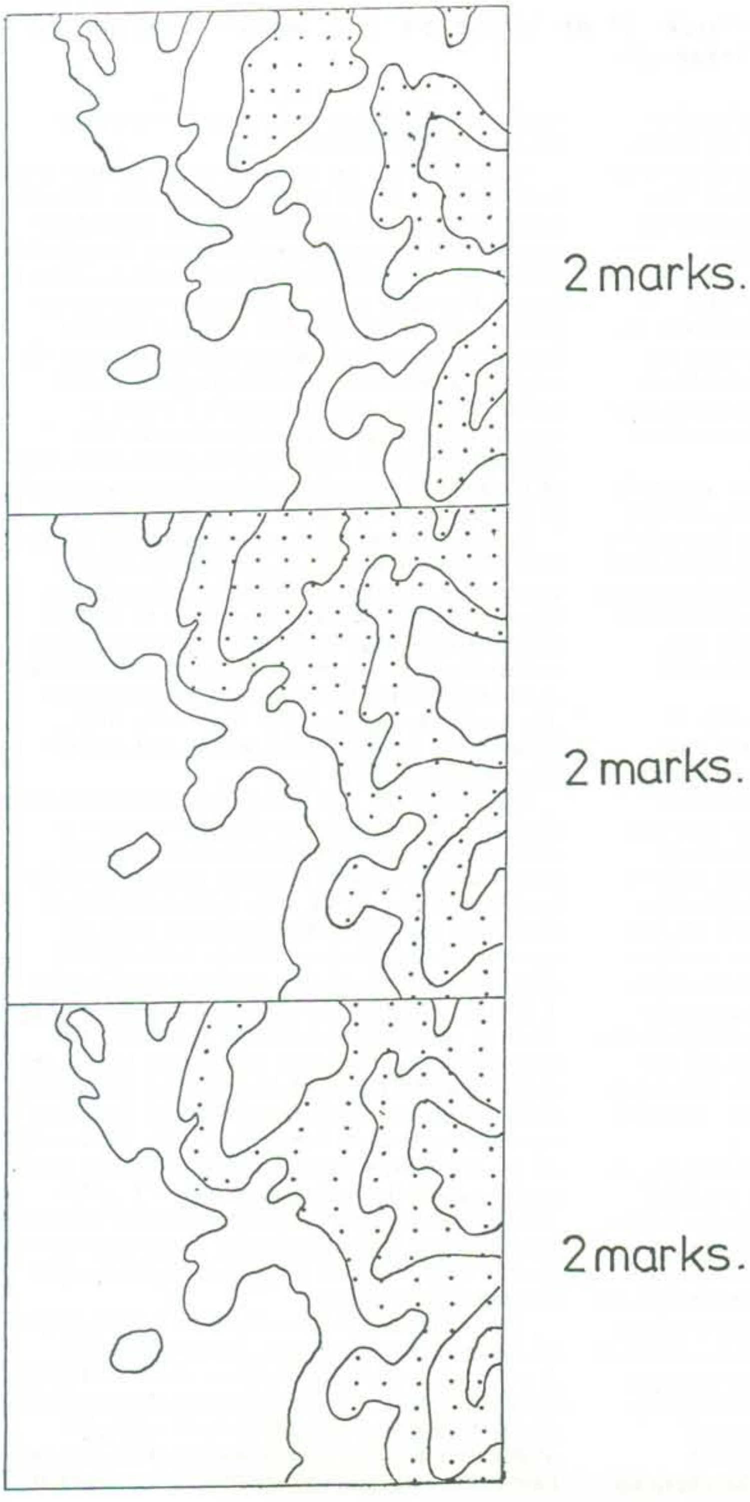
The pupils were then asked to look at each of three short lines A, B and C in turn, decide which end was higher and draw a circle round that end. It will be seen from Table 2 that more pupils did this correctly for line B than for A or C. It appears that the pupils' attention was drawn to the contour numbered 122m near line B, although the contour numbered 107 near line C did not have the same effect. The absence of numbering near line A apparently reduced the pupils' ability to recognise the higher end of that line.

When the pupils were asked to decide which of the three lines lay on the steepest slope, less than half of either the first or third-form pupils identified line C correctly. This clearly indicates that many pupils did not appreciate the relationship between closeness of contours and steepness of

Table 1
Marks Obtained on Relief Shading

	First Form			Third Form		
	Boys n=80	Girls n=86	Total n=166	Boys n=81	Girls n=89	Total n=170
	%	%	%	%	%	%
3 Marks	38	35	36	81	69	75
2 Marks	11	13	12	9	6	7
1 Mark	20	31	26	3	14	9
0 Mark	31	21	26	7	11	9

Fig. 2
Scoring Schedule (Sheet 2).



slope. Most of those who responded incorrectly chose line B. It seems likely that they looked at the three lines and settled for the one which crossed the contour bearing the highest number. They had confused steepness of slope with height of land.

Finally, the pupils were asked to estimate the height of the land at three points E, F and G. Of these E was the easiest to determine because it lay on a numbered contour. Points F and G, however, lay between contour lines and only small percentages of pupils at either first or third-form level were able to estimate their height to within two or three metres on either side of the mid-point (97-101m for F and 112-117m for G). Pupils who gave incorrect answers usually said that F was 91m and G 107m. This suggests that instead of visualising the slope as rising steadily between contours, they regarded it as rising in a series of steps at the contour lines.

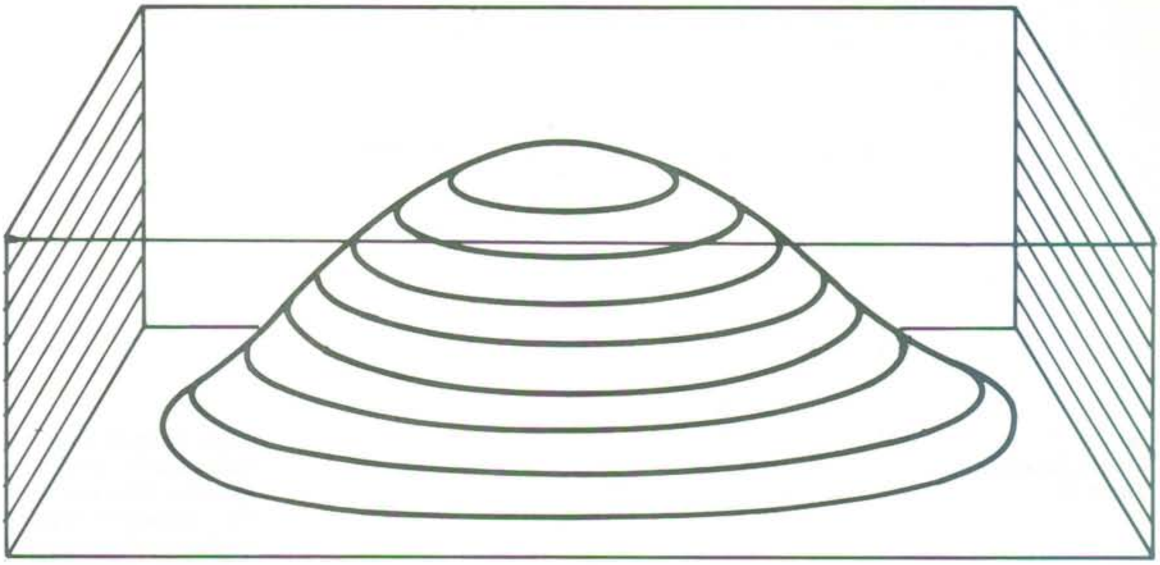
It will be seen from the two tables that third-form pupils obtained higher scores than first-form pupils on all questions. The concept of contours appears to be a difficult one for younger pupils to grasp and understanding seems to develop with age. It will also be noticed that boys generally performed better than girls, particularly at third-form level. The results of this study confirm the findings of earlier research carried out by Boardman and Towner (1979). This has led to the conclusion that the construction of landscape models by pupils is an indispensable aid to the development of their understanding of contour lines and interpretation of contour patterns.

The Construction of Landscape Models

In the initial stages of learning about contour lines an imaginary island can be moulded in plasticine or clay without reference to specific heights or even to a map. The model is placed in an empty transparent plastic tank, one side of which is marked with a scale graduated at regular intervals. The base of the tank represents the dry shore at low tide. Water is poured into the tank until the first mark on the scale is reached. The level of water all the way round the model is then marked on it by means of a line made with any pointed instrument such as a ball point pen or drawn with a waterproof marker. The level

Table 2
Correct Responses on Height Questions

	First Form			Third Form		
	Boys n=80	Girls n=86	Total n=166	Boys n=81	Girls n=89	Total n=170
	%	%	%	%	%	%
Line A	45	58	52	78	75	76
Line B	78	76	77	94	84	89
Line C	44	58	51	78	75	76
Steepest	44	35	39	57	35	45
Point E	76	71	73	96	89	92
Point F	29	10	19	46	27	36
Point G	21	9	14	35	25	29



Contour lines drawn on a model of an island as the water level in the tank is raised at regular intervals

Fig. 3
Contour lines drawn on a model of an island as the water level in the tank is raised at regular intervals.

of water is raised again until the second mark is reached and another line is marked on the model. The process is repeated several times until the water level reaches the highest mark on the tank. The water is then poured out of the tank, leaving the model island with contours drawn on it at regular intervals (Fig. 3).

By looking at the model pupils learn that contours are lines drawn on it and do not exist on the ground. They also see that contour lines are drawn on continuously graded slopes and do not represent steps on those slopes. Furthermore, they realise that contour lines can be drawn below sea level as well as above it.

If a sheet of thick overhead projector acetate is placed over the top of the tank, a sketch showing the shape of the island and the contour lines can be drawn on the acetate by looking at the model from above. When the acetate is removed from the top of the tank the representation of a three-dimensional model in two-dimensional form is clearly seen (Fig. 4). The model has been transformed into a map.

Once the pupils understand the concept of contour lines they should construct their own model of a landscape from the contour patterns shown on a map. Although a simple map of an imaginary area may be used for practice purposes, it is important that pupils subsequently use an actual Ordnance Survey map. The largest scale on which contours are shown is the 1:10,000 series which is gradually replacing the former 1:10,560 (6 inches to one mile) series. Each sheet measures 5km by 5km and the whole country, both urban and rural, is covered by the series. Other readily available maps on which contours are shown are the 1:25,000 (2½ inches to one mile) series and the 1:50,000 (1¼ inches to one mile) series, which has replaced the former 1:63,360 (1 inch to one mile) series.

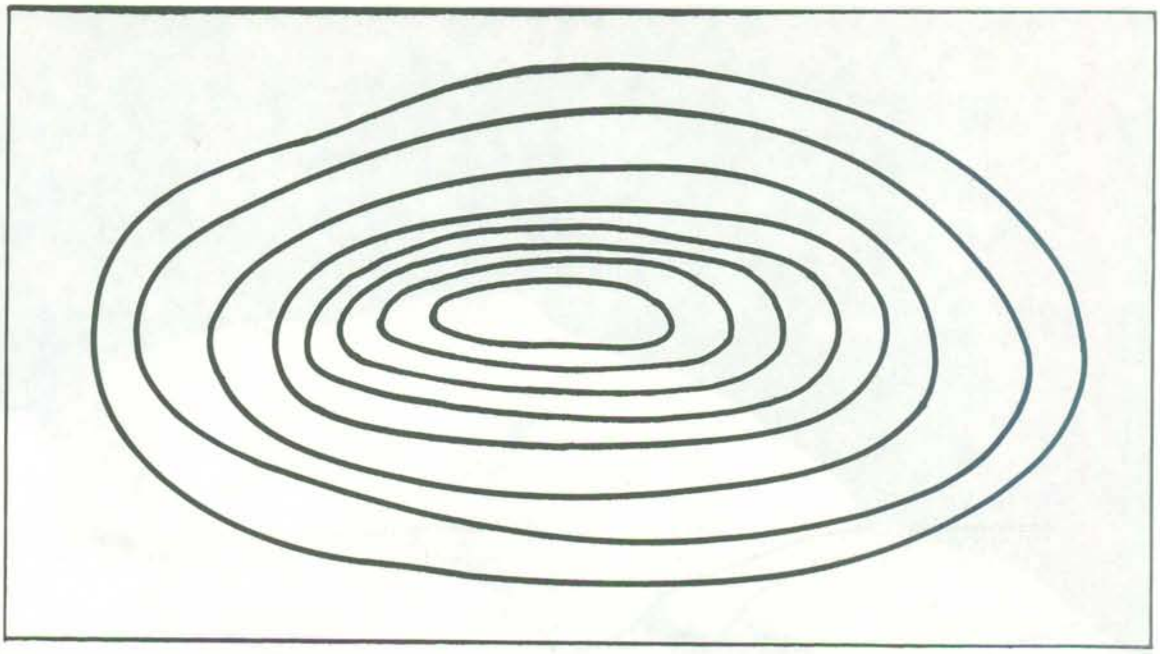
An area of gentle relief should be chosen for the pupils' first attempt at making a layer model of a landscape. Whatever the scale of map that is used, it is best to enlarge a small area by two or three times so that the contours are more widely spaced. This can be done either by copying the contours on to enlarged grid squares or by making an overhead transparency and then projecting it on to a sheet of paper pinned to a wall, on to which the contours can then be transferred. An overall enlarged map measurement of 30cm (12 inches) square is recommended. This is the size of expanded polystyrene ceiling tiles, which are light, cheap and easily cut with a sharp knife, thus forming ideal material for layer models.

A complete tile the same size as the contour map forms the base of the model. Two contour lines are transferred to each subsequent tile by placing the map over it and punching lines of holes through the paper with any pointed instrument such as a sharp pencil. The outer or lower contour is then cut out with a knife whilst the inside or higher contour remains as a marker on which to place the next tile when it has been cut. The tiles are glued in their correct positions until the highest contour is reached and the layer model is complete. The illustration (Fig. 5) shows a layer model of the map of the Kingsbury area to which reference was made in the preceding section of this article.

It is very important that a model should not be left in this form because its terraced or stepped appearance does not resemble the real landscape. The spaces between the layers should be filled in with plaster or filler which is then smoothed over so that the final appearance of the model is similar to the relief of the landscape which it represents. The model can be painted so that rivers, lakes, railways and main roads are shown on it in their correct locations (Fig. 6).

In selecting the map and material for constructing the layers of the model, care should be taken to avoid an excessive exaggeration of relief which would give the pupils a distorted impression of the landscape shown on the map. As an extension of their work in mathematics pupils can work out the vertical exaggeration. Thus in the Kingsbury example used here, an area 10cm by 10cm on the 1:50,000 scale map was enlarged by three times to 30cm by 30cm, giving a scale of 1:16,666. The horizontal scale, therefore, is such that 1cm on the map and model represent 16,666cm on the ground. Each polystyrene tile is 6mm thick and is used to represent an increase in height of 15m. Hence 6mm on the model represents 15,000mm in height on the landscape and the vertical scale is thus 1:2,500. The vertical exaggeration is the difference between the horizontal and vertical scales, in this case between 6 and 7 times. Vertical exaggerations greater than this should be avoided.

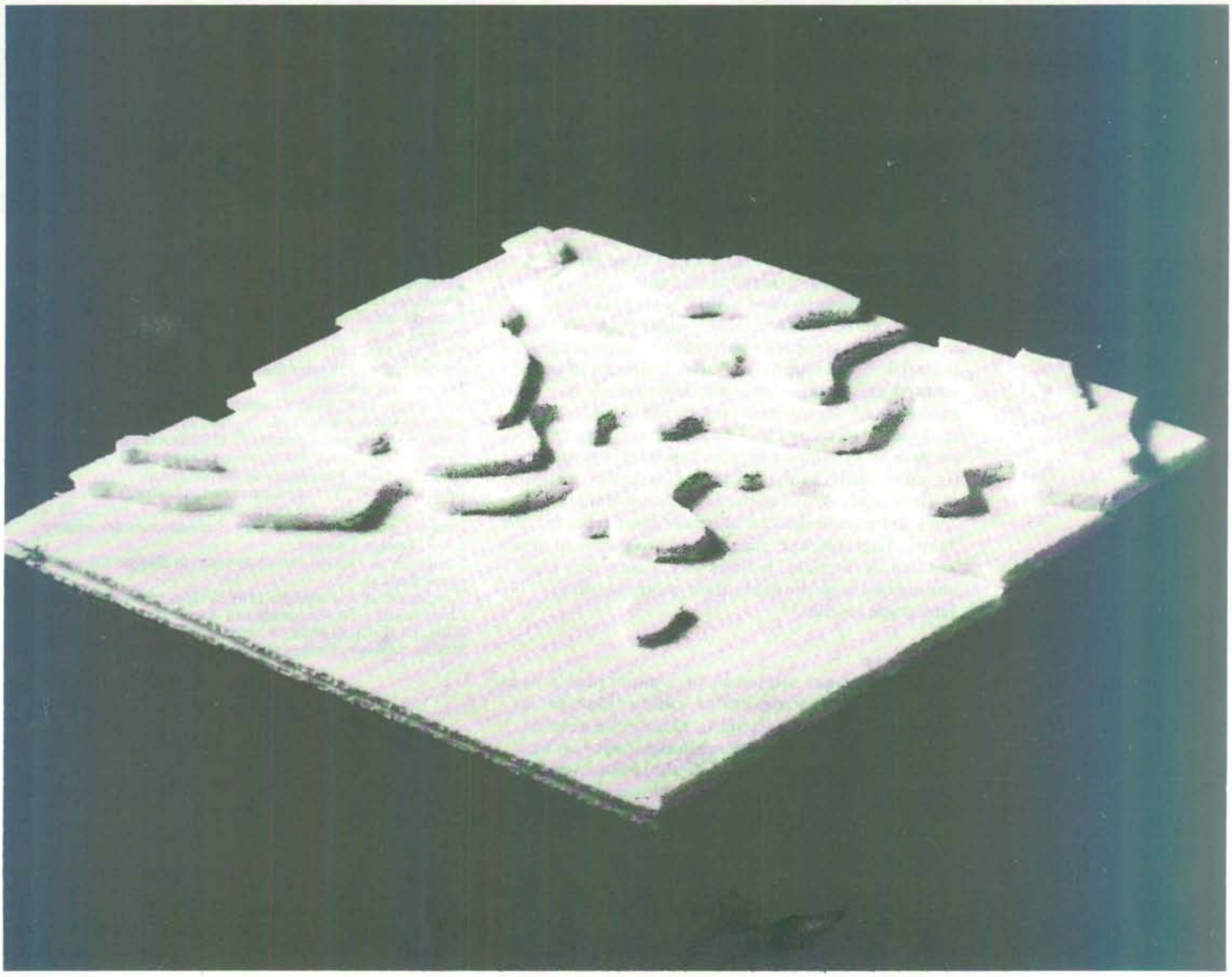
Landscape models are valuable in helping pupils to understand cross sections drawn from maps. A section is most easily described as a slice through the landscape but the concept often seems to puzzle pupils. Understanding is likely to be assisted if pupils attempt cross section drawing only after they have constructed a landscape model. Examination



Contour map of the island drawn on acetate placed over the top of the tank

Fig. 4: Contour map of the island drawn on acetate placed over the top of the tank.

Fig. 5: Model Building Stage 1: Using Polystyrene Tiles.



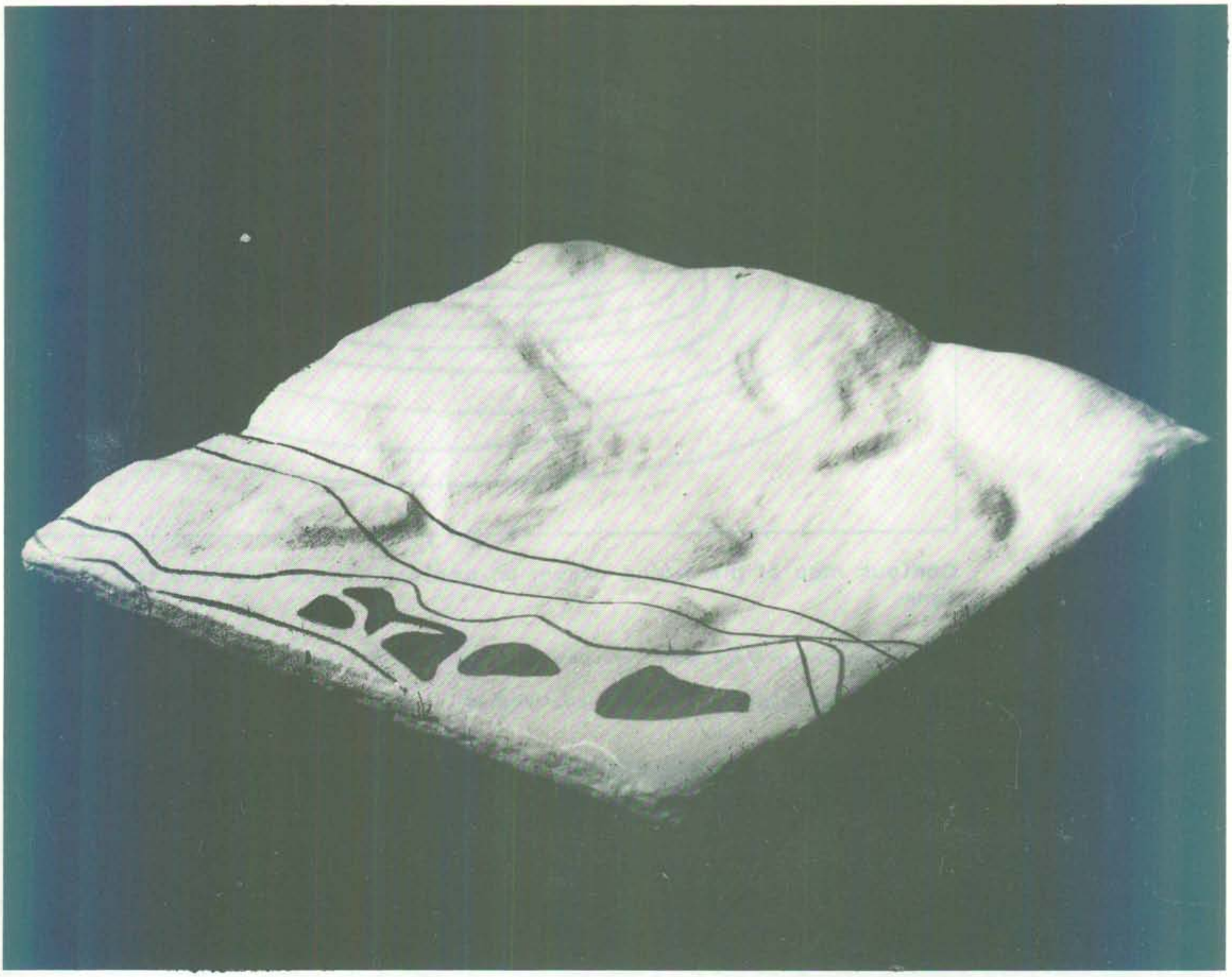


Fig. 6
Model Building Stage 2: Using Plaster and Paint.

of the sides of a model shows that they are, in effect, sections across the landscape.

More substantial and sophisticated landscape models can be constructed by older pupils from more complex contour patterns on maps using material such as hardboard. Rock strata can be painted along the sides of models to show the geology and demonstrate relationships between rocks and relief, or relief and drainage. Most CSE geography syllabuses require candidates to submit for assessment, as part of the examination, reports of field study projects they have undertaken. They are encouraged to illustrate their reports with maps, diagrams, sketches and photographs of areas studied in the field. Is there any reason why they should not also illustrate their reports with landscape models?

Conclusion

Pupils experience numerous perceptual problems in understanding the concept of contour lines and in interpreting contour patterns. Comprehension of relief as shown on two-dimensional maps can be assisted by the construction of three-dimensional landscape models. In developing this important aspect of graphicacy in pupils, geography teachers could usefully collaborate with their specialist colleagues in craft, design and technology.

References

Balchin, W.G.V. and Coleman, A.M. (1965) 'Graphicacy should be the fourth ace in the pack'. *The Times Educational Supplement,* 5 November.

Balchin, W.G.V. (1972) 'Graphicacy'. *Geography.* Vol. 57, Pt. 3, pp.185-195.

Barrett, M. (1979) *Art Education: A Strategy for Course Design.* Heinemann.

Boardman, D. (1976) 'Graphicacy in the Curriculum'. *Educational Review.* Vol. 28, No. 2, pp.118-125.

Boardman, D. and Towner, E. (1979) *Reading Ordnance Survey Maps: Some Problems of Graphicacy.* Teaching Research Unit, University of Birmingham.

Brazil, R. (1975) 'Graphicacy and art education'. *Studies in Design Education and Craft,* Vol. 8, No. 1, pp.32-35.

Design Council (1980) *Design Education at Secondary Level.* Design Council.

Eggleston, J. (1976) *Developments in Design Education.* Open Books.

Geographical Association (1981) *Geography in the School Curriculum 5-16.* Geographical Association.

Mills, D. (Ed.), (1981) *Geographical Work in Primary and Middle Schools.* Geographical Association.