



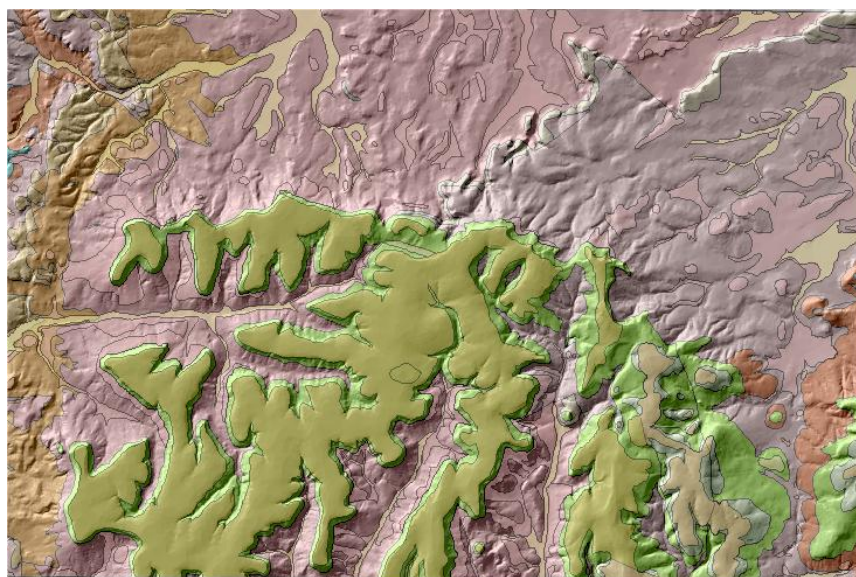
**British
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NATURAL ENVIRONMENT RESEARCH COUNCIL

The use of anaglyph images for geological feature mapping

Digital Geoscience Spatial Model

Internal Report IR/04/004



BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/04/004

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Digital Geoscience Spatial Model

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Shaded relief OS landform profile DTM combined with DiGMap bedrock and superficial geology for the Wellington sheet.

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Foreword

This report publishes the results of a number of case studies by the British Geological Survey (BGS) including geological mapping projects, commissioned by the SIGMA (System for Integrated Geospatial Mapping) project.

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Summary

This report describes the application of anaglyph images for geological feature mapping. A brief introduction is given followed by technical review of generation methods together with some specific examples of how the images have been used.

1 Introduction

Feature mapping is a technique for geological surveying that uses the strong relationship between surface landforms and underlying geology to produce geological maps. Anaglyph images present a rapid, low cost and versatile method of three-dimensional terrain visualisation and are likely to be increasingly used within BGS once high-resolution terrain data becomes available. Techniques have been developed which allow existing geological linework to be projected onto the terrain model allowing rapid assessment and revision and more efficient targeting of fieldwork.

Anaglyph glasses are required to view some images in this report.

1.1 ANAGLYPH IMAGES

An anaglyph image is an established way of visualising information in three dimensions using red-blue or red-cyan (blue-green) glasses. A terrain model is used to create an offset between a red and blue image in proportion to the elevation at particular point. Areas of higher elevation within the image, corresponding to those points closer to the observer, will have a greater separation between the blue and red image. The left eye looking through the red lens will see only the red image with the blue image blocked, the right eye looking through the blue/cyan lens will see only the blue image with the red image blocked. These two images are combined by the brain to produce a single 3D image, with colours other than red and blue passing through the filters.

Anaglyph images are a low cost (in terms of viewing hardware), rapid method for visualising 3D information that can be viewed in hardcopy format or on screen. The degree of vertical exaggeration can be chosen according to the terrain characteristics and is useful in areas where features are subtle. One disadvantage of the anaglyph approach is that, unlike viewing stereo aerial photography in a system such as Stereo Analyst or ImageStation, accurate digitising in three dimensions is not possible, although the future development of 'false stereo' is likely to address this problem. It has also been found that pure red and blue colours do not work well when viewed as anaglyphs giving a 'ghosting' effect and should be avoided.

1.2 PRESENTING GEOLOGICAL INFORMATION IN ANAGLYPH FORM

Although anaglyph images are an established method of viewing information in three dimensions, the integration of geological information and other raster datasets (such as orthorectified aerial photography) is an approach which has not been widely documented.

2 Methodology of Anaglyph Generation

Erdas Imagine 8.5 and above and ESRI ArcMap are required for the method described in this document.

An outline of the method is shown in the diagram below:

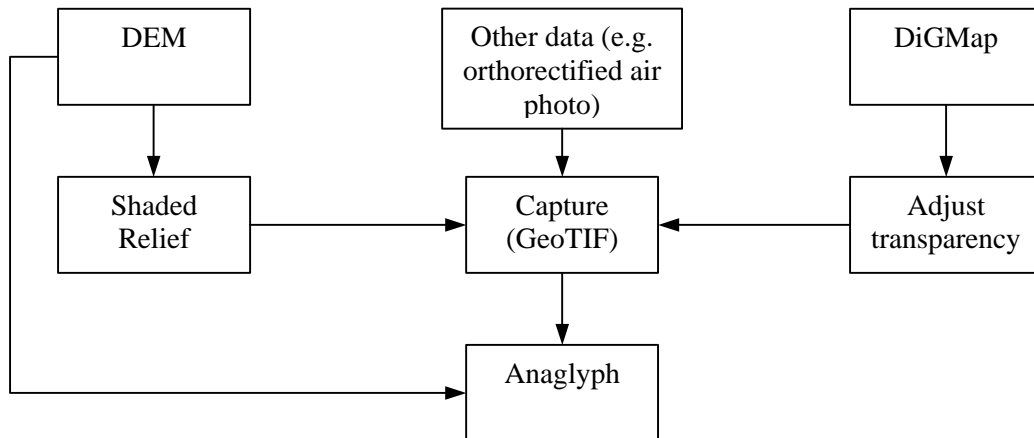
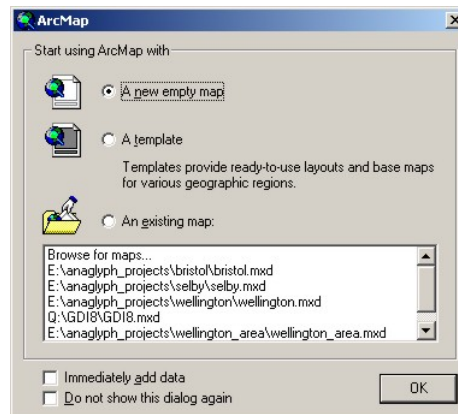


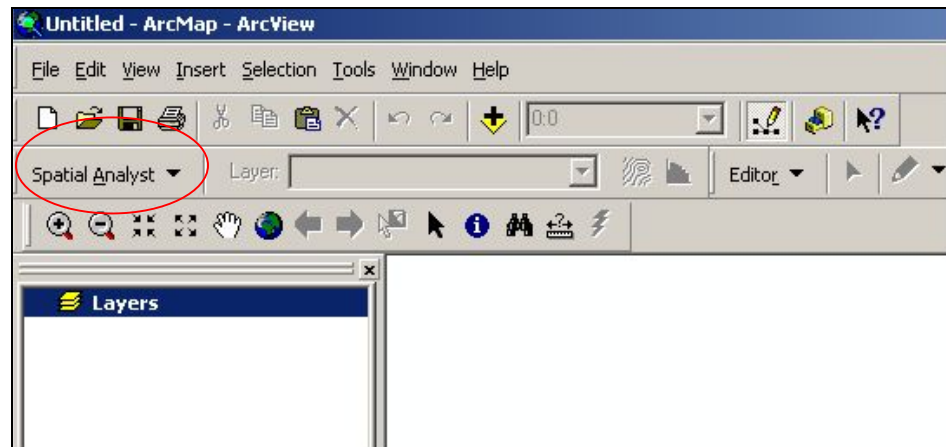
Figure 1. Anaglyph generation workflow

1. Start ArcMap and specify 'A new empty map'



2. Add DEM data. The DEM needs to be converted to a shaded relief image. This can be done in two ways:
 - a. The shaded relief image can be created in another programme before adding the image (for example in Erdas Imagine). Ensure that the light source is towards the north. To add the image go to 'File > Add data..' and then navigate to the appropriate file (esri grid or img format are recommended)
 - b. The shaded relief image can be created within ArcMap, using the spatial analyst extension. Add the DEM file to the view by going to 'File > Add data..' and then

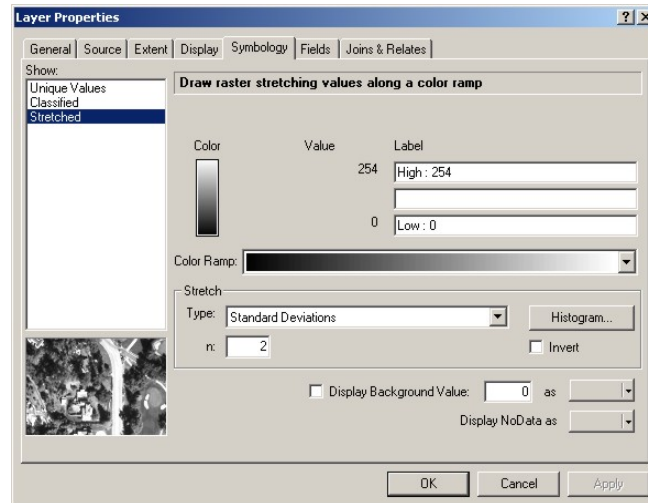
navigate to the file. Check to see if the spatial analyst extension tool bar is loaded. If the extension is loaded the menu bar will look something like this:



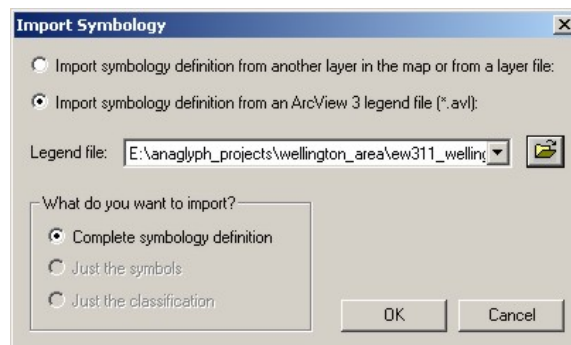
If not right click on the grey toolbar area towards the top of the screen and select spatial analyst.



The tool bar will now appear. Click 'spatial analyst' on the toolbar then 'surface analyst' and 'hillshade'. When the 'hillshade' box appears use the default setting but click 'model shadows' and choose a name and location for the 'output raster'. Click 'ok'. The shaded DEM will be automatically added to the view. Right click on the name of the file in the table of contents and select 'properties'. Click the 'symbolology tab' and change the stretch type to 'standard deviation' and click 'apply'.



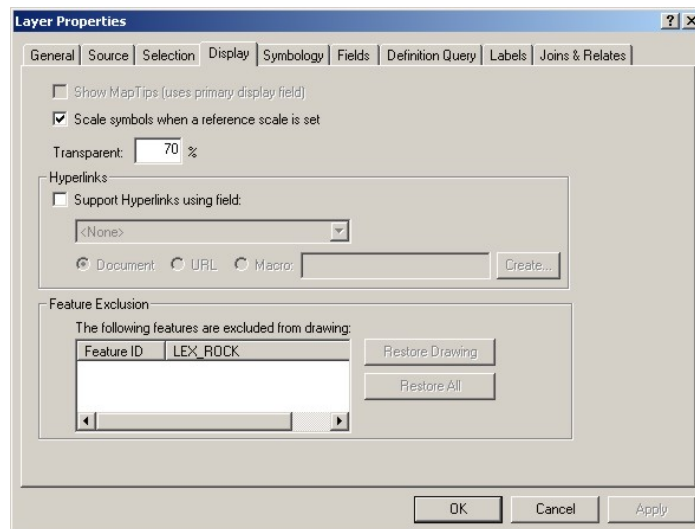
3. Add the DiGMap linework. Go to 'File > Add data..' and then navigate to the directory containing the shapefile to add, highlight the file and click ok. The file will appear in the table of contents.
4. The correct symbology needs to be added to the file. Right click on the shapefile in the table of contents and select 'properties'. Select the 'symbology' tab and then the 'import' button. Toggle the 'import symbology for an ArcView 3 legend file (*.avl)' and navigate to the location of the .avl file.



It should be noted that each geological mapsheet will have its own .avl file and the superficial file will be different to the bedrock file. When the 'import symbology matching dialog' box opens, ensure the value filled is 'LEX_ROCK' and click 'ok'. The symbology will load. Click 'apply' and then 'ok'.

Steps 3 and 4 will need to be repeated if you require both the drift and the solid layers.

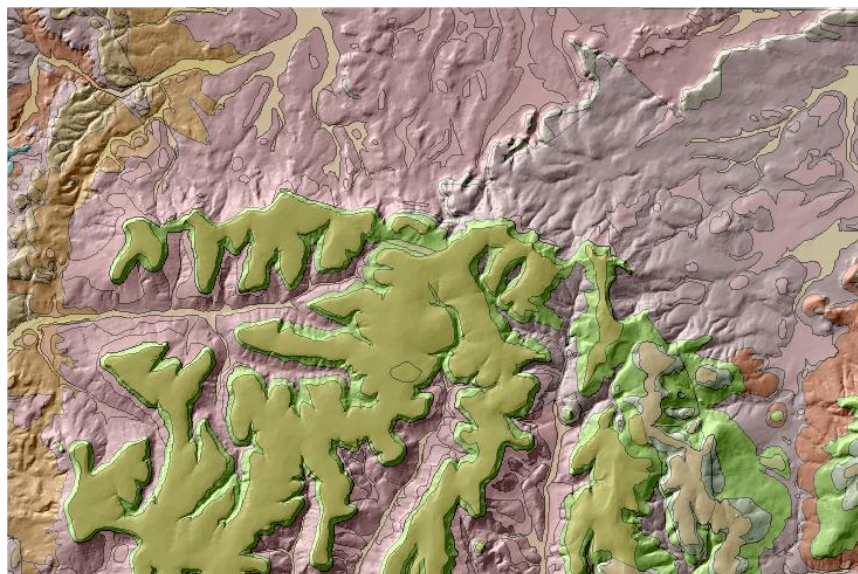
5. The next step is to adjust the transparency of the vector layers in order to combine the geology with the relief. Right click on the shapefile in the table of contents and select 'properties'. Click the 'display' tab. The transparency is set here with 0 being completely opaque and 100 completely transparent.



The appropriate transparency depends on the geological layers used. Use the table below to select the appropriate transparency for your layers

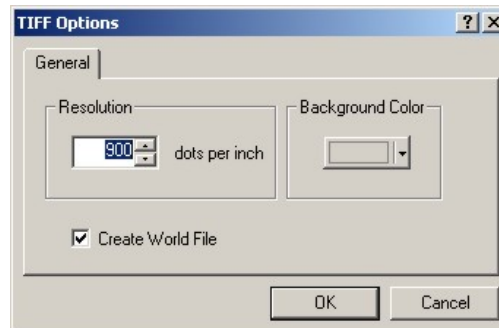
Layers	Transparency
DiGMap Bedrock	60%
DiGMap Superficial	60%
DiGMap Bedrock and Superficial	70% bedrock, 60% superficial

The view should now look something like this:

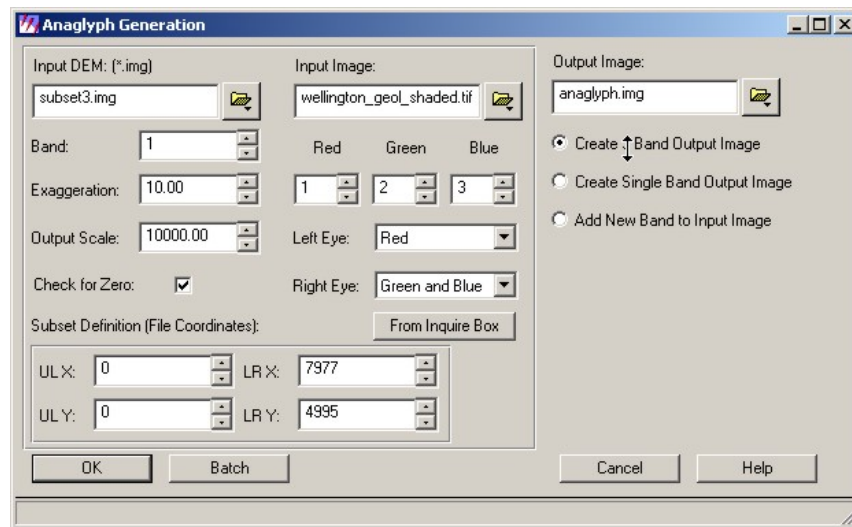


- To capture the combined data as a geotiff resize the content so that the area of interest fills the entire view. The capture will only image the area that is visible. If you have a large number of tool bars open along the top of the view, these should be closed so that the data you want to capture is of a reasonable size.

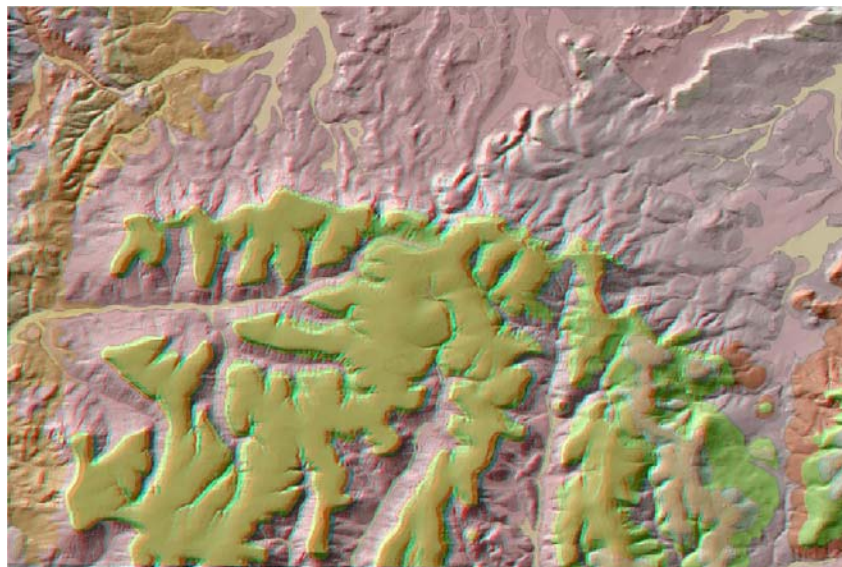
7. Navigate to 'file > export map' and navigate to the desired output location. Specify TIFF (*.tif) from the 'save as type' drop down menu. Now click 'options' and from the 'tiff options menu' set the resolution to 900 dpi and check the 'create world file' option. For a typical 50k map sheet, capturing at 900dpi will generate a file of approximately 130mb, and allow viewing down to 30k without significant pixelling.



8. Click 'ok' and then 'export'. The export process may take some time, and requires a large amount of hard disk swap space. If the export process fails try reducing the dpi or increasing the swap space size.
9. You may wish to save the ArcMap project before exiting.
10. The generated tiff and the DEM can now be combined in Erdas Imagine to generate the anaglyph.
11. Start Imagine and from the imagine tool bar click the 'interpret' button followed by 'topographic analysis'. Select 'anaglyph' from the topographic analysis menu. The anaglyph generation dialog box will open. To specify the DEM click the folder button adjacent to the 'input DEM' box. Locate the original DEM file (not the shaded image). The DEM can be in either ESRI grid or img format.
12. Next input the image file. This is the geotiff that has been captured in ArcMap. Click the folder button adjacent to the 'input image' box and navigate to the captured file.
13. Navigate to an appropriate directory and specify an output image in the 'output image' box. The generation parameters need to be adjusted. An 'exaggeration' of 10 is recommended together with an output scale of 10000. The other parameters can be left with the default set-up.



14. Finally click 'ok' and the anaglyph will be generated, as shown below:



3 Anaglyph Applications

To date a number of studies have been undertaken using anaglyph images based on both OS Landform Profile and trial NEXTMap data. These are outlined below:

3.1 SHEFFIELD –NEXTMAP DATA

The current mapping training area in Sheffield presents an ideal opportunity to evaluate the use of anaglyph images and NEXTMap data in an area where the geology is well understood and familiar to many BGS geologists. The city is underlain mainly by gently dipping Lower Coal Measures of Upper Carboniferous age. The surface topography is profoundly influenced by the underlying geology. Over parts of the area, these topographic features are masked by urban development, creating line-of-sight problems on the ground and increasing the difficulty of traditional walk-over geological feature mapping.

A range of anaglyph images were generated by combining the NEXTMap data with a variety of raster and vector datasets, and some examples are in Figures 2 and 3.

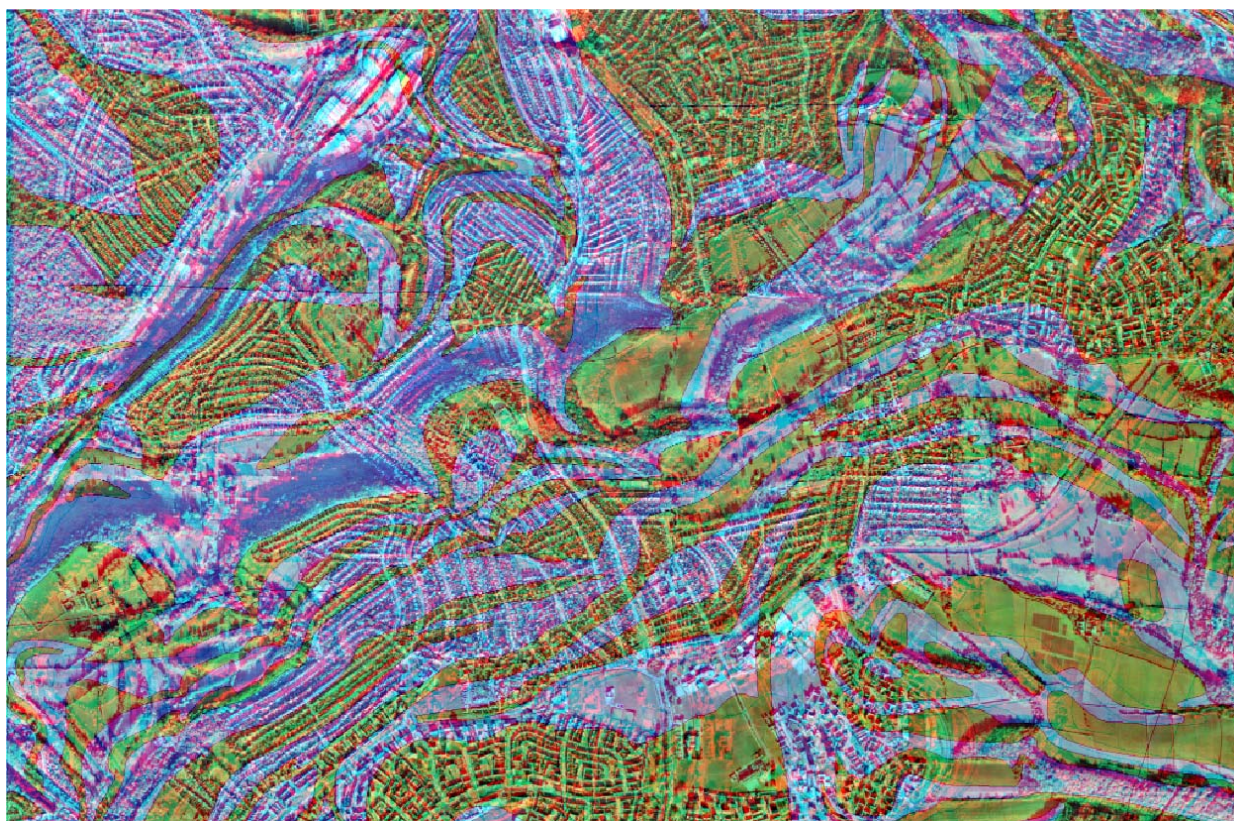


Figure 2. Anaglyph image generated from NEXTMap DSM combined with orthorectified aerial photography and DigMap bedrock geology. Requires anaglyph glasses to view.

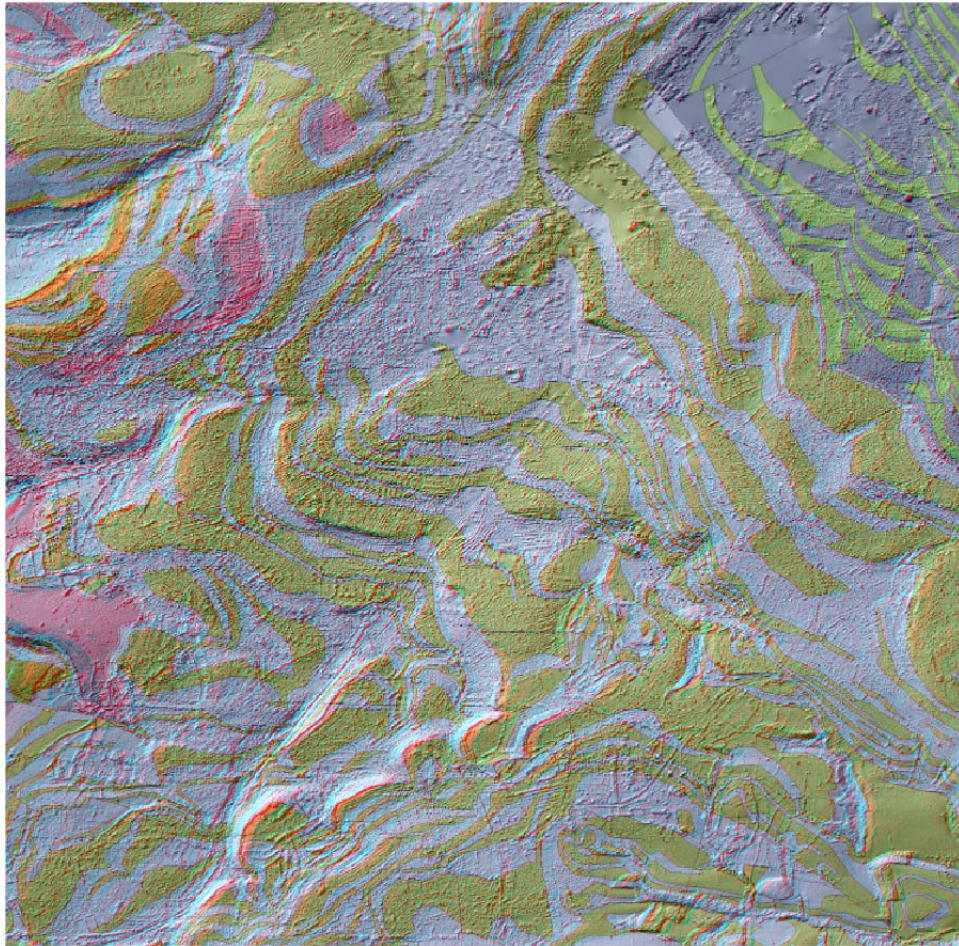


Figure 3. Anaglyph image generated from NEXTMap DSM combined with DiGMap bedrock geology and shaded relief image. Anaglyph glasses required to view.

The main conclusions from this study were that:

1. DiGMap 50k can be quickly evaluated against the DEM at low resolution (25k or lower), so that areas can be selected optimally for desk revision and field survey.
2. The data can be used at higher resolution by individual geologists to evaluate the quality and accuracy of existing mapping and pre-select targets for field checking.
3. Data can be presented as printed-paper anaglyphs or on PC, laptop or PDA screens without the need for specialised 3D image analysis software. The data can thus be used for reference by the geologist throughout the field survey and map compilation stages, using either digital or paper methods.
4. Topographic features can easily be traced through urbanised areas (and are more easily visualised than on stereo air photography- due to the use of a relief exaggeration factor), potentially enabling speed and accuracy of bedrock geology mapping to be substantially increased.

It was found that in anaglyph format the NEXTMap data is best used in combination with orthorectified air photography and/or up-to-date OS topo base maps; nevertheless, its value for feature mapping and checking remains very high even if air photography is not available. In some cases aerial photography can mask some features that would otherwise be visible on NEXTMap data. The use for mapping man-made deposits without aerial photography is not

recommended, as air photos yield highly valuable land use information that is not available on a DEM alone.

3.2 GLOSSOP - OS LANDFORM PROFILE DATA

OS landform profile data was used to generate anaglyphs for the checking and revision of existing line work. It has been found that the OS data is perfectly adequate for low-resolution applications (around 1:50k) and should be used more extensively and routinely for planning geological mapping and revision projects.

Care should be taken when interpreting terrain models generated from interpolated contour datasets as artefacts are likely to be present, which may initially appear to be geological features. Characteristically the artefacts are usually found on gentle slopes where the distance of separation between contours is greatest giving a stepped appearance. NEXTMap data generated from INSAR does not suffer from this problem.

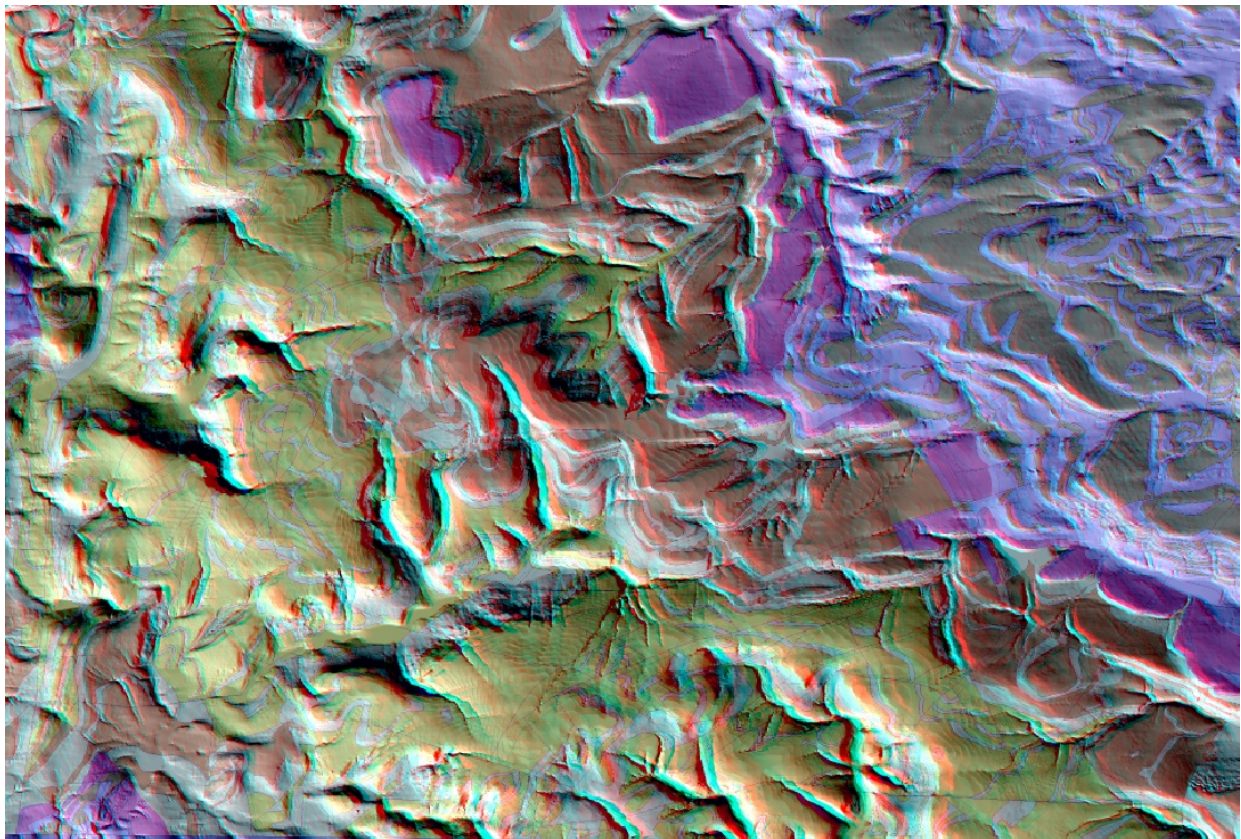


Figure 4. Anaglyph image of the Glossop sheet showing DiGMap bedrock geology combined with Landform Profile DTM. Anaglyph glasses required to view.

The conclusions from this study were that the viewing of the anaglyph DTM allows the identification of major pervasive lineaments and major divisions of strata that influence the broad texture of the terrain. Integration of the 1:50k geological map allows a validation of earlier generations of the mapping of folds, faults and major sandstones. The Coal Measures mainly form rather subdued features in the northeast of the district while the Namurian strata form more consistent escarpments and regularly stepped terrain. The lowest strata of the Coal Measures forms a distinct terraced scarp slope rising from the dip-slopes of the Rough Rock. The principal escarpment formed by Namurian strata lies at the level of the Lower Kinderscout Grit. Other gritstone edges are clearly identifiable and mappable even though correlation of individual grit

units may not be possible. Landslides identified in existing maps closely correspond to lobate features of broken and terraced ground below steep escarpments.

Images may be viewed at scales as great as 1:10 000 when the coarseness of the contour interval intrudes markedly into the perceived model. However when viewed in conjunction with topographic data this does allow a closer spatial referencing of the lineaments and features under review.

Fieldwork carried out in the Longdendale area confirmed revisions of 10k geological data inferred from interpretation of the anaglyph and shaded relief models as well as the validity of the methodologies.

3.3 CENTRAL WALES – NEXTMAP DATA

Trials have been undertaken in Central Wales using anaglyph images generated from NEXTMap. The main aim in this project is to increase the efficiency of the mapping process by extracting information from the anaglyphs before carrying out targeted fieldwork.

It has been found that lines should not be drawn directly on the anaglyph image itself, as distortions are likely to be present. The suggested method is to compile on a separate map or an orthorectified image of the same area and this can be undertaken digitally or manually. This approach has been shown to work particularly well with the use of NEXTMap data. The anaglyph is generated from the NEXTMap DSM and Orthorectified Radar Image (ORI) and compilation takes place on a separate ORI image, either using a transparent overlay or directly on screen.

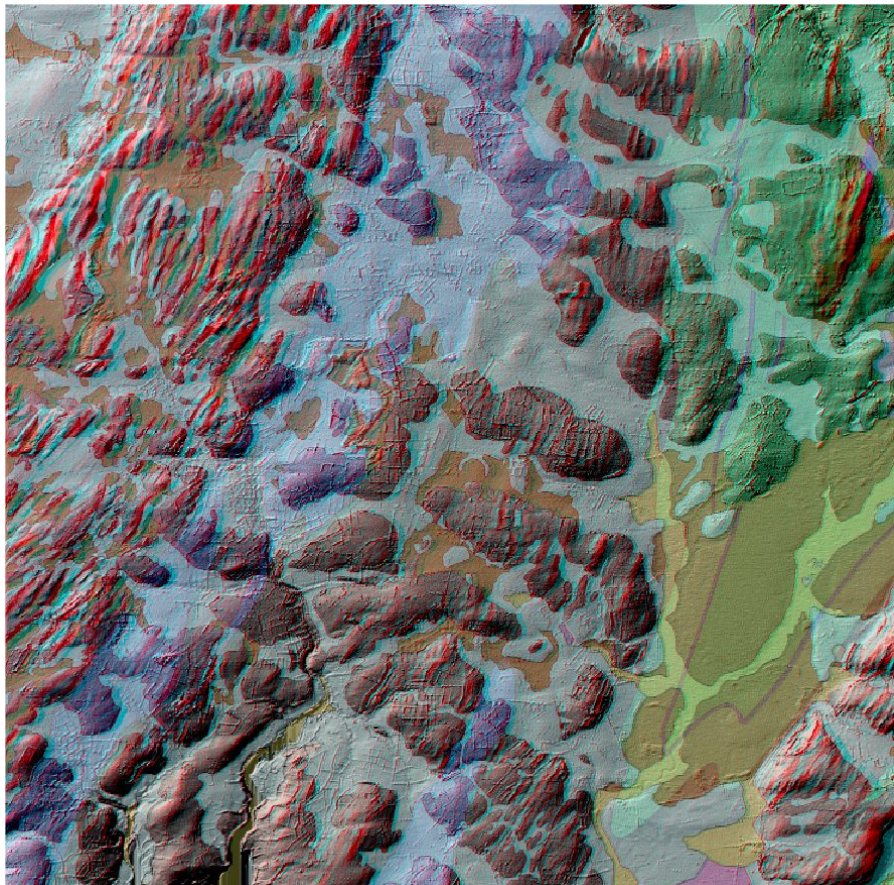


Figure 5. NEXTMap anaglyph showing DSM combined with DiGMap Bedrock and Superficial deposits. Anaglyph glasses required to view.

Comparisons were made between the two terrain datasets which make up the NEXTMap product suite. Due to the filtering algorithm used to generate the DTM, subtle terrain features were found to be eroded or removed altogether, resulting in the loss of valuable information which could aid the interpretation process. It is recommended that the DSM is preferentially used over the DTM for geological interpretation. Because of the level of resolution that the NEXTMap DSM dataset offers, differentiating between cultural clutter and terrain features does not present a significant problem.

NEXTMap Anaglyphs are entirely seamless; they can be produced at a variety of scales and do not suffer from distortion away from the centre point. The area of ground that can be covered by a single image is in effect limited only by plotter size and by using existing in-house facilities areas of 25km² at 1:10K scales (i.e. equivalent to the 'traditional' topographic standard) can be produced rapidly and efficiently.

The quality, lateral continuity and overview that the images provide are such that the nature and 'regional' extent of individual landforms can be better appreciated and a more consistent geological interpretation is likely to result. In addition, the distortion and 'edge matching problems' that are a continual source of frustration and inaccuracy with traditional aerial photography usage are eliminated.

The Anaglyph and ORI plots provide a powerful combination which performs well at a variety of scales and was judged to be useful at both project planning and execution stages and for example for detailed revision purposes. In areas that have a relatively simple structural history changes in topography often relate directly to changes in the underlying geology and such features are well displayed on the NEXTMap Anaglyphs. The NEXTMap Anaglyph /ORI combination was found to be particularly effective for the subdivision of superficial deposits and the separation of these from the solid geology. Individual polygons can be rapidly and accurately delineated and traced over large tracts of ground. In the area of upper Teifi Valley in Central Wales a complex array of glacial, fluvio-glacial and alluvial deposits are present and these were surveyed in detail using 'traditional methodologies' over a period of several weeks in the summer of 2002. The various lithological polygons recognised by this survey are all clearly visible on the NEXTMap Anaglyph and although in general terms there is very good agreement between the two sets of linework in some areas the geological boundaries obtained from NEXTMap and its derivatives are probably to be preferred.

In areas of structural complexities where there is a lack of persistent and distinctive lithological contrasts within the solid geology (e.g. in the Cambrian Mountains in Central Wales) polygon recognition is more difficult to achieve. Nevertheless the images do provide a unique 3D overview of the terrain and succeed in highlighting areas of similar and grossly different solid geology. They also provide information about the regional structural grain and gross textural changes between areas of 'harder' and 'softer' ground (i.e. respectively sandstone and mudstone dominated units) are also discernable. As with other DTMs, Nextmap Anaglyphs when viewed at the appropriate scale are also very effective at imaging regional lineaments many of which on previously mapped ground coincide with major faults.

In conclusion it can be anticipated that the routine use of NEXTMap products will have a positive impact on mapping rate efficiencies for both the superficial and solid geology. In particular it appears that in the case of superficial deposits major polygon boundaries can in most instances be taken directly from NEXTMap plots and hence time spent in the field would be substantially reduced and comprise of a 'polygon ground-truthing' exercise.

Glossary

<i>DTM</i>	Digital Terrain Model. A model of the earth's surface, excluding cultural and vegetation features. Can be produced from a DSM using filtering algorithms.
<i>DSM</i>	Digital Surface Model, A model of the earth's surface, including cultural and vegetation features.
<i>DEM</i>	A collective term for DTMs and DSMs
<i>INSAR</i>	Interferometric Synthetic Aperture Radar. A Radar method used for generating a model of the earths surface.
<i>ORI</i>	Orthorectified Radar Image