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Geological Survey**
NATURAL ENVIRONMENT RESEARCH COUNCIL

Proposed Methodology for the Development of a Mining Geohazards Data Layer

GeoHazarDs

Internal Report IR/03/119



BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/03/119

Proposed Methodology for the Development of a Mining Geohazards Data Layer.

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Summary

This report describes the work carried out for the Mining Geohazard facet of the GeoHazardDs project up to the 31st March 2003 when development work on the mining aspects of the project were suspended. The work carried out so far has been restricted to England and Wales, once the methodology has been verified the area covered will be extended to incorporate Scotland.

Work carried out so far has covered

- Simultaneous data capture of local knowledge and national data coverages as a foundation for the project.
- Establishment of a GIS framework to hold all data produced and utilised by the project.
- Explanations of the data structure from capture and manipulation of the Overview ARUP data layer through to the inclusion of detailed local datasets e.g. the Bath stone information.
- Proposed methodology using shafts, veins and formations rated on a series of factors with worked examples illustrating strengths and weaknesses of the methods.
- Future modifications to the methodology developed so far, looking at spheres of influence rather than raw or generalised themes.

1 Introduction

The potential for Mining Geohazards project was established to draw together mining related information available within British Geological Survey (BGS) and to establish a method for presenting and processing the information to derive a new potential for mining geohazard data layer.

This report establishes the context within which the work was carried out and illustrates the decision making processes which were followed to develop a data framework to facilitate the processing of information to generate the new combined data layer. Also the creation of an infrastructure to store and make available all the collected mining hazard information.

In essence the project has re-discovered, extracted and collated data relating to mineral veins, shafts and lithology, devised methods of rating and combining the information.

Before undertaking the work it was fundamental to establish what is meant by ‘mining hazard’, for the purpose of the project it has been defined as ‘an undesirable environmental effect due to the presence of a past or present mineral working’. Examples include subsidence, collapse, release of toxic or undesirable elements, egress of acid mine water or water with undesirable elements and uncontrolled releases of water..

Using this definition as a basis it is difficult to establish a suitable methodology which will enable the satisfactory capture of mining hazard related information since the majority of this information is anecdotal and locally reported.

2 Data Capture

A dual approach was adopted to the capture of information as one element of the project was to encapsulate material held by District Geologists (see Figure 1) into a standardised auditable data store whilst also amassing mining related information from previous BGS projects.

The main focus of the project was to assemble as much internally produced data as possible to create comprehensive data coverage to enable the generation of a new mining hazard dataset. Initially it was thought that the DigMap lithology and mineral veins could be used alongside mine locations. It was envisaged that the datasets would be extracted and rated according to a series of relevant criteria before combining them to produce a new added value data layer.

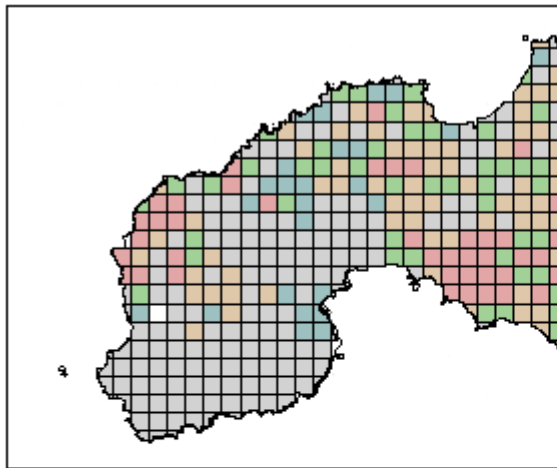
2.1 LOCAL KNOWLEDGE

During the initial phase of the project efforts were made to collate local knowledge, however since it is generally only reported in local newspapers or other contemporary records it is difficult to unearth and lacks any kind of positional accuracy. It was therefore decided that where information was available it would be referenced in an Excel spreadsheet and, if accurate locations were available, site-specific details could be hotlinked into the GIS.

An alternative methodology was devised to collect this ‘local expert knowledge’ from the District Geologists. Using a 1km² set of polygons based on the national grid District Geologists were asked to select grid cells in areas where they are aware of mining related information and add this attribute data into the associated table (Figure 2). This information is supported by references to source materials where possible to provide a data audit trail.



Figure 1 District Geologist areas



1Km² cells derived from National Grid. (cell colours reflect different local knowledge hazard rating assigned by District Geologist.

Section of the underlying attribute table containing innate mining related elements and source attributes

Attributes of Sw_region_Local_Knowledge			
Source	Zkm_sq	Haz_rate	Details
1:10k map, Dines	SW3431	3	1 shaft on sheet edge, Cape Cornwall Mine, Corn 73NW
1:10k map, Dines	SW3531	5	47 shafts, 3 adits, Corn 73NW
1:10k map, county field slips	SW3631	3	10 shafts
1:10k map	SW3731	1	
1:10k, Dines, County Series	SW3831	5	20 shafts, 1 Clay Pit, Corn 73NW
1:10k, Dines, County Series	SW3931	4	3 shafts, Corn 73NE

Figure 2 Local knowledge data capture framework

2.2 MINERAL VEINS

Initially DigMap data which has been captured at 1: 50 000 scale, was not seen as fit for purpose as it has produced an inconsistent data set, mainly due to the original data capture and limitations of the automated extraction techniques, necessitating careful data checking and attributing once the extraction had taken place. An alternative to the DigMap data would be the manual capture of specific information for the Geohazard project. To decide on the most viable course of action to be adopted it is necessary to evaluate fitness for use of the data.

2.2.1 Evaluation of mineral vein data at different scales.

Factors affecting which data are best suited for use in production of the Mining Geohazard map are

- The scale and extent of mineral vein data which has already been captured
- The feasibility of utilising data captured at differing scales whilst establishing level of quality loss.
- The time required to create a national coverage of mineral veins at a 1: 10 000 scale.

To gauge the fitness for use of 1:50 000 maps an assessment of the level of data loss when migrating from 1:10 000 scale is required. In an attempt to quantify this data Cornwall and the South Pennines were compared at the 1: 10 000 and 1: 50 000 scales for the same areas.

2.2.1.1 CORNWALL

Two 1: 10 000 map sheets were selected from the Southwest England study area (SW63NE & SW74SW). These were chosen because they represented some of the most heavily mineralised areas. The comparative areas were then digitised from the 1: 50 000 Falmouth Sheet (352) and a simple count of the number of mineral veins illustrated by each map was made.

Map Sheet	Scale	Number of Mineral Veins	% Data loss
SW63NE	1:10 000	86	30.3%
	1:50 000	60	
SW74SW	1:10 000	160	22.5%
	1:50 000	108	

Table1 Cornwall map sheet and percentage data loss.

A considerable amount of information was lost when transferring to the smaller scale map. The maps demonstrate the differences between the two data sets, not only through data loss but also differences in drawing style, with the original 1: 10 000 map sheets illustrating more detail.

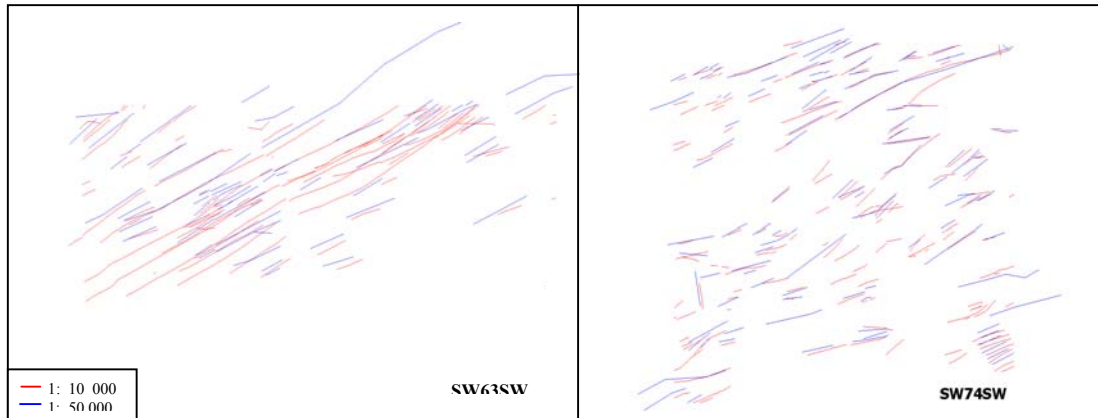


Figure 3 Comparison of the Cornish Mineral veins in the SW63NE & SW74SW sheets.

2.2.1.2 SOUTH PENNINES

The South Pennines Orefield data was created from a series of co-ordinate pairs, which have been joined to convert them to lines. Since the whole of the south Pennines area was available a direct comparison was carried out over the entire area.

Scale	Number of Mineral Veins	% data loss
1: 10 000	3226	35%
1: 50 000	2086	

Table2 South Pennines map sheet and percentage data loss.

From the Figure 3 it can be seen a third of the data was lost when moving from the 1: 10 000 to 1: 50 000 scale. Visual inspection of the mineral vein data highlights areas where very good data matches can be found, areas where the two datasets appear to be offset, also 'holes' in the DigMap data.

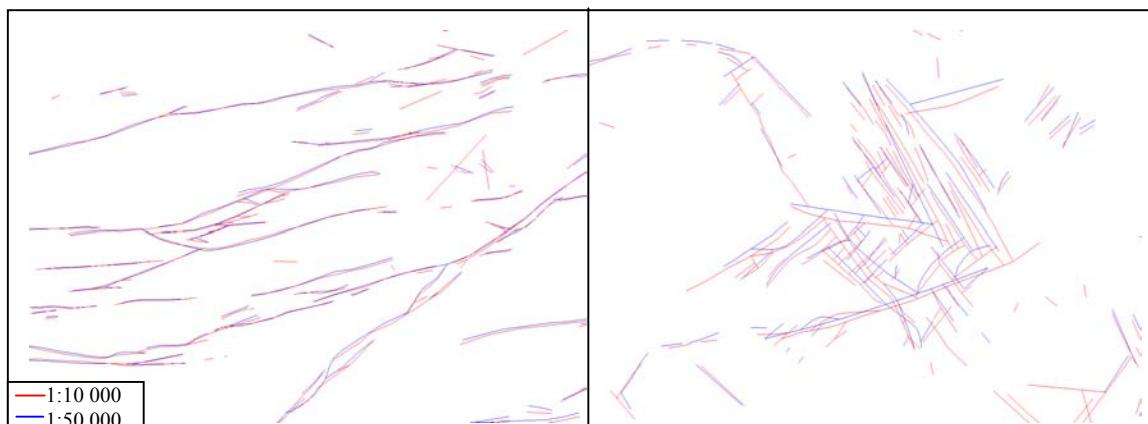


Figure 4 Comparison of the South Pennine Orefield data

2.2.1.3 TIME SCALE FOR CAPTURE

Number of 1: 50 000 maps to cover England & Wales 360

Number of 1: 10 000 maps to cover England & Wales 5800

Currently the only information available for rate of capture concerns the South West data which took one month plus four days checking time for the sixteen 1: 10 000 sheets, this begins to illustrate the enormous task which capturing at 1: 10 000 scale would represent.

2.2.1.4 DEDUCTIONS

- Approximately 30% reduction in data content transferring from 1: 10 000 to 1: 50 000 scale (based on data from heavily mineralised areas.)
- Main areas of mineralisation are already captured at 1: 10 000 scale remaining areas could be supplemented from DigMap 1: 50 000 information.
- Optimum solution uses 1: 10 000 data for Cornwall, the south Pennine Orefield and when available north Pennines which would reflect the most heavily mineralised areas.
- Denote the 1: 50 000 as a national coverage derive from the DigMap data.
- Create simple polygon layer to illustrate areas more detailed information available

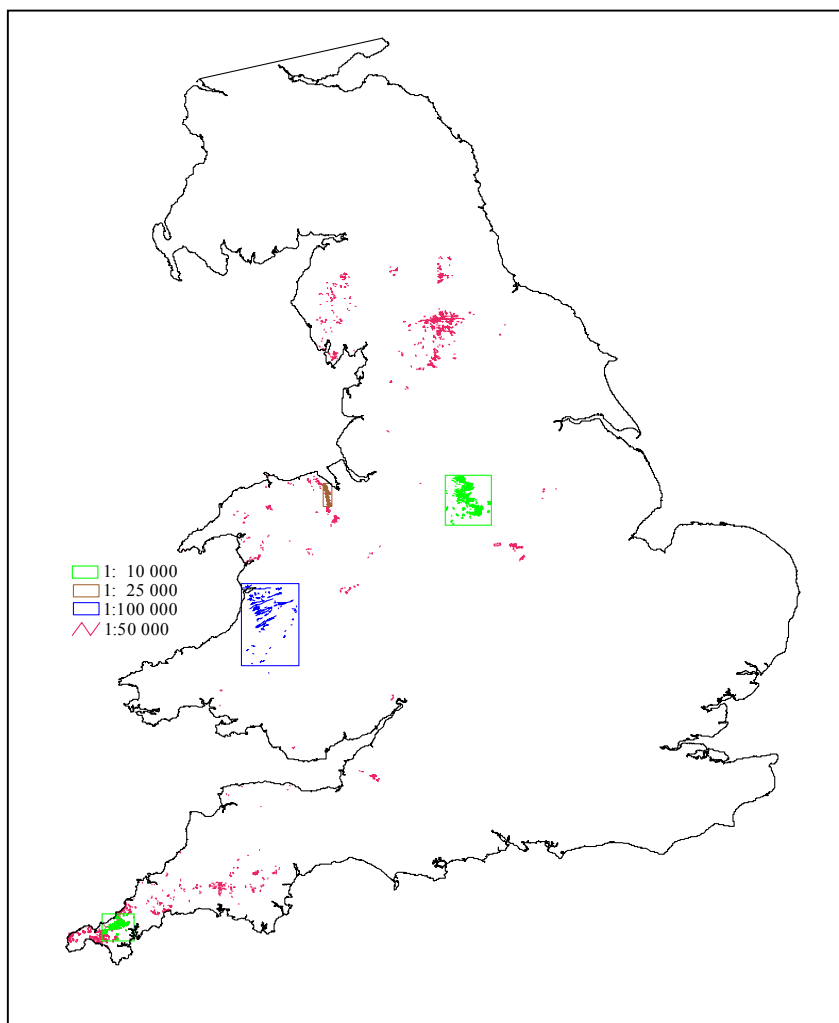


Figure 5 Location of supplementary mineral vein data sets.

This assumes shafts data is not being extracted from 1: 10 000 sheets however if shafts information is extracted at 1: 10 000 scale then it would be more effective to capture both datasets simultaneously.

2.2.2 Proposal

The main outcome of the evaluation is that the detailed datasets should be used where available and any other areas should be represented by the DigMap data. Central Wales should be represented by data from the 1: 100 000 scale map from the MRP report 5 Preliminary mineral reconnaissance of Central Wales. Veins were digitised in September 2001 for use within the Geohazard project as the map was originally compiled purely to reflect mineralisation in central Wales and is therefore more fit for purpose than the DigMap material.

Extraction of mineral vein data from DigMap produced 4407 lines and where available attribution with mineral type has taken place from the paper 1: 50 000 map sheets. These mineral types are used as the basis for rating the mineral veins which is further discussed in section 5.1.2.

2.3 SHAFTS

A wide range of information relating to mine shaft location is available from numerous sources within BGS. It has been collected for a diverse range of uses, however efforts to collate these datasets were curtailed by the development of the Mine Entrances database project. It is envisaged that when the district-by-district work is carried out guidance will be available from District Geologists as to supplementary sources for mineshaft data.

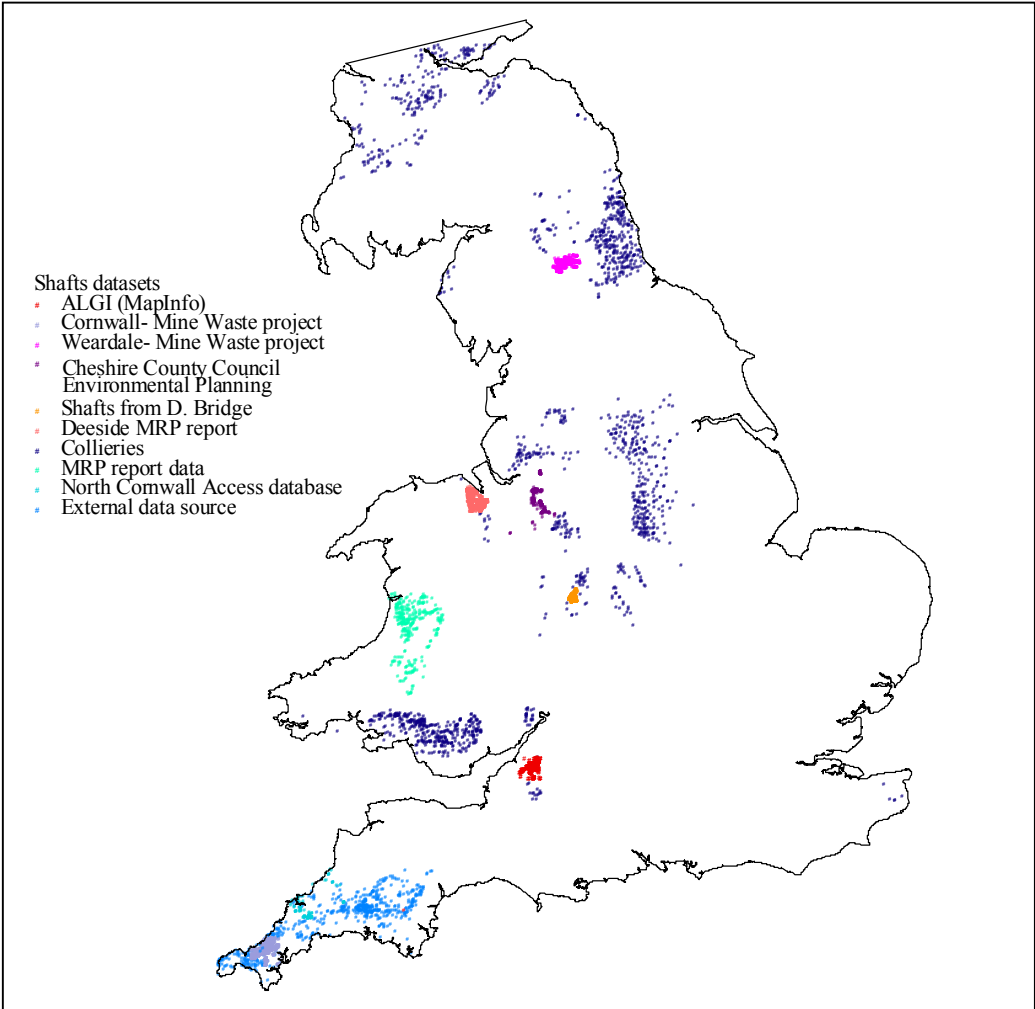


Figure 6 Location of shafts data by source project.

3 Concept and structure of the GIS

A three-tier architecture was adopted to reflect the different levels of detail held within the different data sets.

- An overview level providing national coverage indicating main mining areas and based on the Arup dataset shows Great Britain based on 1km squares.
- An intermediate level by creating a dataset based around the DigMap 1: 50 000 lithology polygons, integrating the mineral veins and shafts data which will be attributed using the ratings described in the potential for mining hazard guidelines.
- A local level allowing the integration of localised knowledge and information. Allowing reuse of shafts and vein datasets but with buffers to show specific features e.g. residue dams from the kaolin production, tailings dams from metal mining.

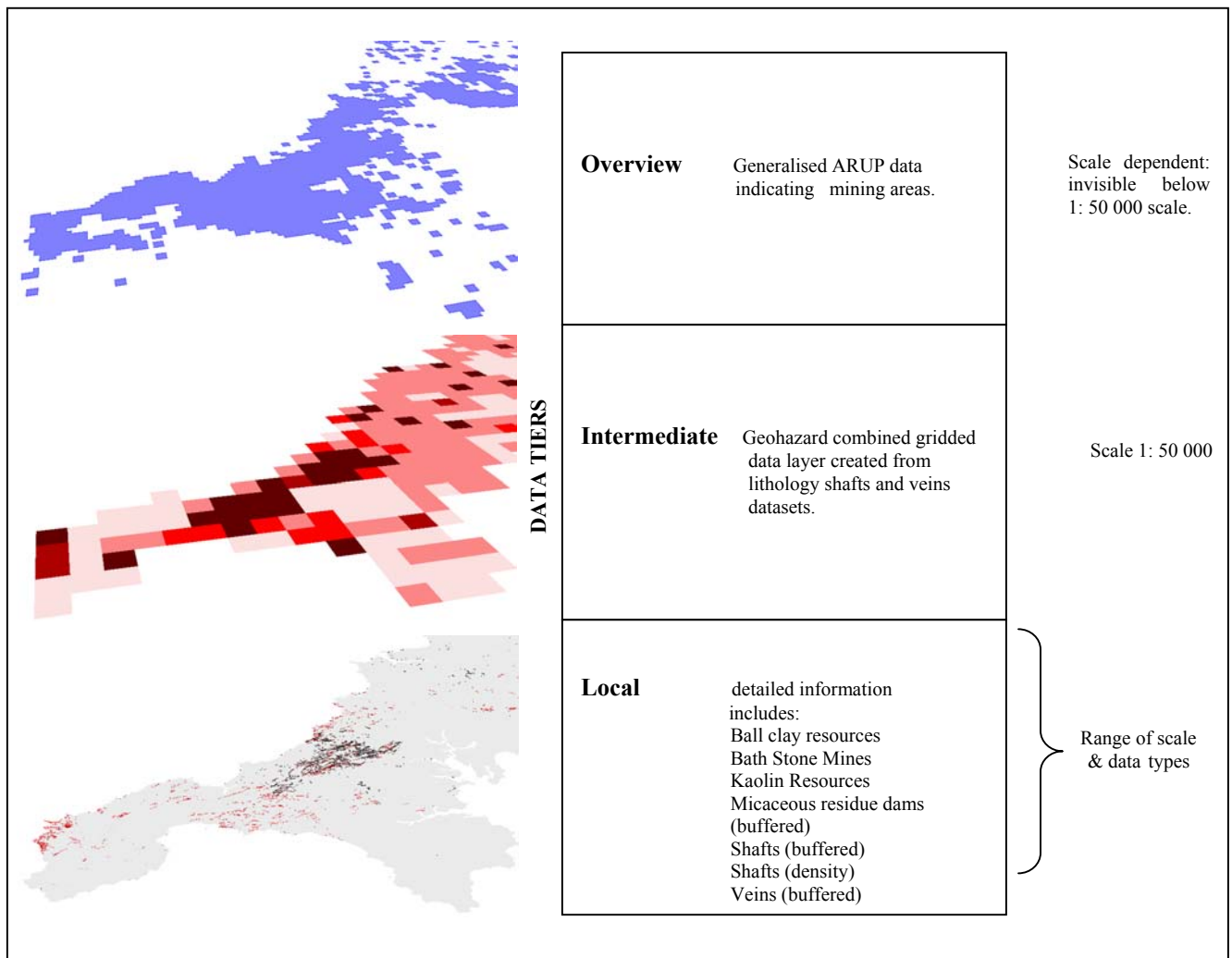


Figure 7 GIS Three tier architecture

4 Overview data level

An external dataset was purchased from ARUP in the form of fifty AutoCAD 14 maps to provide a generalised view of areas in which mining activity is known to have occurred. These were compiled for the ‘Review of Mining Instability in Great Britain’ undertaken by ARUP on behalf of the Department of Environment in 1991. The data was produced as 1km² areas (Figure

8) but required extensive reworking to produce a viable set of 1km squares aligned to the national grid in a polygon format, with a limited range of attributes i.e. Shape, Entity, Layer and Sheet. Layer definitions are restricted to mining type i.e. Coal, Deneholes, Evaporites, Iron, Metalliferous and Rock.

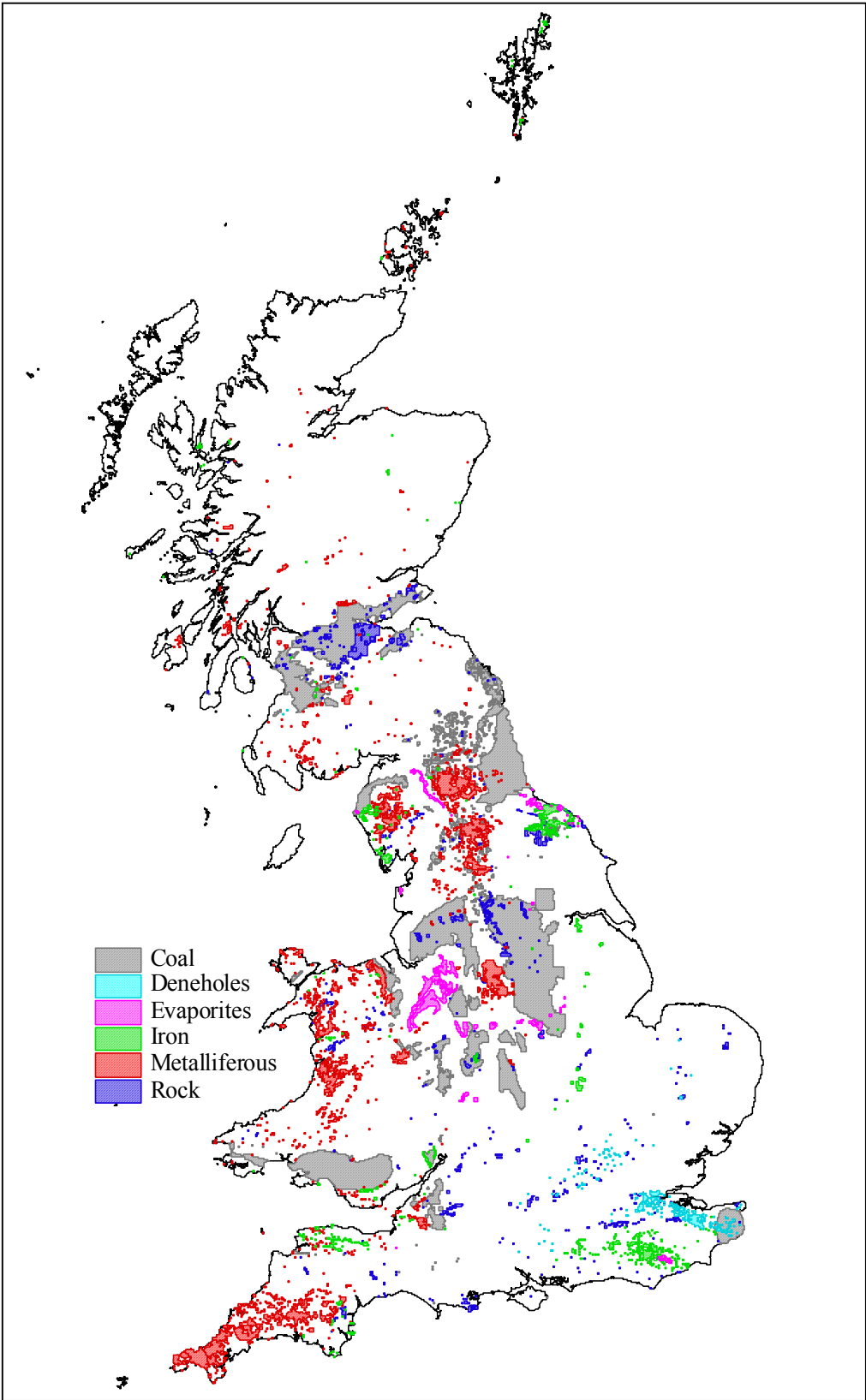
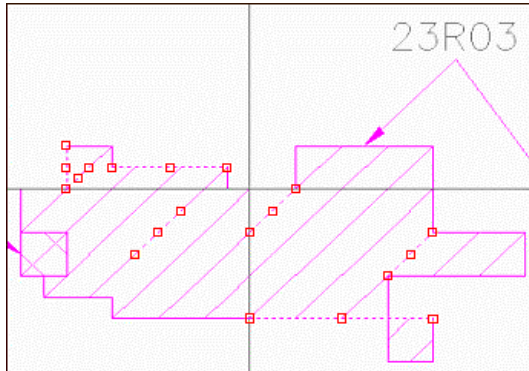


Figure 8 ARUP County Mining Overlay Map

4.1 ARUP DATA PROCESSING

4.1.1 Original AutoCAD Drawing files

The data from ARUP contained two drawing layers for each material type, one showed boundary lines for each area, which although touching were sectional rather than joined and in some areas incorporated map gridlines in place of separate boundary line segments. The second information layer contained hatching lines for filled areas, which were drawn using short line segments. In some areas both boundary lines and hatching were spatially correct, but allocated to an incorrect data layer. All the required line work was present, but straightforward migration of the data as closed polygons into ArcView was not possible. All data processing and work flow development was carried out by Kevin Greally



Dashed lines with square markers illustrate isolated line segments used to create original drawings.

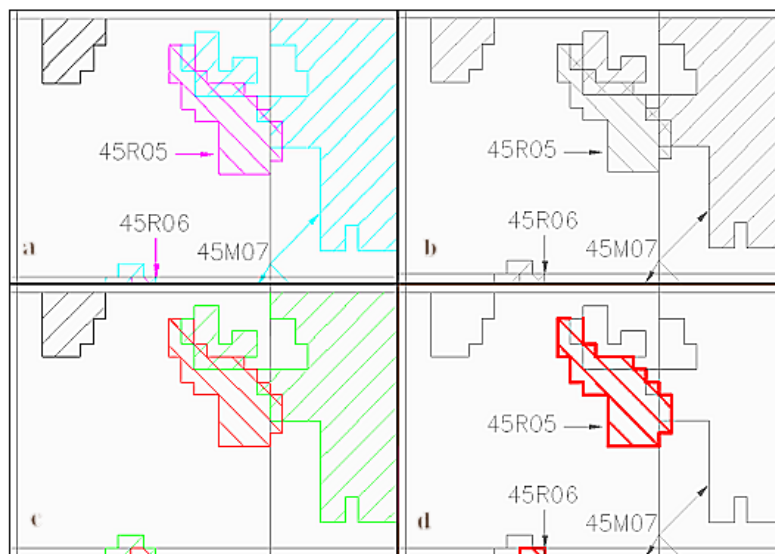
Map gridlines (in grey) have been used as part of the polygon linework.

Figure 9 Original AutoCAD map

4.1.2 Editing AutoCAD drawing files.

AutoCAD 2002 software was used to isolate individual polygons on each layer from other entities in the drawing so that the boundary lines of the area could be viewed as a single closed section. This was achieved by turning the display of individual layers on or off as appropriate.

The AutoCAD command BOUNDARY functionality was used to convert the lines of a closed polygonal area into a drawing entity that could be exported as a polygon area and used within ArcView. To speed up the editing process AutoCAD scripts were created to automate a range of functions including creation of new drawing layers, filling polygons and setting and highlighting individual layers.



(a) Original map showing line weights

(b) After running osetup.scr

(c) After running odata.scr

(d) After running or.scr. All rock polygons are now highlighted in bold red for display in one AutoCAD viewport.

Figure 10 Stages in AutoCAD process to isolate a single rock polygon.

4.1.3 Processing to produce a rock polygon

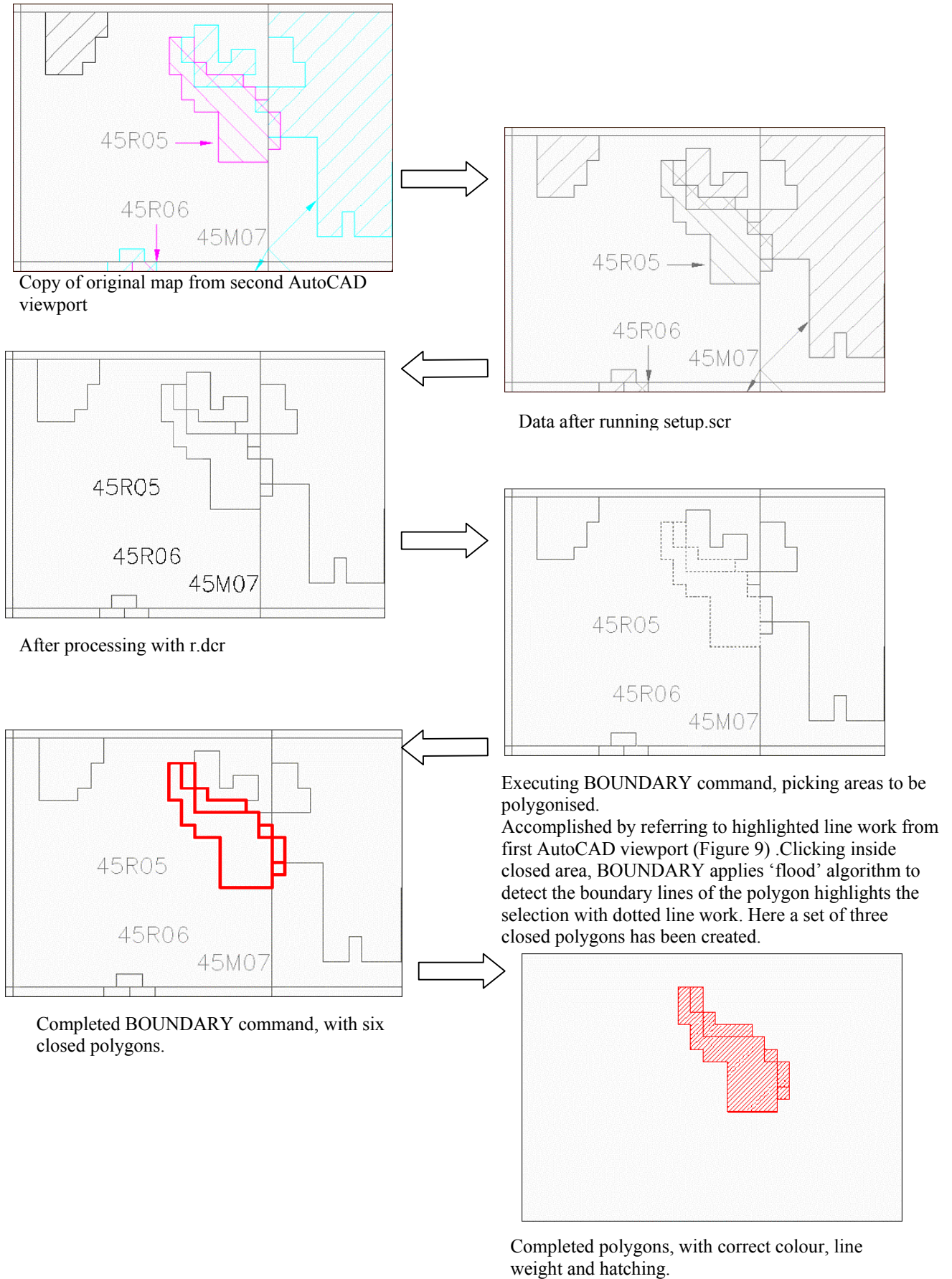


Figure 11 Processing to produce a rock polygon

4.2 COPYRIGHT AND DATA USAGE

Negotiation with the Intellectual Property Rights Manager resulted in confirmation that the copyright ownership of the “derived product” –ArcView mining instability dataset, rests within NERC/BGS.

This means that the following intended activities are permitted:-

- (i) Holding/using the ArcView dataset as part of the GeoHazarDs project.
- (ii) Producing generalised (per km²) information on mining-related hazards from our own ArcView dataset.
- (iii) Licensing the BGS’s ArcView mining instability dataset to third parties (subject to usual BGS’s digital licensing arrangements).

(Taken from Intellectual Property Rights Memo Ref No: IPR35-10tc Ove Mining Data Nov35-10 28/11/02 (IPR Ref IPR/35-10))

Negotiations were also undertaken with DEFRA and ODPM to use the ‘cleaned up’ version of the ARUP dataset (see Appendix 1)

4.3 METADATA

Metadata has been created for the ARUP dataset (see Appendix 2 and is held within the BGS Discovery metadata database. It outlines coverage, data capture and quality assurance information.

4.4 QUALITY CONTROL

Validation of the polygonised dataset was carried out by comparing the newly created BGS dataset with the original ARUP AutoCAD drawings. This comparison was carried out in two stages

- A simple visual check to confirm all the separate map sheets had been polygonised.
- A detailed examination of the newly created dataset against each original map sheet from which it was derived.

4.5 FUTURE USES OF ARUP DATASET

The ARUP dataset, which was originally envisaged as providing a general impression of the main mining areas has, since its conversion to a functional attributed resource, been used as the focal point of a simple application development. This would enable the user to input a postcode and retrieve information on who to contact for further details regarding mining at the specified location. Further development towards a web-based version could provide access to a wider audience to simply give an indication of type of mining and simple details on whom to contact for further information.

5 Intermediate data level

The criterion for deriving this data was to create a scalable solution through the development of a potential for mining hazard layer. The preliminary approach has been to develop hazard-scoring systems based on a range of factors, which can in the simplest form be summed to give a total value for any given location.

5.1 HAZARD RATINGS

5.1.1 Lithology polygons

Assumptions:

- DigMap data currently refers to surface only.
- The discontinuity (joint) spacings are not derived from DigMap, as there is no classification of these parameters. Instead it is derived from the knowledge of some geoscientists, such as Alan Forster.
- There are no hazard parameters on the dip of the rocks as these are not recorded digitally.
- There are no hazard parameters on faults as most (all?) are faults and the density of faulting is strongly dependent on rock type and mapping e.g. the density increases markedly in coal field areas due to the increased information and the utility of the information.
- There are no hazard parameters on alteration of rock types. While this may be useful e.g. a kaolinised granite is weaker than an unaltered granite, it is subjective, sporadically recorded and is not available in DigMap.

5.1.1.1 HOSTROCK LITHOLOGY

Using the lithology polygons from the DigMap dataset as the base units a ‘look-up’ table was developed to score the potential for mining hazard. The ‘look-up’ table could then be joined to the DigMap lithology polygon attribute table. This option has been selected to allow modifications to be made in the hazard rating system and given the size of the dataset (396356 polygons) manual editing was perceived as an unrealistic alternative.

A hazard rating scale has been developed by Tim Colman, it classifies the rocks based on type e.g. igneous, metamorphic and sedimentary and breaks down the sedimentary into sub categories. This is an arbitrary scale on relative ‘hardness’ and ‘toughness’ of each rock type.

Host rock Lithology	GHD_Rating
Igneous	1
Metamorphic	1
Sedimentary Sandstone/Limestone	2
Sedimentary Mudstone/Shale	5
Sedimentary Clay	8
Sedimentary Coal Measures	10
Sedimentary Superficial	10

Table 3 Host Rock Lithology Hazard Rating

The scale was applied to the GHD_Rock_Hazard table and where descriptions indicate combinations of rocks the highest hazard score is applied e.g. STMD sandstone and mudstone is scored as 5 based on the mudstone component rather than 2 for the sandstone.

Having tested this version of the lithology hazard rating and after discussion with the District Geologist for the trial region it was decided that a more appropriate rating criteria would be the host rock formation type rather than the lithology.

The individual lists were disseminated to District Geologists with a clear set of guidelines for hazard rating. It is recognised that the rating process is subjective and that there are risks associated with more than one individual applying hazard ratings however guidelines on rating formations were provided.

A complete list of rock types was derived from the ‘rock’ data in the attribute table of the DigMap shape file (GB_50k_v1_05_solid.shp) and consists of 1040 different classes of rock.

5.1.1.2 DISCONTINUITY SPACING

The same list as used for host rock lithology needs values assigning based round the natural hazard schema. Again this is an arbitrary scale based round Alan Forsters work for the natural hazards.

Discontinuity spacing (mm)	Rock Category	GHD_Rating
Very wide >2000		1
Wide 2000-600	Gabbro	2
	Granite	
	Chalk	
	Carboniferous limestone	
	Pennant Sandstone	
	Sherwood Sandstone	
Medium 600-200	Sandstone	5
	Limestone	
	Basalt	
Close 200-40	Mudstone	7
Very-extremely close <50	Slate	10
	Shale	
	Schist	

Table 4 Host Rock Discontinuity Spacing Hazard Rating

As with host rock lithology where there are combination descriptions the higher rating is applied.

5.1.1.3 HOST ROCK FORMATION

A complete list of formations was extracted from the DigMap shape file (GB_50k_v1_05_solid.shp) that produced 4024 separate formation types (extraction carried out using table_uniquequery.ave, script from the ESRI website, see Appendix 3. This information was then allocated by district based on the District Geologists areas shown in Figure 1. The individual lists were disseminated to the District Geologists with a clear set of guidelines for hazard rating. It is recognised that the rating process is subjective and that there are risks associated with more than one individual applying hazard ratings however guidelines on rating formations were provided.

- 0.** No known mining hazard. An example might be the London Clay Formation
- 1.** Minor mining hazard an example might be where a formation has one or two shallow stone workings, but no extensive workings and no metalliferous or coal workings.
- 2.** Low mining hazard an example might be where a formation has a few small metal or stone mines in a strong formation with no record of collapse or other environmental problems.
- 3.** Low - moderate mining hazard. An example might be the Bee Low Formation in Derbyshire, which has some sporadic mineral veins in very competent rock. There is little danger of collapse or acid mine water.
- 4.** Moderate mining hazard. An example might be the Lower Rhyolitic Tuff Formation in Snowdonia which has number of small veins worked from shafts and adits in an upland area. There is some hazard of collapse, outflow from blocked adits, acid mine drainage and movement of tip material. However, the total impact is still relatively small.

5. Moderate mining hazard. An example might be a formation with some old shallow coal mines which have been worked out. There will have been some collapse and more can be expected. Acid mine drainage is not seen as a major problem due to the small size of the old workings.
6. Moderate mining hazard. An example might be the Monsal Dale Formation in Derbyshire which has hundreds of veins, thousands of shafts and associated tips but the carbonate hostrock prevents acid mine drainage becoming a problem. However, the overall impact is relatively large.
7. Moderate – high mining hazard An example might be some coal mining areas with many coal and ironstone mines, many records of collapse, mine water outflow etc.
8. High mining hazard. An example might be a Formation (?Derwenlas) in the Central Wales orefield with a combination of relatively large Pb/Zn mines, quantities of pyrite, shale hostrock and large tips in an upland area.
9. High - extreme mining hazard. An example might be some areas of SW England which have been heavily mined with many shafts, many unrecorded, though at a lower level than 10 below.
10. Extreme mining hazard Highly mineralised with significant hazard of collapse, mine shafts, tips, acid mine drainage and pollution from Cu, Pb, As etc. An example might be some formations within the Killas of the Camborne - Redruth area.

Table 5 Initial Formation Hazard Rating System.

5.1.2 Mineral Veins

5.1.2.1 MINERALISATION MORPHOLOGY

Values assigned based on Table 6. A default value of 1 has been allocated as most veins will be either vein or pipe deposits, exceptions to this will be known and well documented. All data where mineralisation morphology is unknown and has been assumed are marked with an * in the GHD_mineralisation_morphology_estimate column. Other types of formation will be identified through BGS knowledge base.

Disseminated	3
Irregular	3
Pipe	1
Seam	2
Salt/Potash	4

Table 6 Mineralisation Morphology Hazard Rating

5.1.2.2 MINERALISATION ATTITUDE

This information is not readily available, although it may have been collected for areas where specific project work has been undertaken. No value has currently been added since no data is available for any of the veins. Example values are shown in Table 7.

Dipping <45°	3
Dipping >45°	3
Horizontal	1
Vertical	1

Table 7 Mineralisation Attitude Hazard Rating

5.1.2.3 VEIN MINERAL

Describes the mineral type found in the vein. Where more than one type of mineral occurs the hazard rating is based on the highest value e.g. Copper and zinc in combination would be given a rating of 3 based on copper rather than 2 for zinc. Where the mineral type is unknown an average value of 2 has been added, these values can be recognised as they are marked with an * in the GHD_mineral_estimate column of the table.

Antimony	2	Iron ore	1
Arsenic	5	Lead	4
Barytes	2	Manganese	1
Bismuth	5	Nickel	3
Boron (tourmaline)	2	Phosphate	1
Building stone	1	Quartz	0
Coal	2	Silver	2
Cobalt	3	Tin	2
Copper	3	Tungsten	2
Fluorite	2	Uranium	5
Graphite	1	Witherite	5
Gold	1	Zinc	1

Table 8 Vein Mineral Type Hazard Rating

5.1.3 Shafts

5.1.3.1 MINING METHOD

Where available this can be rated. For the majority of sites a default value of 1 will be assigned as most workings where further details are unavailable will be the underground category.

Long wall	3
Open pit	1
Other	3
Pillar & stall	2
Underground	1

Table 9 Mining Method Hazard Rating

5.1.3.2 MINE SIZE

Where no details of the mine size are available a default medium rating of 5 has been applied.

Trial	1
Small	2
Medium	5
Large	10

Table 10 Mine Size Hazard Rating

5.1.3.3 MINERAL MINED

Metals mined have been rated based on the scale given in table 11, as with other data where more than one mineral occurs the highest rating is applied.

Antimony	2	Iron ore	1
Arsenic	5	Lead	4
Barytes	2	Manganese	1

Bismuth	5	Nickel	3
Boron (tourmaline)	2	Phosphate	1
Building stone	1	Quartz	0
Coal	2	Silver	2
Cobalt	3	Tin	2
Copper	3	Tungsten	2
Fluorite	2	Uranium	5
Graphite	1	Witherite	5
Gold	1	Zinc	1

Table 11 Mineral Mined Hazard Rating

5.1.3.4 LOCATION

Location is a subjective assessment carried out by overlaying the point data on the OS Landform Panorama contour data and a visual assessment being made.

Hillside	3
Hill top	5
Valley	1

Table 12 Location Hazard Rating

5.1.3.5 TOPOGRAPHY

Topography is also a subjective assessment carried out by overlaying the point data on the OS Landform Panorama contour data and visual assessment being made.

Flat	1
Rolling	2
Steep	3

Table 13 Topography Mining Hazard Rating

Having created values for each of the criteria defined previously a cumulative total is created to produce and Total hazard rating, the results of this are illustrated in Section 5.2.2

5.1.4 Further analysis.

Shaft density, calculated using mass/volume or number of shafts/polygon area (hectares)

- Number of points per polygon.

The number of shafts (points) in each polygon is calculated. Adding the shafts data to the lithology polygons. An extension was obtained from the ESRI website (see Appendix 3(countpoints.avx) which enabled the calculation of the number of points within a polygon this value is simply added to the DigMap lithology polygons.

This is the same data used to create the point density map illustrated in the shafts section. This data should be used with care as it does not show the shaft density merely a count per polygon, therefore taking no consideration of the area of the polygon. They can however be used with the area in hectares to calculate a density per unit area.

- Number of lines per polygon.

This data only represents the number of veins inside each polygon; it does not consider those, which intersect more than one polygon. The figures give a rough estimate of veins per polygon and can be used to evaluate if there is a link between lithology and mineralisation.

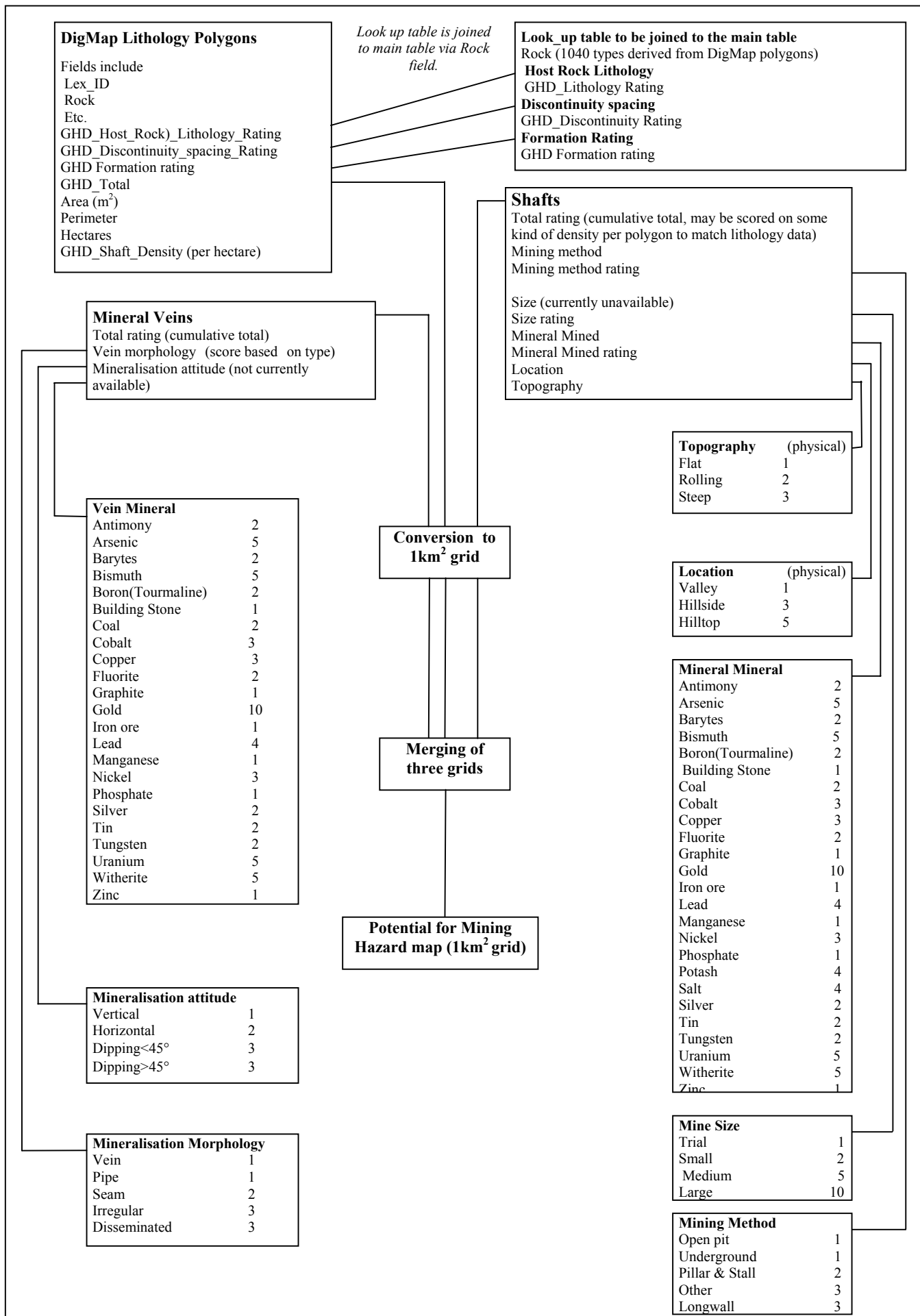


Figure 12 Inter-relationships between ratings and datasets.

5.2 COMBINING DATASETS

5.2.1 Grid size

Grid size is key to the creation of the new mining Geohazard data layer. It is important that an appropriate grid size be selected which will give useful national coverage. It must provide enough detail to be useful but not swamp the user with unnecessary information or loose essential data. After testing of varying mesh sizes a 1000 x 1000m grid giving 1km² cells has been adopted providing both manageable sets of data in terms of processing capacity and speed of data rendering. All new gridded data has been aligned to the national grid.

5.2.2 First iteration: Conversion to grids to combine separate data types.

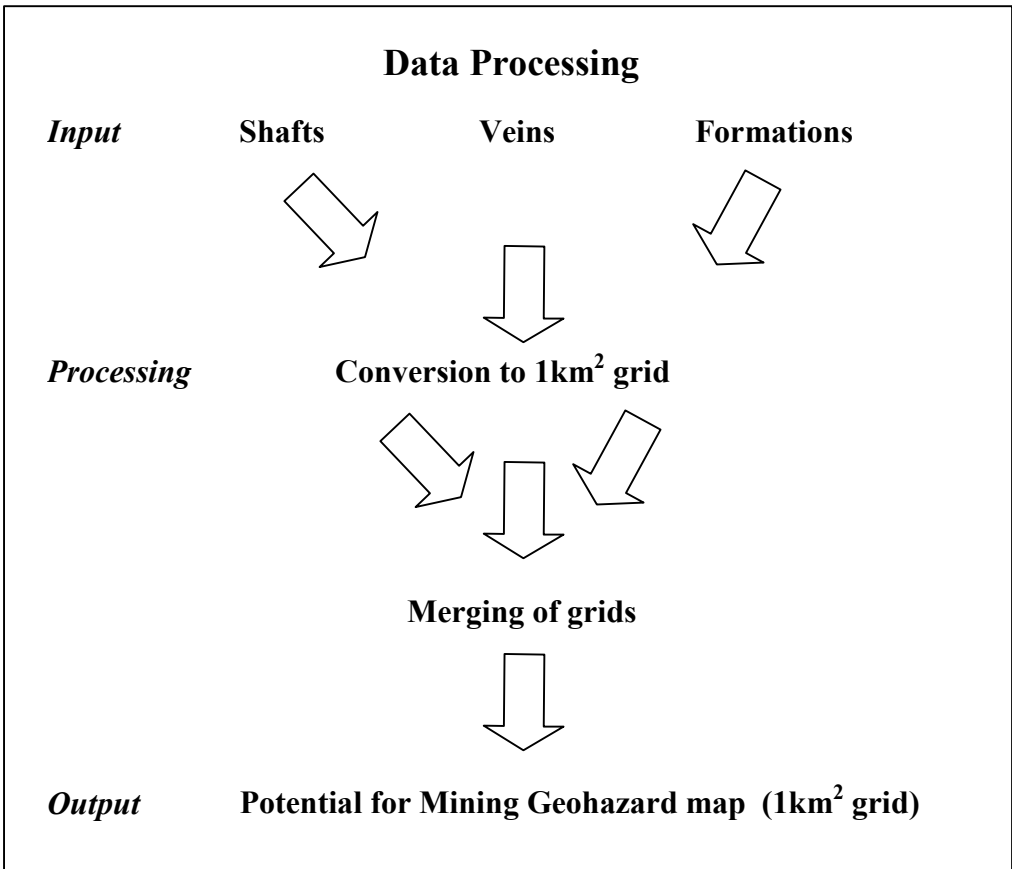


Figure 13 Methodology for Conversion of Raw data to Mining Geohazard Map

Having created the three separate themes, each with a cumulative total for hazard, it is necessary to combine the datasets to give an overall cell value. In order to achieve this each dataset must be converted to a standard unit. The themes are converted to grids using the following parameters.

Extent: Same as nation grid

Output grid size: 1000m

Once grids are created they must be reclassified by shifting the No data category to zero using Analysis, Reclassify. This will allow the aggregation of different gridded data sets. The grids are added using Analysis, Map Calculator and creating an add expression. Once the data is merged to a single grid the values in the combined grid should be checked and re-classified using a graduated classification.

The method described previously was adopted to create grids for mineral vein and shafts datasets. These were combined into a single grid, and converted to a polygon shapefile.

These polygon outlines were used to carry out an intersect on the test_geology.shp (lithology shapefile). Selecting only those geology polygons which have mining associated with them, originally the ARUP data was to be used once polygonised, providing more generalised mining areas however processing of the data was more time consuming than originally envisaged and when it became available the methodology had already moved to the second iteration.

Once the subset of geology polygons has been created then it can be used to produce a grid as above. The SW_geology grid needs to be reclassified and can then be added to the veins and shafts grids.

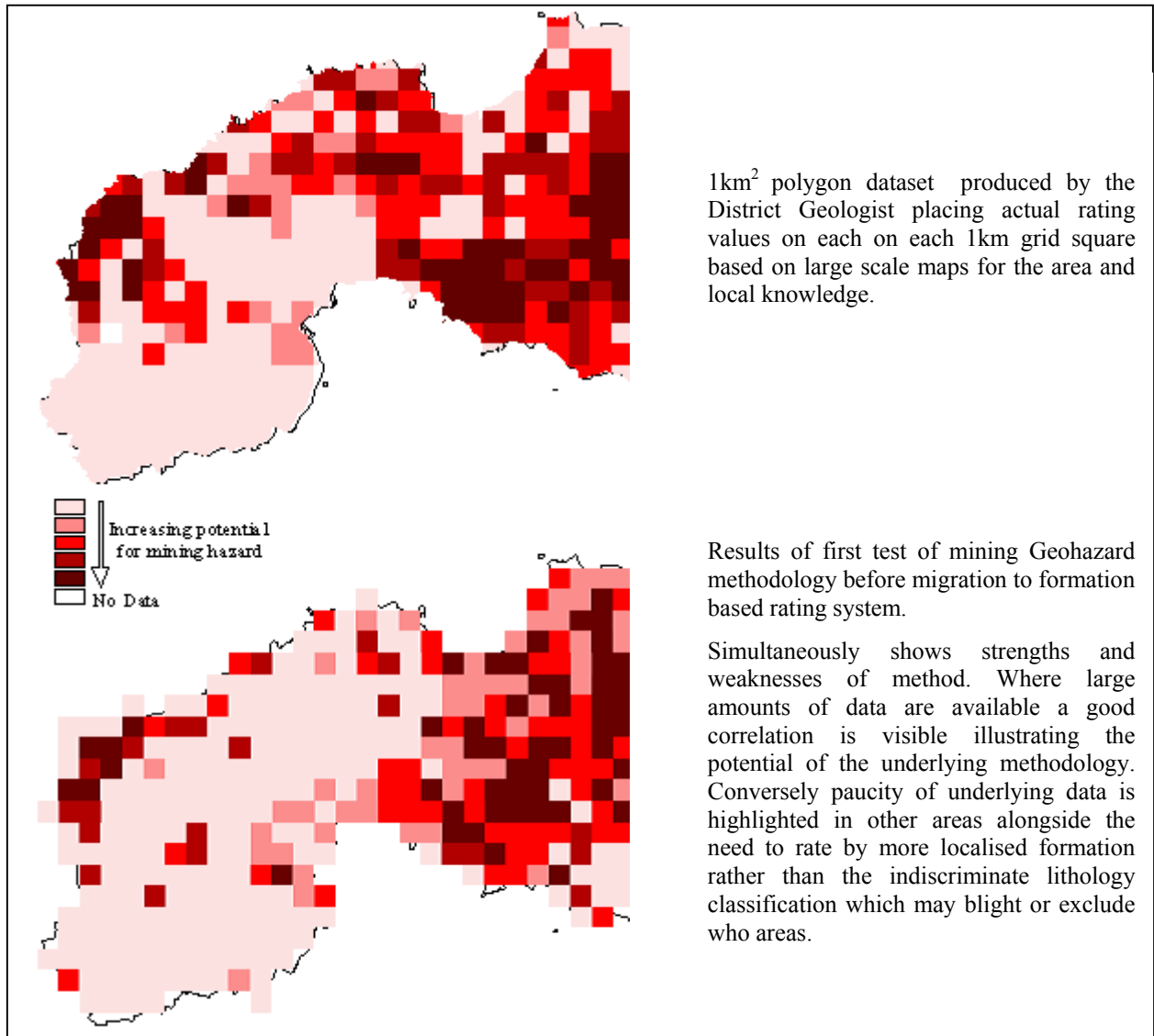


Figure 14 First iteration results for part of the Cornwall, Devon & West Somerset District

5.2.3 Second iteration: Utilising formation type in place of lithology.

Having established the initial methodology the test data for the SW region was passed to the District Geologist for evaluation. This assessment concluded that the formation rather than the lithology should be utilised since mineralisation is more closely associated with the individual formations than the overall lithology of an area.

This migration towards ratings based on formation type initially invoked difficulties as when a rating system was devised it was seem as too difficult to implement and too subjective (see Table 5).

In order to overcome these problems a second simplified rating system was developed which could be more uniformly adopted with little scope for individual interpretation and bias.

- | |
|---|
| <ol style="list-style-type: none">0. No mining in the formation1. Presence or absence of mining unknown2. Mining expected (due to the nature of the formation) but no known mines3. Mining known |
|---|

Table14 Final Formation Hazard Rating System

A test area in the South Pennine Orefield was used to validate this rendering of the method and positive results were obtained (Figure15) although the dominance of the underlying formation type is plainly visible. An illustration of the combined ratings resulting from the formation and vein datasets can clearly be seen on the western margin of the map.

5.2.4 Future Developments of the Method

Essentially the underlying techniques have proved to be sound. The plethora of complex rating systems applied to the shafts and veins may require modification since they are time consuming to apply and in certain areas are subjective in nature for example the differentiation between ‘Rolling’ and ‘Steep’ for Topography is biased by an individuals perception of the underlying contoured data.

Improved data coverage would also greatly enhance the results obtained. Ongoing work on the DigMap project should increase the mineral vein information, whilst the development and population of the Mine entrance/shafts database will provide a much broader coverage of shaft

location information than has so far been drawn together. Although it has been suggested that a migration towards using a sphere of influence around the shaft locations this has to some extent been mitigated by the implementation of a 1km grid, as this effectively creates a buffered region around each data point. The combined improvements in these datasets will clearly enable the development of a much more accurate mining hazard map.

Alongside these improvements due to expanded data coverage it is fundamental that a shift is made away from the use of hazard rated DigMap formation polygons since these reflect only the surface conditions and not the subsurface from which most incidents of mining hazard originate. In order to do this it is vital that the District Geologists participate in the generation of polygon data which reflects the sphere of influence which mining activity creates and establish an audit trail for the creation of this new information.

The simple additive approach to the generation of a final hazard rating will also require considerable modifications to highlight particularly hazardous areas. However the diverse range of physical and chemical hazard parameters will make this difficult.

6 Detailed information tier

The information contained within this level of the GIS reflects detailed local information; it includes the shafts and veins data, which was utilised in the creation of the intermediate gridded dataset but includes more localised information. Outlined here are brief details of added localised datasets depicted so far.

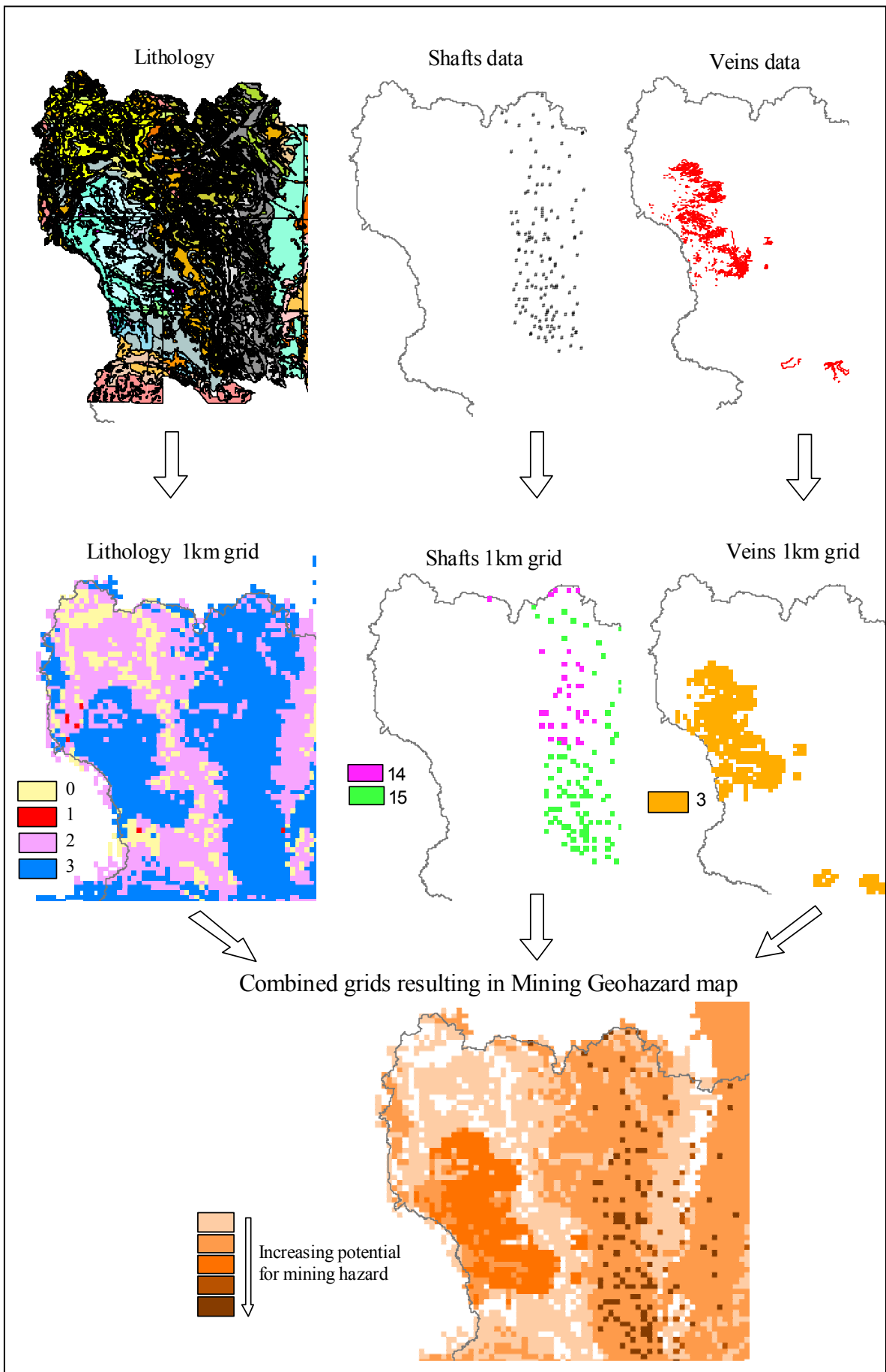


Figure 15 Second iteration using rated formations (data shown for South Pennine Orefield)

6.1.1 Ball Clay

Production of ball clay in the UK is confined to three relatively small areas in the SW of England, the Bovey and Petrockstowe basins in Devon and the Wareham basin in Dorset.

Future commercial interest in ball clay extraction is likely to be confined to sites suitable for surface working, however, in the past underground extraction has been undertaken at several locations in the Wareham and Bovey basins. The last small mines closed in 1999 due to health and safety issues and the high cost of extraction.

Most historical underground mines were relatively inconspicuous operations and the limited subsidence they caused did not change the character of the landscape. If this method was adopted in the future, modern mine structures would be more substantial and it may be impossible to extract from beneath or close to sensitive natural sites without subsidence and the resultant environmental changes. Currently the operational constraints would result in low yields and wastage of otherwise usable clay and market assessments demonstrate underground mining of ball clay is unlikely to prove economic in the foreseeable future.

Production is now solely by opencast method. The modern approach to restoration is backfilling using sand and waste clay overburden excavated from the site but which cannot be sold. In some cases this may result in the formation of lakes or ponds but there is no mining hazard.

6.1.2 Kaolin

China clay resources of Britain are confined to the granites of South West England and Cornwall accounts for 90% of total UK production.

Kaolinised zones contain a variety of rock types from hard, unaltered granite to a soft kaolinised 'clay matrix' and coarse-grained kaolinite. The kaolinite content of the matrix varies, but is typically between 15-25%, however the presence of hard unaltered granite and quartz/tourmaline veins mean overall recoveries of china clay may be as low as 10%. The average waste to clay ratio in the largest pits is 9:1. As a consequence large areas are required for waste disposal.

Annual arisings of china clay waste are about 20-24 Mt/y of which only perhaps 2 Mt are currently sold although there are attempts to increase this to 5 Mt/y. Waste tips contain between 450-600 Mt of china clay waste.

China clay mining is a combination of hydraulic mining using water jets to breakdown the kaolinised granite and ripping, drilling and blasting of the unkaolinised granite and its subsequent removal. During processing the >53µm fraction consisting of mica, with some quartz, feldspar and coarse kaolinite is removed and pumped to the mica residue dams for disposal.

Historically china clay production has been based on the central and western parts of the St Austell Granite (some 83.5% of total production) and south-western margin of the Dartmoor Granite in Devon. In Cornwall the only other source of china clay is the Bodmin Moor Granite, which accounts for 6.3% of total production. China clay deposits in South-west England have yielded over 150 million tonnes of marketable product since production began in the mid 18th century. Production of china clay on the Bodmin Granite has been about 200 000 tonnes a year in recent years. Current workings are at Park GR 219400, 070800, but abandoned pits are widespread in the western part of the granite. Kaolinisation is also found in numerous, relatively small areas elsewhere. Within the Land's End Granite, localised deposits have been worked in the past, with Bostraze GR238500, 031600 east of St Just ceasing production in 1991.

Although the working of kaolin has been extensive in the southwest region, no serious mining hazard is associated with this type of surface mining. The extent of the workings, location of the residue dams and buffering of these polygons based on a 10, 20 & 30 meter radius to indicate a gradually decreasing sphere of influence.

The main effect is occasional discharge of mica-laden water from failure of tailings dams. This is non-toxic but has a disastrous effect on the environment.

6.2 BUILDING STONE

Although a wide range of building stones occurs across the country, as shown on the ARUP map. Currently detailed information is only available for the Bath stone mines in the southwest. This information was digitally captured from the report 'An Environmental Geology Study of parts of West Wiltshire and South East Avon' at a scale of 1: 25 000. The attribute table contains information relating to type of stone mined, depth of working and condition where available. Further information will be added as the different districts are explored.

6.3 SALT

Information was obtained relating to the Cheshire salt workings indicating the extent of the workings and can be used as a basis to hotlink the anecdotal locally published information which is available. Most of the work relating to salt has been carried out under the solution aspects of the GeoHazarDs project.

7 Conclusions

A robust GIS design has been implemented providing easy access to information collated for the project. Clearly much more data will be uncovered, allowing the creation of a detailed mosaic particularly at the local level as individual districts are explored.

Despite initial reservations about the merits of the ARUP data the intensive cleaning up of the data has produce a beneficial and feasibly commercial data layer. This has been documented and copyrighted according to the BGS criteria for both internal and external use.

The methodology for creating an interim data layer has been evaluated only on small areas. However they represent the most heavily mined regions and consequently when positive initial results were obtained in these areas the methodology could be viewed as a sound platform for extending across other districts. Before this occurs however some adjustments to the methodology are recommended.

- Simplification of the rating systems for shafts and veins as details for many of the criteria are unavailable and implementing a default value may bias results obtained.
- Migration towards use of undermining areas rather than DigMap formation data which reflects surface rather than the underground situation; this can only be carried out with the support of the District Geologists whose local knowledge would be required to create, populate and validate the new data layer.

These combined improvements, in conjunction with increased data availability as a result of other BGS projects, for example the mineshafts and entrances project, should present a strong foundation from which to build a new mining Geohazard layer.

Although only small areas of the country have been evaluated and all data is not available the methodology described and tested here presents a sound platform for the development of a potential for mining Geohazard data layer.

Appendix 1 Copyright confirmation from DEFRA & ODPM

-----Original Message-----

From: Walsby, Jennifer C
Sent: 21 March 2003 14:24
To: Culshaw, Martin G; Jackson, Ian
Cc: Colman, Tim B; Linley, Kathrine A
Subject: RE: Ove Arup

Martin

Mike, Ian and I have all discussed this with Brian Marker who is very keen for us to use the data. One of us could ask him for a formal written statement for safety.

Jen

-----Original Message-----

From: Culshaw, Martin G
Sent: 21 March 2003 14:05
To: Walsby, Jennifer C; Jackson, Ian
Cc: Colman, Tim B; Linley, Kathrine A
Subject: RE: Ove Arup

Dear All,

Can we all be a bit careful here. I am not sure that the historical legacy of the Ove Arup data belongs to DEFRA, despite what their Departmental Records Officer says. Yes, the work was done for the old Department of the Environment. But, the part that commissioned the work (Mineral and Waste Planning) did not go to DEFRA but is part of the Office of the Deputy Prime Minister. Why not ask Brian Marker about this at ODPM?

Martin Culshaw

-----Original Message-----

From: Walsby, Jennifer C
Sent: 20 March 2003 17:35
To: Jackson, Ian
Cc: Colman, Tim B; Culshaw, Martin G; Linley, Kathrine A
Subject: FW: Ove Arup

-----Original Message-----

From: Harding, Catherine [mailto:catherine.harding@pro.gov.uk]
Sent: 20 March 2003 16:59
To: Jennifer C Walsby (E-mail)
Subject: FW: Ove Arup

Hi Jenny

Permission from DEFRA to use the Ove Arup Data.

Catherine

-----Original Message-----

From: Kaye, Mike (CSD) [mailto:Mike.Kaye@defra.gsi.gov.uk]

Sent: 20 March 2003 15:06
To: 'Harding, Catherine'
Subject: RE: Ove Arup

Catherine,

We spoke today about the release of information on the Review of Mining Instability in Great Britain - Ove Arup Commission.

I can confirm that Defra has no objection to the use, reproduction and sale of any reports containing data obtained as part of this commission.

Regards, Mike 20/3

Mike Kaye
Departmental Records Officer
DEFRA
GTN 238 6389

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Appendix 2 Discovery Metadata for ARUP dataset

Identifier	GEOHAZ_ARUP		
Description	ARUP Review of Mining Instability in Great Britain		
Abstract	<p>Dataset represents a value added product based on original AutoCad (R14) DWG format. These drawing files were dumb copies of the origin paper maps produced for the Department of the Environment. Extensive work was carried out by BGS to clean this data. This was a two phase process initially the separate sections of line were joined to produce closed polygon data, then individual polygons were merged with adjacent ones to produce a facsimile of the original dataset, in an attributed shapefile format.</p>		
Start Date Comment	This is the date at which the original OVE ARUP dataset was produced		
Start Date	1990-01-01 00:00:00	End Date	2002-01-01 00:00:00
End Date Comment	This end date is when BGS data conversion was completed.		
Update Frequency Comment	Unlikely to be updated once the final amendments have been made.		
Completeness	All existing data available, final minor amendments to be made.		
Level of Spatial Detail	1km squares with attribute information regarding type of mining activity		
Logical Consistency	Unknown as original dataset produced outside BGS to an unknown standard.		
Lineage	<p>Dataset originally created in 1990 by an outside organisation (OVE ARUP) on behalf of Department of the Environment as paper maps. Produced as figures in a series of reports 'Review of Mining Instability in Great Britain' ARUP Geotechnics (Library Ref 622.83 OVE 1990) Converted by OVE ARUP to 'dumb' digital format as AutoCad R14 dwg files. Purchased by BGS for GeoHazarDs project 2002. Extensive work undertaken to merge line sections to produce closed polygons and to merge together the individual sheets to produce a cohesive consistant national dataset.</p>		
Metadata Entered	2003-01-23 14:24:22	Metadata Updated	

Access Constraints	See IPR Section, reference IPR/35-10		
Use Constraints	Fees to be determined		
Spatial Reference System	BRITISH NATIONAL GRID		
Bounding Coordinates			
West	0	East	700000
North	1300000	South	0
Areal Extent	GREAT BRITAIN	Areal Extent Type	SUB-KINGDOM
Storage Format	ARCVIEW		
Delivery Format	ARCVIEW		
Language	ENGLISH		
Supplier	BRITISH GEOLOGICAL SURVEY		
Postal Address	KINGSLEY DUNHAM CENTRE KEYWORTH		
Town	NOTTINGHAM		
Post Code	NG12 5GG		
Contact Telephone	0115 9363100	Contact Fax	0115 9363200
Metadata Originator	KATHRINE LINLEY		
Metadata Originator	KEVIN GREALLY		
Authority for Reliability of the Datasets	KATHRINE LINLEY		

Appendix 3 Avenue Scripts

TABLE_QUERYUNIQUE.AVE

```
'script downloaded from www.esri.com May 2002
'
' Table.QueryUnique.
'
' Selects the first record for each instance of the active field.
'
' Run from a table document: open and compile this script, then
' open the table, activate the desired field (NOT a shape field--
' all shapes will be considered unique), go immediately back to
' this script, and run it.
'
' Alternatively, attach this script to a button or menu item in a
' table GUI. For an update script use Table.SortUpdate.
'
' Side-effects:
' Creates a temporary public variable _theDictionary.
' Creates a temporary SED "__select_first__".
'
' 19 December 2000, Quantitative Decisions.
'=====
theTable = av.GetActiveDoc
if (theTable.Is(Table).Not) then
  MsgBox.Info("This script works when run from a table document.",
    Script.The.GetName)
  return NIL
end
theVTab = theTable.GetVTab
theField = theTable.GetActiveField

if (theField <> NIL) then
  ' Create the select-first script.
  '
  _theDictionary = Dictionary.Make(theVTab.GetNumRecords)
  sScript = "b = (_theDictionary.Get(SELF) = NIL)" + NL +
    "_theDictionary.Set(SELF, true)" + NL +
    "return b"
  theSEd = SEd.MakeFromSource(sScript, "__select_first__")
  theSEd.Compile
  '
  ' Perform the selection.
  '
  sSelect = "av.Run(" + theSEd.GetName.quote + ",[" + theField.GetAlias +
"])"
  theVTab.Query(sSelect, theVTab.GetSelection, #VTAB_SELTYPE_NEW)
  theVTab.UpdateSelection
  av.GetProject.SetModified(true)
  '
  ' Clean up.
  '
  _theDictionary = NIL
  av.GetProject.RemoveDoc(theSEd)
end
' end of script
```

COUNT_POINTS.AVE

'script downloaded from www.esri.com June 2002

' Programmed by Yingming Zhou
' Dept. of Geography
' University of South Carolina
' Columbia SC29208
' email: zhouy@ellie.cla.sc.edu
' Phone: (803)777-4581
' April. 17, 2000

' Title: Count points being contained in polygons
' Keywords: Points, Polygon, Count, Contain, Summarize
' Description: This Extension is used to count points from a point shape theme
' which are contained by each polygon from a polygon shape theme. The count is
' stored in the field "PointCount" in the polygon feature table, which should be
' editable.

' Requires: An active view with at least one polygon theme and a point theme.

```
theView = av.GetActiveDoc
theThemeList = theView.GetThemes
if (theThemeList.count = 0) then
  Return Nil
end
```

'Extract polygon theme list and point theme list

```
thePolygonThemeList = {}
thePointThemeList = {}
for each t in theThemeList
  if ( t.Is(FTHEME) ) then

    theVTab = t.GetFTab
    theShapeField = theVTab.findField("shape")
    if ( theShapeField = nil ) then
      continue
    end

    theTotalRecs = theVTab.GetNumRecords

    if( theTotalRecs < 1 ) then
      continue
    end

    theShape = theVTab.ReturnValue(theShapeField, 0)

    if ( theShape = Nil ) then
      Continue
    end

    theClassName = theShape.GetClass.GetClassName
    if ( theClassName = "Polygon" ) then
      thePolygonThemeList.Add(t)
    elseif ( theClassName = "Point" ) then
      thePointThemeList.Add(t)
    end

  end 'if
end
```

'Check whether the polygon theme list or point theme list is empty

```

if ( thePolygonThemeList.count = 0 ) then
  MsgBox.Info("There is no polygon theme in the active view", "error")
  Return Nil
end

if ( thePointThemeList.count = 0 ) then
  MsgBox.Info("There is no point theme in the active view", "error")
  Return Nil
end

'Request user to select a polygon Theme and a point theme
thePolygonTheme = MsgBox.List(thePolygonThemeList, "Select a polygon theme ",
"Select a Polygon Theme")
thePointTheme = MsgBox.List(thePointThemeList, "Select a point theme ",
"Select a Point Theme")

if ( thePolygonTheme = Nil ) then
  Return Nil
end

if ( thePointTheme = Nil ) then
  Return Nil
end

'Get FTab for the polygon theme and the point theme
thePolygonFTab = thePolygonTheme.GetFTab
thePointFTab = thePointTheme.GetFTab

if ( thePolygonFTab.CanEdit.not ) then
  MsgBox.info("The Polygon theme cannot edit", "Error")
  Return Nil
end

thePolygonFTab.SetEditable(true)

thePointCountField = thePolygonFTab.FindField("PointCount")
if ( thePointCountField = Nil ) then
  thePointCountField = Field.Make("PointCount", #FIELD_LONG, 10, 0)
  thePolygonFTab.AddFields({thePointCountField})
end

thePolygonShapeField = thePolygonFTab.FindField("Shape")
thePointShapeField = thePointFTab.FindField("Shape")

' Added for count variety aug 19, 2000
theNSFields = {}
thePointFields = thePointFTab.GetFields

for each f in thePointFields
  if (f.IsTypeString or f.IsTypeNumber ) then
    theNSFields.add(f)
  end
end

bCountVariety = MsgBox.YesNo("Do you want to count variety?","Count Variety",
false)

if (bCountVariety) then
  theVField = MsgBox.list(theNSFields, "Select a field to identify variety",
"Variety Field")
  if (theVField = nil ) then
    bCountVariety = false
  end
end
end

```

```

if (bCountVariety ) then
  for each recPoly in thePolygonFTab
    theCount = 0
    theVFValueList = {}
    thePolygon = thePolygonFTab.ReturnValue( thePolygonShapeField, recPoly )

    for each recPoint in thePointFTab
      thePoint = thePointFTab.ReturnValue( thePointShapeField, recPoint)
      theVFValue = thePointFTab.ReturnValue( theVField, recPoint)
      if ( thePolygon.Contains( thePoint ) ) then
        if ( theVFValueList.FindByValue(theVFValue) < 0 ) then
          theCount = theCount + 1
          theVFValueList.add(theVFValue)
        end
      end 'if
    end 'for

    thePolygonFTab.SetValue(thePointCountField, recPoly, theCount)
  end
else
  'Check the containment and get the count
  for each recPoly in thePolygonFTab
    theCount = 0
    thePolygon = thePolygonFTab.ReturnValue( thePolygonShapeField, recPoly )

    for each recPoint in thePointFTab
      thePoint = thePointFTab.ReturnValue( thePointShapeField, recPoint)
      if ( thePolygon.Contains( thePoint ) ) then
        theCount = theCount + 1
      end 'if
    end 'for

    thePolygonFTab.SetValue(thePointCountField, recPoly, theCount)
  end
end

thePolygonFTab.SetEditable(false)

```

Appendix 4 ARUP data files and script details.

ORIGINAL DRAWING FILES SUPPLIED BY ARUP:

Last Modified	File Size	File Name	Date Created
10/12/2001 18:04	292,852	23b.dwg	13 Jan 1992
10/12/2001 18:06	295,075	40.dwg	10 Jan 1992
10/12/2001 18:07	261,704	41.dwg	10 Jan 1992
10/12/2001 18:08	549,803	42.dwg	10 Jan 1992
10/12/2001 18:11	323,193	42b.dwg	13 Jan 1992
10/12/2001 18:13	387,648	43.dwg	10 Jan 1992
10/12/2001 18:14	324,692	43b.dwg	13 Jan 1992
10/12/2001 18:15	302,443	44.dwg	10 Jan 1992
10/12/2001 18:16	577,020	44b.dwg	13 Jan 1992
11/12/2001 10:18	402,766	45.dwg	10 Jan 1992
11/12/2001 10:20	507,806	46.dwg	10 Jan 1992
11/12/2001 10:21	371,437	46b.dwg	13 Jan 1992
11/12/2001 10:22	370,964	47.dwg	10 Jan 1992
11/12/2001 10:24	508,061	48.dwg	10 Jan 1992
11/12/2001 10:26	430,778	49.dwg	10 Jan 1992
11/12/2001 10:27	304,170	50.dwg	10 Jan 1992
11/12/2001 10:32	441,910	51.dwg	1 Jan 1992
11/12/2001 10:34	385,339	51b.dwg	13 Jan 1992
11/12/2001 10:35	338,795	52.dwg	10 Jan 1992
11/12/2001 10:36	534,867	53.dwg	10 Jan 1992
11/12/2001 10:38	281,668	53b.dwg	13 Jan 1992
11/12/2001 10:39	436,524	54.dwg	10 Jan 1992
11/12/2001 10:40	296,252	56b.dwg	13 Jan 1992
11/12/2001 10:41	352,854	57b.dwg	13 Jan 1992
11/12/2001 10:42	286,067	58b.dwg	13 Jan 1992
11/12/2001 10:43	423,206	63b.dwg	13 Jan 1992
11/12/2001 10:44	439,670	64b.dwg	13 Jan 1992
11/12/2001 10:45	297,485	653.dwg	10 Jan 1992
11/12/2001 10:46	294,931	655.dwg	10 Jan 1992
11/12/2001 10:47	306,267	657.dwg	10 Jan 1992
11/12/2001 10:49	655,913	659.dwg	10 Jan 1992
11/12/2001 10:50	174,766	65b.dwg	13 Jan 1992
11/12/2001 10:51	310,574	661.dwg	10 Jan 1992
11/12/2001 10:54	286,632	663.dwg	10 Jan 1992
11/12/2001 10:55	288,627	665.dwg	10 Jan 1992
11/12/2001 10:57	289,829	667.dwg	10 Jan 1992
11/12/2001 10:58	284,019	669.dwg	10 Jan 1992
11/12/2001 10:59	282,793	671.dwg	10 Jan 1992
11/12/2001 11:00	289,110	673.dwg	10 Jan 1992
11/12/2001 11:01	392,434	675.dwg	10 Jan 1992
11/12/2001 11:02	376,246	677.dwg	10 Jan 1992
11/12/2001 11:03	366,700	679.dwg	10 Jan 1992
11/12/2001 11:04	452,759	681.dwg	10 Jan 1992
11/12/2001 11:06	264,715	683.dwg	10 Jan 1992
11/12/2001 11:08	778,697	685.dwg	10 Jan 1992
11/12/2001 11:09	671,993	687.dwg	10 Jan 1992

11/12/2001 11:10	70,871	689.dwg	10 Jan 1992
11/12/2001 11:12	313,797	691.dwg	10 Jan 1992
11/12/2001 11:17	500,785	693.dwg	10 Jan 1992
11/12/2001 11:19	298,499	73b.dwg	16 Mar 1992

50 File(s) 18,676,006 bytes

ORIGINAL DRAWINGS LAYERS:

Layer Name	Layer Colour	Layer Contents
0	White	Empty default AutoCAD layer
ARROWS	White	Arrows linking text to areas -- see Notes below
AURP_DATA_FRZ	White	Empty layer
CLIPMARK	White	Cornerpoints for map sheets
GRID	White	Map gridlines, drawing frame, text box frame and
map scale		
GRIDTEXT	White	Coordinate for gridlines
KEY	White	ARUP map key
SCONS	White	Empty layer
TEXT	White	Text associated to an area by an arrow -- see
Notes below		
CHATCH	White	Hatch lines for coal
COAL	White	Boundary lines for coal Coal (and associated minerals)
DHATCH	Green	Hatch lines for deneholes
DENEHOLES	Green	Boundary lines for deneholes Deneholes & Chalkwells
EHATCH	Blue	Hatch lines for evaporites
EVAPORITES	Blue	Boundary lines for evaporates Evaporites
IHATCH	Yellow	Hatch lines for iron
IRON	Yellow	Boundary lines for iron Iron (non-coalfield)
MHATCH	Red	Hatch lines for metalliferous
METALLIFEROUS	Red	Boundary lines for metalliferous Metalliferous (non-ferrous) eg copper, arsenic, lead, tin
RHATCH	Green	Hatch lines for rock
ROCK	Green	Boundary lines for rock Rock eg slate, limestone, sandstone

NOTES (from ARUP map key):

- Letters and numbers on the plan correspond to entries in the Mining Area Schedules eg Mining Area Code 63R15 is County 63; Rock Mining Area number 15
- Where two or more Mineral Types have been worked in a single mining area, in some cases only the dominant type is shown. Subsidiary types are described in the Mining Area Schedules eg where minor quantities of iron ore have been mined in a predominantly

metalliferous (non-ferrous) mining area, generally only the latter is shown. Where other minerals such as ironstone and fireclay have been mined in coalfields, the Mineral Type is shown as Coal.

- Metalliferous (non-ferrous) includes associated minerals eg fluorspar & barites.
- Rock includes all types of earthy minerals such as fullers' earth.

PROCESSED DRAWINGS LAYERS:

Layer Name	Layer Colour	Layer Contents
0	Grey	Empty default AutoCAD layer
AURP_DATA_FRZ	Grey	Empty layer
KG-COAL	White	Polygons and hatching for coal
KG-DENEHOLES	Green	Polygons and hatching for deneholes
KG-EVAPORITES	Red	Polygons and hatching for evaporites
KG-IRON	Cyan	Polygons and hatching for iron
KG-METALLIFEROUS	Magenta	Polygons and hatching for metalliferous
KG-ROCK	Blue	Polygons and hatching for rock

AUTOCAD SCRIPT FILES:

For use with the original map sheet:

osetup.scr	initialise the drawing layers: unlock, thaw set layer colours and line weights
oc.scr	highlight the working layer: turn all layers on set all line work to grey and thin lines (default line weight) turn off all hatch lines and arrows set the working layer ("coal") to use thick (heavy line weight) cyan lines od.scr, oe.scr, oi.scr, om.scr, or.scr --ditto-- for use with other layers.
odata.scr	set the layer colours and line weights in the original map sheets and turn on boundary lines, hatching and gridlines.
oonly.scr	set the layer colours and line weights in the original map sheets and turn on boundary lines only.

For use with the working copy of the map sheet:

setup.scr	initialise the drawing layers: unlock, thaw set layer colours and line weights create and set colours for new layers: kg-coal, kg-deneholes, kg-evaporites, kg-iron, kg-metalliferous, kg-rock
c.scr	highlight the working layer: turn all layers on set all line work to grey and thin lines (default line weight) turn off all hatch lines and arrows set the working layer ("kg-coal") to use thick (heavy line weight) cyan lines d.scr, e.scr, i.scr, m.scr, r.scr --ditto-- for use with other layers.

hc.scr turn off all layers except "kg-coal"
 hatch all polygons
 hd.scr, he.scr, hi.scr, hm.scr, hr.scr --ditto-- for use with other layers.

kgonly.scr reset the colour and line weight of the completed layers ("kg-*")

layer-erase.scr delete entities and layers that are no longer needed (keep only "kg-*" layers)

Appendix 5 Data file details

Ball_clay_basins

Data source: DigMap50/mineral resources of East Dorset project for DTLR
Scale of capture: 1: 50 000
Date of capture: 2001
Original purpose: Digital capture of all geological paper map data
Scale: 1: 50 000
Output files: ball_clay_basins.shp
Attributes: shape, mslink0, BGSref, Geological, Mintext1_e, Basin name, sales_of_ball_clay
Location of file: V:\ism\ghd\mining-hazards\mining_data(kal)\detail

Bs_bath_stone

Data source: paper maps captured for geohazards
Scale of capture: 1: 25 000
Date of capture: 08/01
Original purpose: Paper maps produced for 'An Environmental Geology Study of parts of Wiltshire and South East Avon by A. Forster, PRN Hobbs, RA Monkhouse and RJ Wyatt (1985)
Scale: 1: 50 000
Output files: bs_bath_stone.shp
Attributes: shape, entity, layer, colour, name, present_use, mined_stone, depth, overburden, condition
Location of file: V:\ism\ghd\mining-hazards\mining_data(kal)\detail

China clay (kaolin) resources

Data source: Cornwall County Council
Scale of capture: unknown
Date of capture: 1997
Original purpose: 'Cornwall: A summary of Mineral Resource Information for Development plans Phase One'. (BGS/DETR)
Scale: 1: 100 000
Output files: china_clay_(kaolin).shp
Attributes: shape, layer, area, type of resource, county, epr.
Location of file: V:\ism\ghd\mining-hazards\mining_data(kal)\detail

Micaceous_residue_dams

Data source: Cornwall County Council
Scale of capture: unknown
Date of capture: 1997
Original purpose: 'Cornwall: A summary of Mineral Resource Information for Development plans Phase One'. (BGS/DETR)
Scale: 1: 100 000
Output files: micaceous_residue_dams.shp
Attributes: shape, layer, area, type of resource, county, epr.
Location of file: V:\ism\ghd\mining-hazards\mining_data(kal)\detail

Micaceous_residue_dam_buffer

Data source: Based on micaceous residue dam data/Cornwall County Council
Scale of capture: unknown
Date of capture: 1997
Original purpose: 'Cornwall: A summary of Mineral Resource Information for Development plans Phase One'. (BGS/DETR)
Scale: 1: 100 000
Output files: micaceous_residue_dam_buffer.shp
Attributes: shape, ID, Buffer_distance, GHD_rating
Location of file: V:\ism\ghd\mining-hazards\mining_data(kal)\detail

SW_shafts see above

SW_shafts_buffer

Data source: various, results from several different projects and data sources
Scale of capture: 1: 50 000, 1: 25 000
Date of capture: various
Original purpose: Range of different project uses.
Scale: 1: 50 000
Output files: SW_shafts_buffer.shp
Attributes: shape, ID, Buffer_distance,(m), GHD_Buffer_rating (5,3,1 relating to distance from shaft)
Location of file: V:\ism\ghd\mining-hazards\mining_data(kal)\detail

Sw shaft density

Data source: Based on SW_clip_shafts
Scale of capture: various
Date of capture: various
Original purpose: Merged dataset from a range of other project data
Scale: 1km² grid
Output files: Density_from_SW_clip.shp
Location of file: V:\ism\ghd\mining-hazards\mining_data(kal)\detail

SW_veins see above.

Veins (lines)

Data source: veins.shp
Scale of capture: 1:10 000
Date of capture: July/August 2001
Original purpose: Ben Klinks Mine waste project
Output file:

Data source: DigMap50_veins(v1_01).shp
Scale of capture: 1:50 000
Date of capture: 13 August 2001
Original purpose:
Output file: Veins_total_50k.shp

Attributes:

Attribute	Alias	Data held	Description
Shape		Polyline	
MsLink		105501/10550	Coded vein type
Fname		Vein_obs/Vei	Vein type described
Cname		Vein	
Version		1.01	DigMap version number
Checked		Y	Whether 1:50 000 paper map has been checked
Ag_Silver		Y or empty	Presence/absence
As_Arsenic		Y or empty	Presence/absence
Ba_Baryte		Y or empty	Presence/absence
Co_Cobalt		Y or empty	Presence/absence
Cu_Copper		Y or empty	Presence/absence
F_Fluorit	F_Fluorite	Y or empty	Presence/absence
Fe_Iron		Y or empty	Presence/absence
Mn_Mnagan	Mn_Manganese	Y or empty	Presence/absence
P_Phospho	P_phosphorous	Y or empty	Presence/absence
Pb_Lead		Y or empty	Presence/absence
S_sulphur		Y or empty	Presence/absence
Sn_tin		Y or empty	Presence/absence
U_uranium		Y or empty	Presence/absence
W_tungste	W_tungsten	Y or empty	Presence/absence
Zn_zinc		Y or empty	Presence/absence
Sb_antimo	Sb_antimony	Y or empty	Presence/absence
Quartz		Y or empty	Presence/absence
Bo+boron		Y or empty	Presence/absence
C_graphit	C_graphite	Y or empty	Presence/absence
Au_gold		Y or empty	Presence/absence
Bismuth	Bi_bismuth	Y or empty	Presence/absence
GHD_min_es	GHD_vein_mineralisation_estimate	*or empty	Estimate or true value
GHD_min	GHD_vein_mineral_rating	Rating value	See table 8
GHD_attitu	GHD_mineralisation_attitude	Rating value	See table 7
GHD_mor_es	GHD_mineralisation_morphology_estimate	* or empty	Estimate or true value
GHD_mor	GHD_Mineralisation_morphologyrating	Rating value	See table 6
GHD_total		Cumulative total	GHD_vein_mineral_rating+GHD_mineralisation_attitude+GHD_mineralisation_morphology_rating.

Shafts (points)

Data source: shafts.dbf
Scale of capture: Not applicable (point data)
Date of capture: Various
Original purpose: Various data represents information from a range of projects which has been merged to create a single point dataset
Output file: shafts_total.shp

Attributes:

Attribute	Alias	Data held	Description
Shape		Point	
Name			
Easting			
Northing			
Descriptiv	Descriptive location		
Antimony		Y or empty	Presence/absence
Arsenic		Y or empty	Presence/absence
Barytes		Y or empty	Presence/absence
Bismuth		Y or empty	Presence/absence
Boron		Y or empty	Presence/absence
Buiding_s	Building_stone	Y or empty	Presence/absence
Coal		Y or empty	Presence/absence
Cobalt		Y or empty	Presence/absence
Copper		Y or empty	Presence/absence
Fluorite		Y or empty	Presence/absence
Graphite		Y or empty	Presence/absence
Gold		Y or empty	Presence/absence
Iron_ore		Y or empty	Presence/absence
Lead		Y or empty	Presence/absence
Manganese		Y or empty	Presence/absence
Nickel		Y or empty	Presence/absence
Phosphate		Y or empty	Presence/absence
Silver		Y or empty	Presence/absence
Tin		Y or empty	Presence/absence
Tungsten		Y or empty	Presence/absence
Uranium		Y or empty	Presence/absence
Witherite		Y or empty	Presence/absence
Zinc		Y or empty	Presence/absence
Location			
Type_of_wo	Type_of_working	Shaft,adit,trial	
Other_deta	Other_details		
Internal	Internal-external	Internal external	Whether BGS is source or not
Data_origi	Data_origin		Where data came from
Data_sourc	Data_source		Original data source
Further_in	Further_information		
Date_enter	Data_entered		
Entered_by			
Date_updat	Date_updated		
Hazard_typ	Hazard_type		
Severity			
Date(mont)			
GHD_topo	GHD_topography_rating		See table 13
GHD_loc	GHD_location_rating		See table 12
GHD_minera	GHD_mineral_estimate	* or empty	Estimate or true value
GHD_minera	GHD_mineral_mined		See table 11
GHD_mine_s	GHD_mine_size_estimate	* or empty	Estimate or true value
GHD_mine_s	GHD_mine_size_rating		See table 10
GHD_mine_m	GHD_mining_method_rating		See table 9

Shafts Data Sources.

This dataset has been compiled from a range of different source including:

Internal data sources:

Colliery locations

Originator: G.Lott
Format: Excel spreadsheet
Original file name: Collieries_new.xls
Accessed on: 24th September 2001

Colliery locations

Originator: D. Bridge/ Wolverhampton Borough Council
Format: Excel spreadsheet
Original file name: shafts.xls
Accessed on: 24th September 2001

ALGI

Originator: P Strange / K Westhead
Format: Mapinfo
Original file name: various
Accessed on: 24th September 2001

Mine waste project data for Weardale and Cornwall

Originator: B. Klink
Format: Arcview
Original file name:
Accessed on: 24th September 2001

External Data sources:

Web based data, list of Cornish Mine shafts

Obtained from : <http://www.dawnmist.demon.co.uk/minedata.htm>
Format: .htm
Original file name: minedata.htm
Accessed on: 20th September 2001

Cheshire Salt data

Obtained from: Access database listing details of the shafts in the Cheshire region
Cheshire County Council, Environmental Planning, Backford Hall,
Chester, Cheshire CH1 6PZ Tel: 01244 603102 Fax: 01244 603110
Format: Access database
Original file name: salt.mdb
Accessed on: October 2001