A new edition of the bedrock geology map of the United Kingdom

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Abstract

This paper describes how the digital data and published paper map for the new 5th edition 1:625,000 scale bedrock geological map of the United Kingdom were created. The map is published in two sheets, North and South, covering Scotland, Northern Ireland, the Isle of Man, England and Wales. The first edition was created in 1948 by the simplification and reduction of more than 500 individual maps at 1:63,360 scale (one-inch to one-mile) and this remained the basis for revisions up to the 4th edition. In contrast, the digital data for the map face of the 5th edition were created from two main sources: a digital geological map dataset of Great Britain at 1:50,000 scale; and the geological map of Northern Ireland at 1:250,000 scale. The following phases of work are described: a) data analysis and provisional unit selection; b) re-digitising; c) data review and revision; d) cartography and compilation of marginalia.

For users of earlier editions the map retains a familiar appearance even though it is completely new. The rocks are grouped together differently and classified in new ways and they are identified with a new alphanumeric system of labels. The content and layout of the marginalia have been redesigned with new explanatory notes and cross sections included. Two explanatory booklets provide succinct summaries of the geological history of each area.The maps accompanying this article are customised digital images created especially for publication, for non-commercial use, in the Journal of Maps.

1. Introduction

The 1:625,000 scale (625k) geological map of the United Kingdom is one of the British Geological Survey's (BGS) most popular publications; commonly known as the 'ten-mile-map' with a scale of approximately ten miles to one inch. There are two sheets: North, for Scotland, Northern Ireland, the Isle of Man and northern England; and South, for England and Wales. The 1st edition was created in 1948 by the simplification and reduction of more than 500 individual 1:63,360 scale (one-inch to one-mile) maps. The 2nd edition in 1957 included changes to the youngest strata. A standard numerical key with a set of 115 coloured tablets, applicable to both maps, was introduced for the 3rd edition in 1979 and the 4th edition (British Geological Survey, 2001a, b) was essentially a reprint of this on a new topographic base. This 5th edition (British Geological Survey, 2007a, b) is completely new, on a different topographic base (HarperCollins, 2005) with a new layout including cross sections (Figure 1). The printed map has a similar complexity and colouring to earlier editions and will be familiar to previous users, though every line is new and the geological interpretation is the most up-to-date possible. The 625k Digital Geological Map of Great Britain dataset, [now released as DiGMapGB-625 (British Geological Survey, 2008)] was used to create the map and is available for download from the BGS website at http://www.bgs.ac.uk/products/digitalmaps/data_625k.html.

The geology is based on two main sources: a) the 1:50,000 scale (50k) vector dataset of digital geology called DiGMapGB-50 (British Geological Survey, 2005) with nearly complete cover of Great Britain; and b) the 1:250,000 scale (250k) geological map of Northern Ireland (Cooper, 1997) which needed little simplification. This paper describes in outline how the large and complex 50k dataset was simplified to 625k for this 'one-off' product.

2. Origin and properties of the source 50k digital dataset

After the introduction of digital map production at 50k into BGS in 1989 a unified system was rapidly developed to produce data to print maps, and use in a geographic information system (GIS). In 1998 the Digital Geological Map of Great Britain (DiGMapGB) project started to systematically digitise and apply up-to-date nomenclature to published 50k and earlier 1:63,360 paper maps. The goal was to obtain, as near as possible, complete coverage of Great Britain by combining these legacy maps with recent digitally-produced maps. Version 1 of the dataset (DiGMapGB-50 V1) was released in 2001 and Version 2 in 2004, after refitting and rationalisation of nomenclature to reduce misfits between tiles. As maps ranged over many decades in age, geological interpretations on contiguous tiles could differ markedly producing misfits requiring cosmetic fitting at 625k.

Each polygon in the 50k data was at that time identified by a two-part 'LEX_ROCK' code such as MMG_MDST (Mercia Mudstone Group_Mudstone). The first part, Lexicon code, refers to the name of the unit, as listed in the BGS Lexicon of Named Rock Units and accessible on the BGS website at http://www.bgs.ac.uk/lexicon/home.cfm. The second part, ROCK code, refers to the composition or lithology of the unit in a BGS database then in use. Additional information fields are attached to every polygon determined by each unique LEX_ROCK pair. Fields present in the V2 dataset (shown in Table 1) include index level information such as map sheet, and type of unit. The parentage of each unit is shown at six different levels or rank (Bed, Member, Formation, Subgroup, Group, Supergroup or 'equivalents'). Age is in chronostratigraphical units (Stage, Series, Subsystem, System and Erathem). Further information on DiGMapGB data is available at http://www.bgs.ac.uk/products/digitalmaps/digmapgb.html

3. Methods

A 'snapshot' of the DiGMapGB-50 V2 dataset taken in 2005 was used as the primary source. It contains 485 tiles (319 for England & Wales and 166 for Scotland) with more than 400,000 bedrock polygons representing some 4000 uniquely named bedrock units and over 9300 unique LEX_ROCK combinations. A spreadsheet derived from the data listing each LEX_ROCK pair on every 50k tile, together with the additional information held in the fields shown in Table 1, comprises nearly 18,000 rows. Most of the geological compilation was carried out by two geologists: one for the northern map and the Scotland dataset another for the southern map and the England and Wales dataset.

The first phase in preparing the dataset was to decide which 50k component units would be grouped together, into which 625k generalised units. A series of database queries were run and tables of results generated for each geological period. These were assembled into a set of instructions for the initial processing of the data. Lithostratigraphic units were combined using the parentage information in the Lexicon to select at group level. Some proved straightforward, for example, 27 different LEX_ROCK codes (Table 2) combined to form the 'Lias Group'. This single unit in the early Jurassic replaces three (Lower, Middle and Upper Lias) units on previous editions (Figure 2). In some systems there are too many individually named Groups to show separately and related ones were consolidated together. Other units lacking a formal lithostratigraphy were selected in a step-by-step process according to their age or lithology until all the 50k LEX_ROCK codes had been dealt with. Particular units were chosen to show major geological structures not seen on earlier editions; for example, sandstones in the Devonian (Figure 3). Igneous intrusions were grouped together by their age and their lithologies simplified into one of seven classes based on a primary twofold division into felsic and mafic rocks. At each step, the results were reviewed on check plots to see if the initial selections to produce a provisional simplified dataset appeared satisfactory.

The second phase was digitisation by cartographic/GIS staff using a combination of traditional skills for compiling generalised linework and digital vector capture within a customised GIS. Plots were made of all the 50k polygons in the 625k groupings at about 1:300,000 scale using a temporary colouring scheme. The required boundaries around the composite polygons were 'blacklined' or emphasised by hand with a marker pen (Figure 4), scanned and georeferenced. Blacklining by experienced cartographers was found to be more efficient and effective than any automated line filter or topological generalisation process then available. These lines were digitised and the polygons attributed with temporary 625k codes. Working closely with the two principal geological compilers, a selection of 50k faults was added. Thrust faults were more clearly differentiated, including some not yet shown on the published 50k maps and requiring additional geological interpretation, for example around the Lizard (Figure 5). Igneous dykes, showing the main intrusion-trends of differing ages and compositions, were captured as linear features and then converted to polygons. The 625k data were fitted to a HarperCollins topographical base map with adjustments made to the geology to fit the new coastline.

A third phase, summarised as review and revision, followed. Plots of the data were repeatedly checked and modified until the geological generalisations were satisfactory. Also, whilst the 625k map was being prepared, new 50k maps continued to be published with new or replacement tiles added to the DiGMapGB-50 dataset. Two new DiGMapGB-50 versions were released: V3 in 2006, and V4 in 2007. The 625k production procedures were flexible enough to include relevant revisions. For example, a new pre-publication 50k geological interpretation for Llanidloes in central Wales was generalised to 625k and refitted to the surrounding data.

Whilst a selection of 'scientific rules' were followed to simplify the data, making the cartographic generalisations to create a geological map also remains an art. A small outcrop, for example, might be too small to show ordinarily; however, if it is an isolated outcrop of say Precambrian volcanic rock surrounded by Mesozoic sediments, and judged too important to omit, then it would be exaggerated in size to enable it to be satisfactorily included.

A fourth phase dealt with all the design elements regarding the paper map: the map-face geology and marginalia. The dataset could not be completed until the key had been finalised. Two opposing designs were initially considered for the sedimentary (and metamorphosed sedimentary) rocks: one was a simple key of colour tablets similar to the previous editions; the other for a series of generalised vertical sections (or geological columns) based upon the BGS stratigraphical charts (Waters, 2008a, b) either gathered together in one large panel or placed nearby in the 'sea' area. A compromise design was chosen with one main geological column (including lithological variants) supplemented by mini columns where required to show regional variation (Figure 6). This provided valuable additional geological information without overwhelming the general user with complexity. Similarly, many options for labelling the map face were tried on the key. These included numbering upwards (old to young) downwards (young to old), using decimal numbers. Finally a relatively simple, and adaptable, combination of uppercase letter and number was devised, for example 'J1' with the letter prefix 'J' indicating the Jurassic period. Where the initial letters conflict, for example 'C', so alternatives are used: C for the Carboniferous, K for Cretaceous and E for Cambrian (Table 3). In each geological period rocks are numbered sequentially upwards, for example J1 to J 7 for the Jurassic rocks (Figure 6) with 1 the oldest, and rocks of the same or similar age given the same number.

The second part of the key (Figure 7) describes the igneous (and metamorphosed igneous) rocks in two columns: for intrusive (plutonic and hypabyssal) and extrusive (volcanic) rocks. Each igneous unit is labelled with an italic letter or letters as above showing the age or age range, for example *OS* for Ordovician and Silurian, and no number. Where either lavas or tuffs are predominant this is indicated with *lv* or *tf*, otherwise no suffix letters are used.

Having completed the dataset and key design, the colours were finalised. BGS maintains its own geological colour scheme, and these are assigned where possible, but may be altered to improve legibility. Some colour changes reflect improved geological understanding: for example, much of the Grampian Highlands is now coloured green for the Dalradian Supergroup, distinguishing it from the Moine Supergroup of the North West Highlands which retains its yellow colour. Rocks of similar age and lithology are given the same colour; those of the same age but different lithology are given a different colour. The igneous rocks are coloured according to their lithology with variations, where required, for rocks of different ages. Throughout, colours were chosen so that neighbouring units on the map face would not be too similar.

Marginal notes aid map interpretation and cross sections illustrate the structure at depth. For the first time, the printed map is accompanied by two explanatory booklets (Jackson, 2008; Stone, 2008) in a glossy paperback format, providing succinct summaries of the geological history of each area illustrated with full colour photographs and sketches. Maps and booklets are available separately or combined into packages in a protective plastic case, as listed in the BGS Catalogue (of maps, books and data) downloadable at http://www.bgs.ac.uk/catalogue/home.html.

For the final 625k data release the LEX_ROCK codes were replaced with LEX_RCS, using lithology codes derived from the hierarchical BGS Rock Classification Scheme (RCS), which may be accessed on the BGS website at http://www.bgs.ac.uk/bgsrcs/home.html.

The accompanying 625k maps are published in portable document format (PDF) on the Journal of Maps website for non-commercial use. These PDFs were created from the original digital files used to print the paper maps. They are customised maps with no topography to reduce file size and have hyperlinks added from the geological units in the map legend to the BGS Lexicon at http://www.bgs.ac.uk/lexicon/home.cfm, but the geology remains unchanged.

4. Conclusions

The 5th edition map provides an up-to-date summary of the bedrock geology of the United Kingdom, and its accompanying booklets explain how the different rock units were formed over geological time. A large number of data files were successfully processed by a combination of automated and manual procedures in an iterative manner periodically reviewing and modifying selections until the desired result was obtained.

5. Software

Microsoft Excel® 2000 and Access® 2000 were used to summarise the 50k data in spreadsheets and to query and sort the 50k data into groupings suitable for the 625k dataset. MicroStation® GeoGraphics® V7.2 was used for all the cartographic work from digitising on screen scans to compiling the finished map with marginalia. Adobe® Illustrator® CS2 and Photoshop® CS2 were used to create the marginalia. Cadscript® was used to export to Adobe format. Adobe CS Suite was used to combine design elements, and produce proof plots and PDF print files for the final map.

Acknowledgements

Geological interpretation and map compilation was carried out primarily by James D Floyd (northern map and the Scotland dataset), Robert Addison (southern map and the England and Wales dataset), and Derek Reay (Northern Ireland dataset). The digital cartography was by John W Arbon (northern map) and Ian L Cooke (southern map). Data preparation was by Anthony H Myers and Paul Turner. The geological cross sections were compiled by A Graham Leslie and Timothy D C Pharaoh. The author also acknowledges the contributions made by other BGS staff to the final maps and wishes to thank Henry H Holbrooke for preparing the figures for this paper.

Map Design

On previous editions the two map sheets were the same size (about 106 cm wide by 95 cm high) and designed to be fitted together above one another, in their correct positions for display as a single map. They used a standard Ordnance Survey 'Routeplanner' topographic base of Great Britain but this excluded the westernmost part of Northern Ireland; whilst the southernmost part on the southern sheet was replaced by the geological key. At an early stage in the design process the Open University provided useful input, as one of the main users of the earlier edition of the 625k map in their popular geology course, S260. The new OU geology course, S276, starting 2010, makes extensive use of the 5th edition through the entire course.

For the 5th edition, it was decided to include all of Northern Ireland on the northern sheet, retain the north-south-fit for wall-mounting, and use the same size for both sheets now increased to about 112 cm wide by 100 cm high. An overlap of about 13 cm (80 km) is included along the top of the southern sheet. The overlap area was designed to allow all of the Lake District and the North Yorkshire Moors, both areas of important geology, to be shown in full on both sheets. This area is also used for the map explanation at top left (which is essentially a repeat of that on the northern map) and the main title panel at top right (the main elements of which are repeated at bottom left). Both of these can be masked without loss when the maps are mounted as a combined pair. However, the cross section along the bottom of the northern map needs to be folded back or cut off in order to fit the maps together for display. The maps are available flat or folded. With the bigger paper size it was necessary to adopt a larger size for the folded map in order to retain a 4-fold pattern rather than the initially proposed 4½-folds which would have required hand-folding.

The map is designed for use by undergraduate students, keen amateurs and professional users. To this end the new edition provides more comprehensive and informative geological information without compromising legibility. The readability of the legend is enhanced by colour banding and other design techniques, such as the vignetting to give a soft edge to the coast, provide a more attractive product.

Field	Example
ID	22000
SHEET	251_malmesbury_v2
BGSTYPE	BEDROCK
LEX_ROCK	SWLCM-MDSS
LEX	SWLCM
LEX_D	SOUTH WALES LOWER COAL MEASURES FORMATION
ROCK	MDSS
ROCK_D	MUDSTONE, SILTSTONE AND SANDSTONE
RCS	MDST + SLST + SDST
RCS_D	MUDSTONE (UNDIFFERENTIATED) and SILTSTONE
RANK_DESC	FORMATION
BED_EQUIV_DESC	Not Applicable
MEMBER_EQUIV_DESC	Not Applicable
FORMATION_EQUIV_DESC	SOUTH WALES LOWER COAL MEASURES FORMATION
SUB_GROUP_EQUIV_DESC	
GROUP_EQUIV_DESC	SOUTH WALES COAL MEASURES GROUP
SUPER_GROUP_EQUIV_DESC	No Parent
MAX_AGE_LEGEND	1321240
MIN_AGE_LEGEND	1321240
MAX_STAGE	LANGSETTIAN
MAX_SERIES	WESTPHALIAN
MAX_SUBSYSTEM	SILESIAN
MAX_SYSTEM	CARBONIFEROUS
MAX_ERATHEM	PALAEOZOIC
BGSREF	222
MSLINK	16325
COUNTFOUND	1

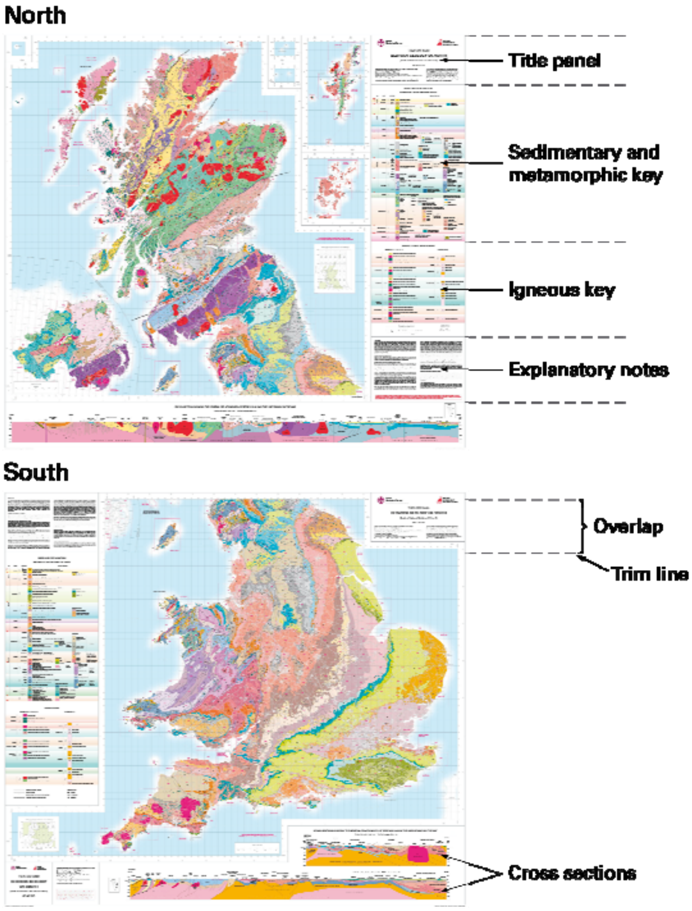
Table 1. Information fields in source DiGMapGB-50 data

GROUP_EQUIV _DESC	LEX_ROCK	LEX_D
LIAS GROUP	BDS-SDST	BRIDPORT SAND FORMATION
LIAS GROUP	BDPY-LSSA	BROADFORD BEDS FORMATION AND PABAY SHALE FORMATION (UNDIFFERENTIATED)
LIAS GROUP	CHAM-IRND	CHARMOUTH MUDSTONE FORMATION
LIAS GROUP	RIPS-MDIR	RAASAY IRONSTONE AND PORTREE SHALE FORMATION (UNDIFFERENTIATED)
LIAS GROUP	MRGF-SHLM	BLUE LIAS FORMATION (MARGINAL FACIES)
LIAS GROUP	BFB-CASI	BROADFORD BEDS FORMATION
LIAS GROUP	RMU-MDST	REDCAR MUDSTONE FORMATION
LIAS GROUP	CDI-IRST	CLEVELAND IRONSTONE FORMATION
LIAS GROUP	DYSM-SLST	DYRHAM FORMATION AND MARLSTONE ROCK FORMATION (UNDIFFERENTIATED)
LIAS GROUP	SMCM-MDLM	SCUNTHORPE MUDSTONE FORMATION AND CHARMOUTH MUDSTONE FORMATION (UNDIFFERENTIATED)
LIAS GROUP	SMD-LMST	SCUNTHORPE MUDSTONE FORMATION
LIAS GROUP	BRKH-LSSA	BREAKISH FORMATION
LIAS GROUP	DYS-MDST	DYRHAM FORMATION
LIAS GROUP	SCS-MSDS	SCALPAY SANDSTONE FORMATION
LIAS GROUP	ADS-STMD	ARDNISH FORMATION
LIAS GROUP	BNLS-LMST	BEACON LIMESTONE FORMATION
LIAS GROUP	PEE-ARG	PORTREE SHALE FORMATION
LIAS GROUP	BLCD-MDST	BLUE LIAS FORMATION, CHARMOUTH MUDSTONE FORMATION AND DYRHAM FORMATION (UNDIFFERENTIATED)
LIAS GROUP	BLCR-MDLM	BLUE LIAS FORMATION AND CHARMOUTH MUDSTONE FORMATION (UNDIFFERENTIATED)
LIAS GROUP	STA-SDST	STAITHES SANDSTONE FORMATION
LIAS GROUP	BLI-LSMD	BLUE LIAS FORMATION
LIAS GROUP	MRB-FGLM	MARLSTONE ROCK FORMATION
LIAS GROUP	ADSB-SARL	ARDNISH FORMATION AND BREAKISH FORMATION (UNDIFFERENTIATED)
LIAS GROUP	PABS-MDST	PABAY SHALE FORMATION
LIAS GROUP	CDST-SDSM	STAITHES SANDSTONE FORMATION AND CLEVELAND IRONSTONE FORMATION (UNDIFFERENTIATED)
LIAS GROUP	BW-SDST	BLEA WYKE SANDSTONE FORMATION
LIAS GROUP	WHM-LMST	WHITBY MUDSTONE FORMATION

Table 2. The 1:50,000 components shown as the Lias Group at 1:625,000

Eon	Era	Period	Map Code
Phanerozoic	Cenozoic	**Neogene**	**N**
		Palaeogene	**G**
	Mesozoic	**Cretaceous**	**K**
		Jurassic	**J**
		Triassic	**T**
	Palaeozoic	**Permian**	**P**
		Carboniferous	**C**
		Devonian	**D**
		Silurian	**S**
		Ordovician	**O**
		Cambrian	**E**
Proterozoic	**Neoproterozoic**		**X**
	Mesoproterozoic		**Y**
	Palaeoproterozoic		**Z**
Archaean			**A**

Table 3. The letter scheme used to label geological units on map



Topography © HarperCollins Publishers Ltd 2005, Geological Mapping, BGS © NERC

Figure 1. Bedrock geology map of the UK (North and South) 1:625 000 scale, 5th edition

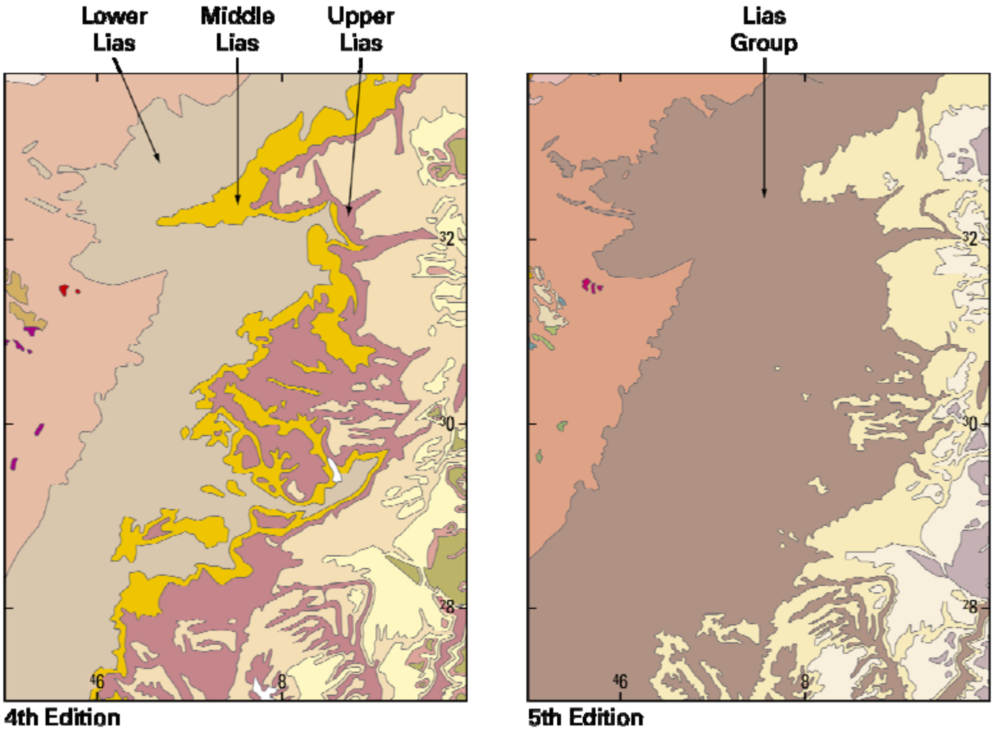


Figure 2. Lower, Middle and Upper Lias on 4th edition simplified to Lias Group on 5th edition.

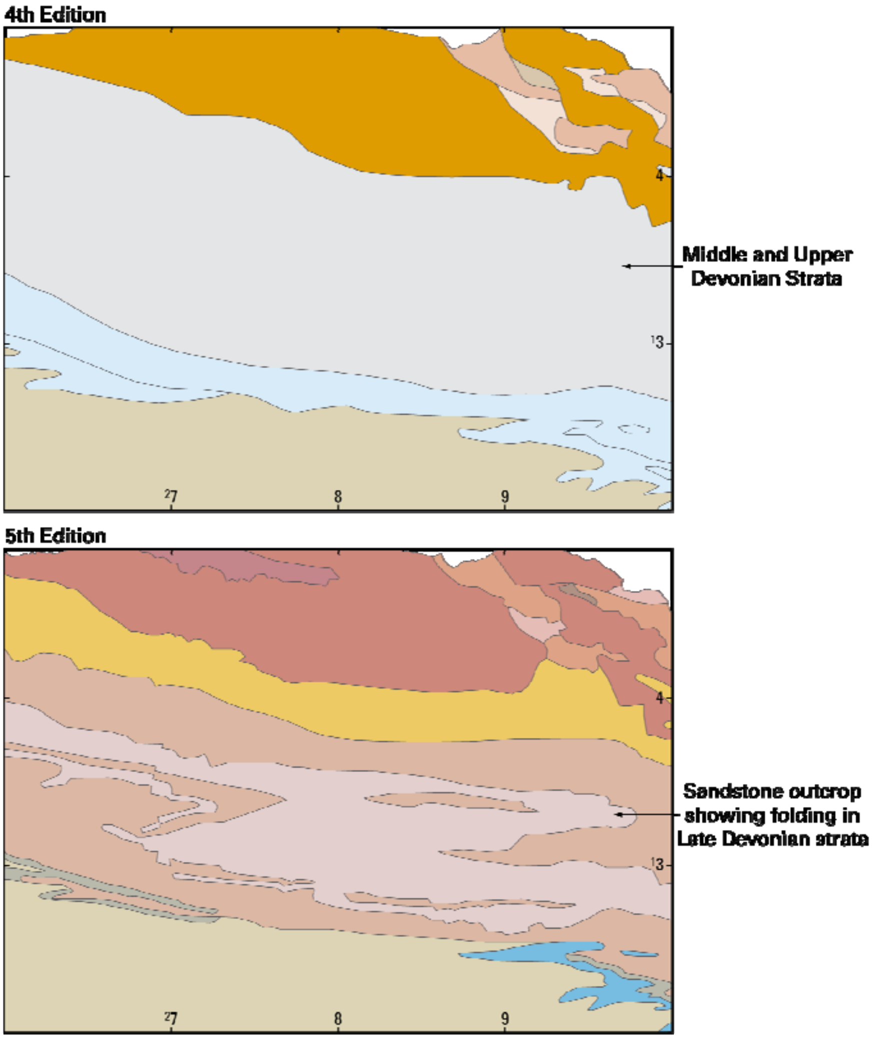


Figure 3. Fold structures as revealed by outcrop pattern of sandstones in late Devonian of Exmoor.

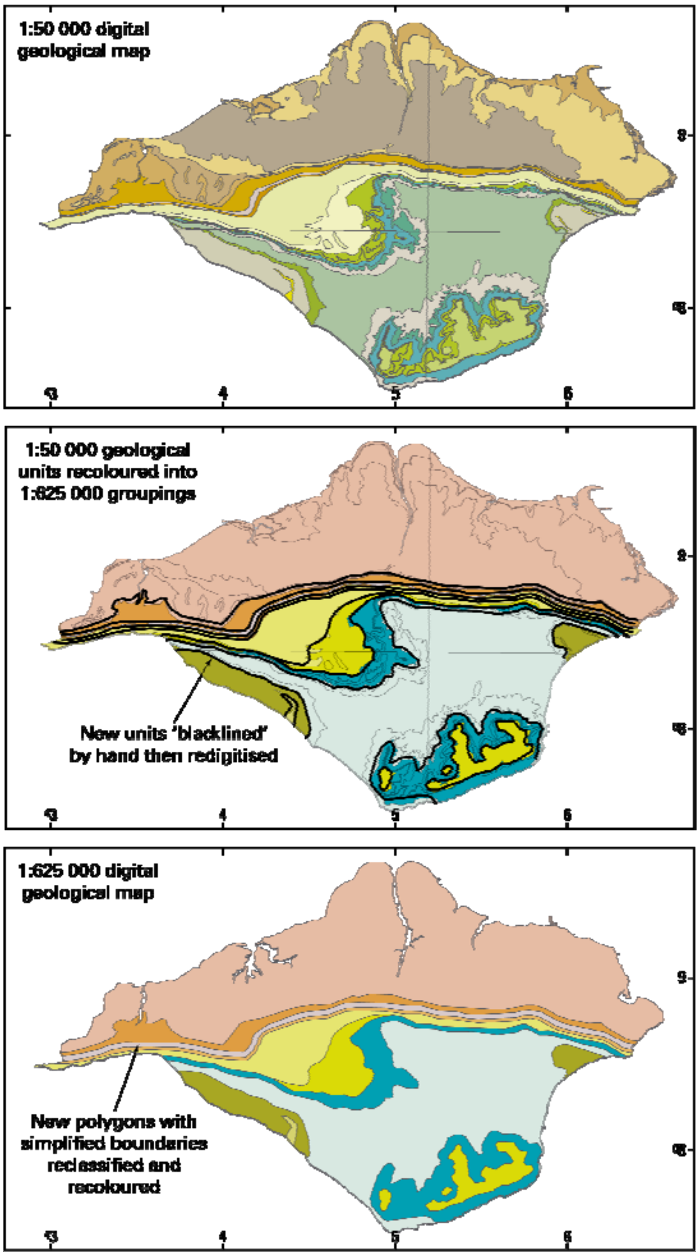


Figure 4. Geology of the Isle of Wight showing simplification from 50k.

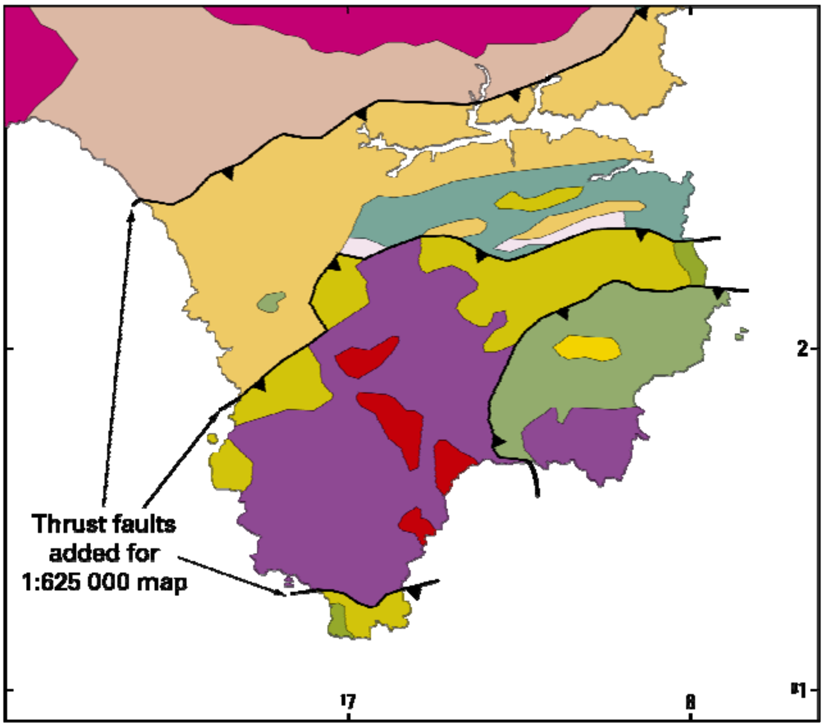


Figure 5. Additional interpretation of thrust faults north of the Lizard.

Figure 6. Part of map key showing Jurassic sedimentary rocks.

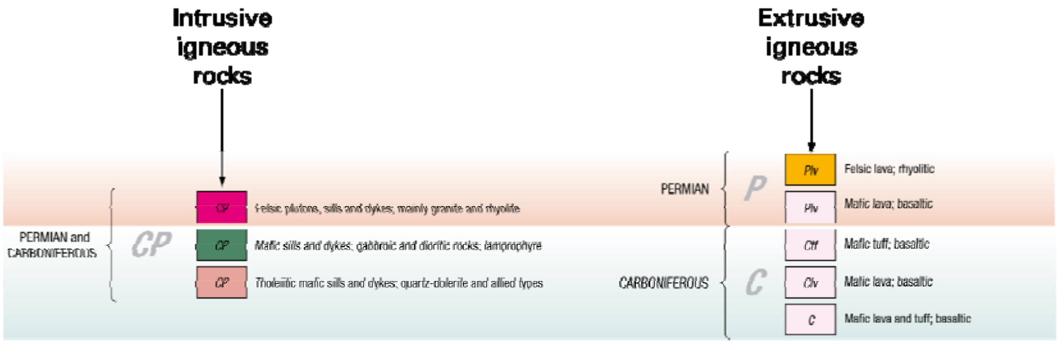


Figure 7. Part of map key showing igneous rocks.

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