BGS DIGITAL

User guide: Mining Hazard (not including coal) GB version 8

Open report OR/20/048

British Geological Survey

BRITISH GEOLOGICAL SURVEY

BGS DIGITAL

OPEN REPORT OR/20/048

User guide: Mining Hazard (not including coal) version 8

British Geological Survey

Keywords

Mining, hazard, underground, zone of influence.

Front cover

P711016 The ruined engine houses on the Crowns section of Botallack Tin Mine, situated near St. Just, Cornwall.

Bibliographical reference

BRITISH GEOLOGICAL SURVEY 2021. User guide: Mining Hazard (not including coal) version 8. *British Geological Survey Open Report*, OR/20/048. 25pp.

DOI: 10.5285/9a558ef2-0081-4e86-917f-ae60b9df40a2

Keyworth, Nottingham British Geological Survey 2021

BRITISH GEOLOGICAL SURVEY

The full range of our publications is available from BGS shops at Nottingham, Edinburgh, London and Cardiff (Welsh publications only) see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications, including maps, for consultation.

We publish an annual catalogue of our maps and other publications; this catalogue is available online or from any of the BGS shops.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as basic research projects. It also undertakes programmes of technical aid in geology in developing countries.

The British Geological Survey is a component body of UK Research and Innovation.

British Geological Survey offices

Nicker Hill, Keyworth,
Nottingham NG12 5GG
Tel 0115 936 3100

BGS Central Enquiries Desk
Tel 0115 936 3143
email enquiries@bgs.ac.uk

BGS Sales
Tel 0115 936 3241
email sales@bgs.ac.uk

The Lyell Centre, Research Avenue South,
Edinburgh EH14 4AP
Tel 0131 667 1000
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road,
London SW7 5BD
Tel 020 7589 4090
Tel 020 7942 5344/45
email bgslondon@bgs.ac.uk

Cardiff University, Main Building, Park Place,
Cardiff CF10 3AT
Tel 029 2167 4280

Maclean Building, Crowmarsh Gifford,
Wallingford OX10 8BB
Tel 01491 838800

Geological Survey of Northern Ireland, Department of Enterprise, Trade & Investment, Dundonald House, Upper Newtownards Road, Ballymiscaw,
Belfast, BT4 3SB
Tel 01232 666595
www.bgs.ac.uk/gsni/

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU
Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

UK Research and Innovation, Polaris House,
Swindon SN2 1FL
Tel 01793 444000
www.ukri.org

Website www.bgs.ac.uk
Shop online at www.geologyshop.com

Foreword

The British Geological Survey (BGS) is a world-leading geological survey, focusing on public-good science for government, and research to understand Earth and environmental processes.

We are the UK's premier provider of objective and authoritative geoscientific data, information and knowledge to help society to:

- use its natural resources responsibly
- manage environmental change
- be resilient to environmental hazards

We provide expert services and impartial advice in all areas of geoscience. As a public sector organisation, we are responsible for advising the UK Government on all aspects of geoscience as well as providing impartial geological advice to industry, academia and the public. Our client base is drawn from the public and private sectors both in the UK and internationally.

The BGS is a component body of the Natural Environment Research Council (NERC), part of UK Research and Innovation (UKRI).

DATA PRODUCTS

The BGS produces a wide range of data products that align to government policy and stakeholder needs. These include baseline geological data, engineering properties and geohazards datasets. These products are developed using in-house scientific and digital expertise, and are based on the outputs of our research programmes and substantial national data holdings.

Our products are supported by stakeholder focus groups, identification of gaps in current knowledge and policy assessments. They help to improve understanding and communication of the impact of geo-environmental properties and hazards in Great Britain, thereby improving society's resilience and enabling people, businesses, and the government to make better-informed decisions.

Acknowledgements

A large number of individuals have contributed to the project. This assistance has been received at all stages of the study. In addition to the collection of data, many individuals have freely given their advice, and provided the local knowledge so important to the understanding of mining hazards in Great Britain. Key staff have helped to review draft chapters of this report. Of the many individuals who have contributed to the project, we would particularly like to thank the following: Dr R.P. Shaw (formerly of BGS) and Tom Bide.

The current version of this dataset was developed by, and the report compiled by T.J. Brown and K. A. Linley.

Contents

FIGURES

TABLES

Summary

Mining Hazard (not including coal) summarises the location, extent and indicates the level of hazard associated with former and present underground mine workings.

The dataset covers Great Britain and is published at 1: 50 000 scale. The content is derived from a range of data sources including, but not limited to the bedrock geology, extensive literature reviews of both published and unpublished documents, abandonment and mine plans, combined with a wealth of expert knowledge and experience.

The release of version 8 builds on the content of previously published versions. The coverage has been expanded with the inclusion of newly identified areas and drawing on data from the BGS published BGS BritPits and other resources. For the first time, zones of influence have been integrated (for evaporites, oil shales and building stones) to indicate the areas surrounding mining sites which might be impacted.

The data have been compiled and presented in an easy to use format to provide a national overview of the country's mining legacy. Given the long and complex mining history of Great Britain, this dataset represents the best information available at the present time (September 2020). Work continues to develop this product, which will result in the release of ad hoc updates in the future.

The information provided in this User Guide is intended to provide a quick-start guide to using and understanding this BGS data product.

1 Introduction

Mining Hazard (not including coal) identifies areas where past non-coal underground mining may have occurred resulting in underground voids. The presence of former underground workings, particularly where shallow, may collapse and as a consequence may cause surface settlement. Former coal mining areas are not included in the dataset as comprehensive data is available from the Coal Authority.

The defined mining areas are based on a combination of geological factors relating to the known distribution of mineral veins, building stones, chalk workings and other commodities, which have been mined. The geological data has been supplemented by information (both published and unpublished) on known or suspected locations of workings. Figure 1 shows the data coverage and includes a sample of the data at 1: 50 000 scale.

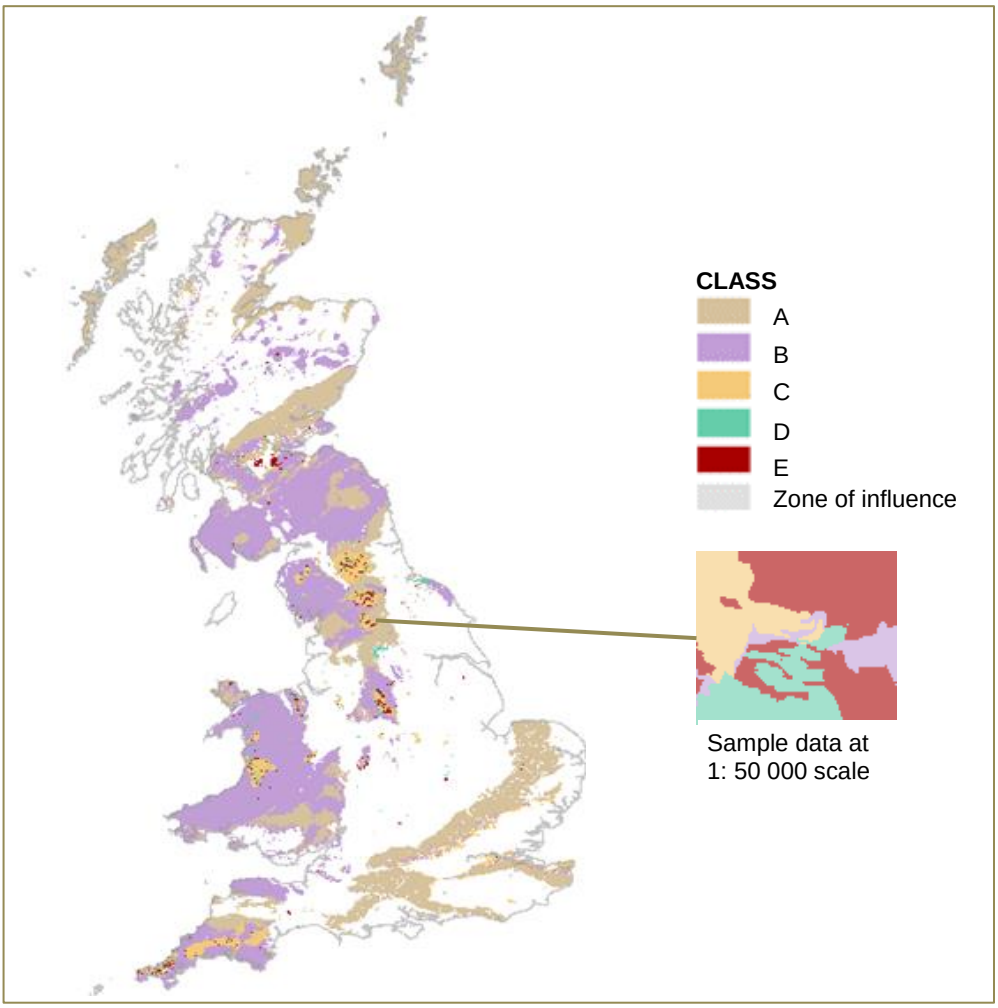


Figure 1 Data coverage

The dataset identifies the likelihood of past non-coal mining at any particular location. It does not attempt to classify the risk of instability. Even where undermined, the workings may be stable and therefore either present no risk of subsidence, or be at such a depth that even if collapse has occurred, the surface will not be affected. The user is advised to seek further advice on the existence of known workings and, if present, their potential to affect surface stability.

Stabilisation by remedial treatment is not taken into account in this dataset. The impacts of mining methods, such as roof collapse behind longwall workings, where surface impacts occur within a few years of the mining activities following which surface effects are minimal, have also not been considered. Owing to these factors, some previously extensively mined areas have been rated E but may not have any surface stability issues as a result of mining.

Included in the dataset are zones of influence; areas surrounding known workings which may be subject to subsidence as a result of their proximity to former workings. These have been created around class E and D areas from the evaporite, oil shale and building stone sites and are classified as Ez and Dz.

2 Case Study: road subsidence due to historic mining activity

Owners and managers of infrastructure assets such as roads need to identify areas of potential weakness and susceptibility to geological and man-made hazards. This enables them to manage their asset portfolio, maintain accessibility to property and ensure safety of all road users.

2.1 THE CHALLENGE

Identifying areas most likely to be impacted by historic mining hazards. Knowledge with regard to where infrastructure such as road networks are most susceptible to this type of subsidence. Awareness and understanding of the location of our mining legacy would enable prioritisation and planning for their repair prior to damage similar to that shown in Figure 2.

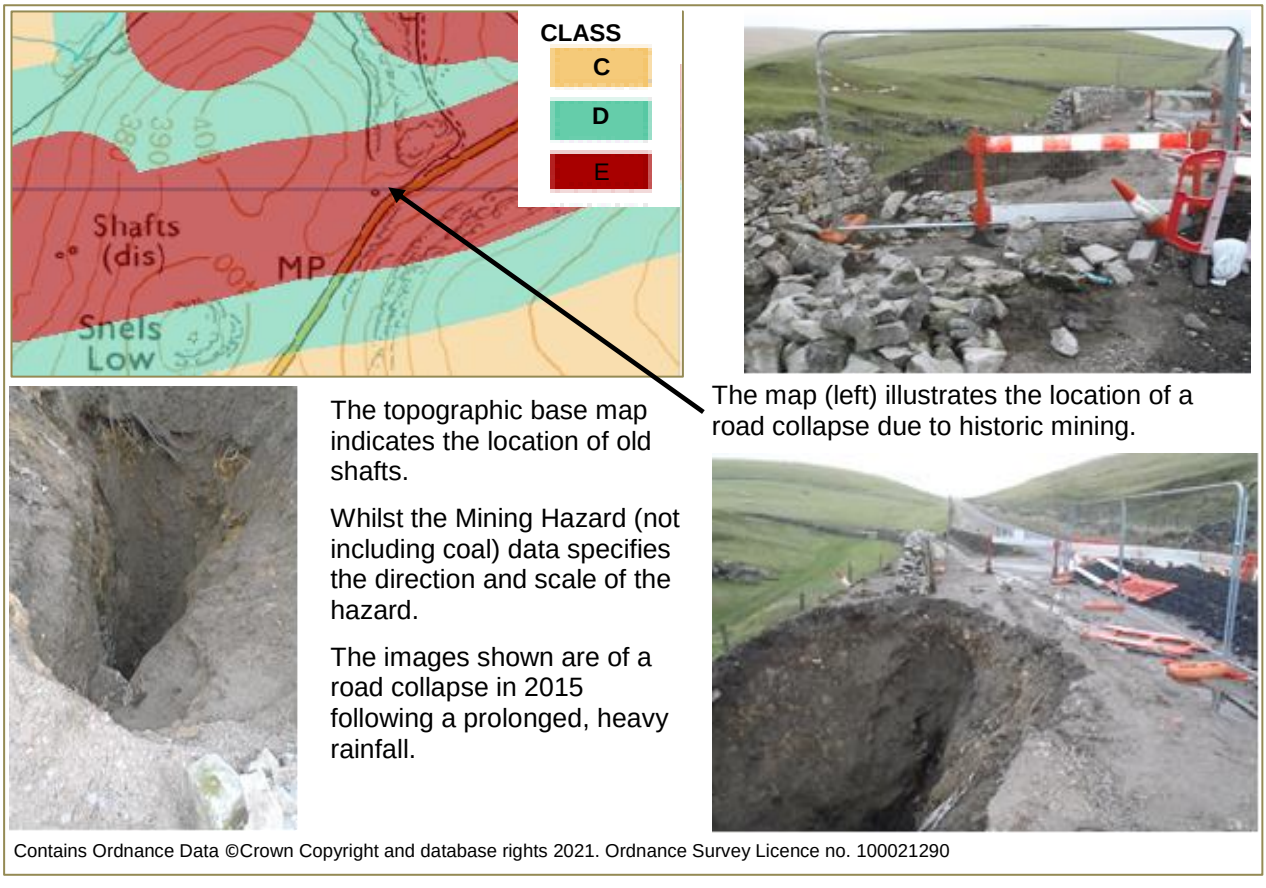


Figure 2 Example of road subsidence due to historic mining activity

2.2 THE SOLUTION

Figure 2 shows a subsidence event that occurred on a road built over a historic lead mining site after heavy rainfall. Whilst the underlying topographic map indicates the presence of old mine shafts, the Mining Hazard (not including coal) data provides insight into the scale and direction of workings. Armed with this knowledge provision could have been made to shore up or relay sections of road prior to the collapse event. This would reduce costs, impact and enable budgeting and planning for maintenance work.

3 Methodology

3.1 OVERVIEW

The dataset draws together published information and expert knowledge, combined with details of the underlying geology. It identifies locations where mining is known or is likely to have occurred. The dataset summarises Great Britain's long and complex mining history.

Due to the diversity, complexity and broad range of commodities (see Table 1), a data processing workflow was designed. It allowed the commodities to be split into seven general categories with shared characteristics:

1. Vein Minerals, including copper, lead, and zinc, tin.
2. Chalk
3. Oil shale
4. Building stone, including limestone, sand, sandstone, slate.
5. Bedded ores, including iron ores (haematite), manganese, sulphides.
6. Evaporites, including gypsum, anhydrite, potash, salt.
7. Other commodities, including ball clay, black marble, jet, graphite, chert.

This sub-division enables the management, compilation, manipulation and processing of a large volume of raw data.

Table 1 Commodities included in the Mining Hazard (not including coal) data

Commodity	Commodity	Commodity
Anhydrite	Graphite	Ragstone
Ball clay	Gritstone	Salt - Rock salt/brine
Barytes (Bedded)	Gypsum and anhydrite	Sand
Bauxite	Hearthstone	Sand - Glass making
Bedded Ore (Manganese)	Hornstone	Sand & Gravel
Black Marble	Iron - Orchre	Sand Rock
Chalk	Iron Ore (Bedded)	Sandstone
Chert	Iron Ore (Non Vein)	Sandstone - Chilmark Stone
Chromite	Jet	Sandstone - Elland Flags
Clay	Lead	Sandstone - Flagstones
Copper	Lignite	Silica
Fireclay	Limestone (including Bath stone, Beer stone, Black country, Burford, Ketton)	Slate
Firestone	Limestone (hydraulic)	Sulphide (Bedded)

Flagstone	Manganese (Bedded)	Talc
Flint	Oil shale	Vein Mineral
Fullers Earth	Potash and salt	Whetstone
Ganister	Raddle	Whinstone

A methodology was devised for each separate category based on local geological factors, expert knowledge and detailed research from literature. Whilst the methodologies were broadly similar, the distribution of commodities being constrained by geological distribution, local or market factors play a significant part in where materials were worked. Examples include:

a) Chalk - Due to its widespread distribution, historically material would not have been worked in areas below the water table.
b) Building stone production - constrained by economic factors such as distance to end use and accessibility to transport infrastructure. These form constraining factors on where material was worked.

Where mitigating criteria are known to influence location and extent of mining they have been used to constrain the mining areas shown in the data. Where no supplementary information is available, the full geological coverage has been retained.

Initial processing resulted in seven separate data layers. The contents of each layer are classified against a single A-E classification scheme. This standardisation ensures for example that a C rating for vein minerals is equitable with a C rating for chalk.

Having created the seven separate data layers (vein minerals, chalk, oil shale, building stones, bedded ores, evaporites, other commodities) they are brought together into a single comprehensive Mining Hazard (not including coal) layer.

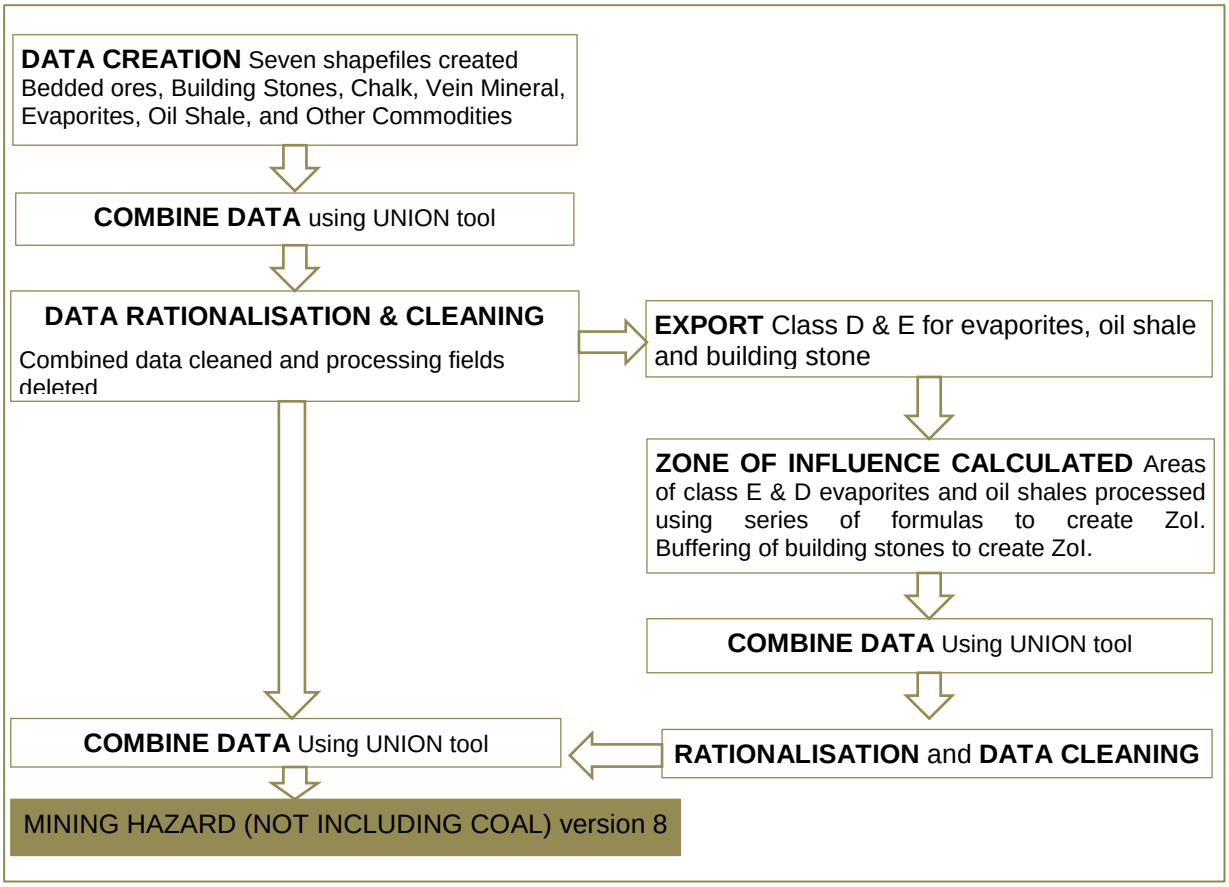


Figure 3 Simplified data processing workflow

All data processing and spatial data checking has been carried out using ESRI ArcGIS software.

3.2 ZONE OF INFLUENCE

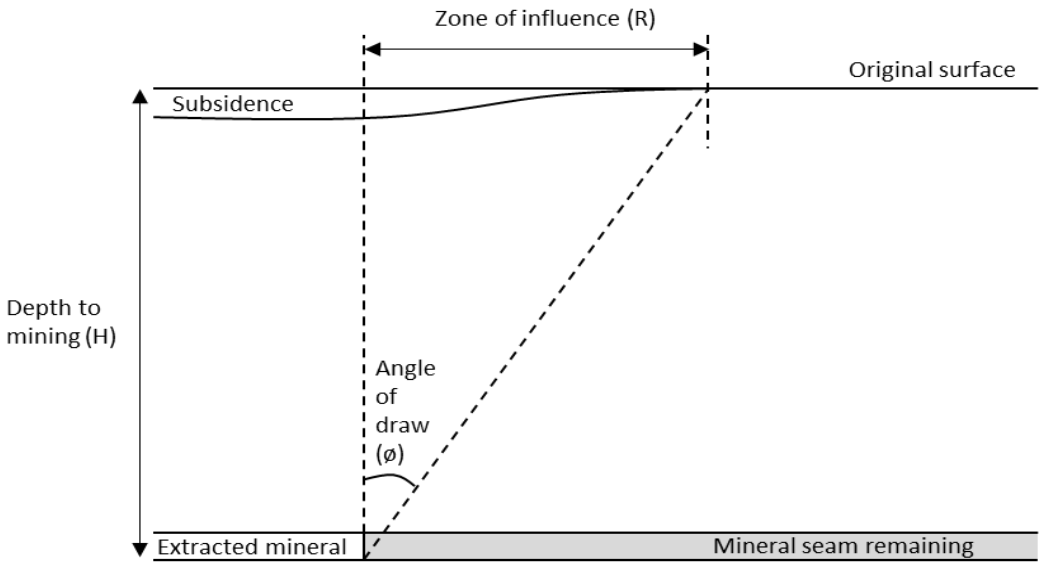
The BGS Mining Hazard (not including coal) dataset identifies areas of known and recorded underground workings in Great Britain. Whilst this data in itself is valuable and extensively used, it only tells half the story. Any underground working will be surrounded by an area of ground, which is affected by additional stresses due to its close proximity to the working, and subsequently may be subject to some degree of subsidence. The extent of this area is controlled by a number of factors including depth and extent of underground working but may be partially mitigated by other aspects such as type and size of working. This area is known as the zone of influence (ZOI) see Figure 4.

3.2.1 Methodology

The use of different methods to develop and capture the Mining Hazard (not including coal) dataset has resulted in creation of zones of influence using different methodologies. The creation of these remains a work in progress.

3.2.1.1 EVAPORITES AND OIL SHALES

The evaporite and oil shale layers areas of class D and E were identified as these are described in the Mining Hazard (not including coal) data as presenting a likelihood of hazard. Areas of class C, B or A were not included in the development of zones of influence. Borehole data identified within each hazard polygon was used to identify the depth to workings and the thickness of material extracted. This information is fed into a series of formulae to calculate the surface expression of the zone of influence (see Figure 4) for each mineral working.



The width of the zone of influence from a point vertically above the outer edge of a mine to the maximum extent of likely subsidence is calculated using Formula [1] (Ren & Li, 2008).

$$R = H \tan ø \qquad [1]$$

Where R is the zone of influence
H is the depth to the mining void
ø is the angle of draw.

These relationships are shown graphically above.

Figure 4 Simplified illustration of the relationship between the zone of influence, the depth to mining and the angle of draw

3.2.1.2 BUILDING STONES

Areas where building stones are known to have been worked are lacking in borehole information. As a result, a set of key criteria were considered, which govern the potential for subsidence. Nature of overburden, strong, massive beds overlying mine workings would act as bridge to span workings and prop up overburden, in situ stress i.e. horizontal stresses which tend to restrain surface subsidence by forming a ground arch in the mine roof (highly stressed arches may result in catastrophic failure). These criteria are likely in building stone workings.

Geological discontinuity e.g. faults, folds, bedding planes, fractures and lineaments increase potential for subsidence but are less likely in areas of building stone resources.

The degree of extraction (less extraction leaving greater support), mined area and method of working e.g. room and pillar (commonly used in building stone extraction) may provide support for the roof void over a prolonged period.

Evaluating these criteria lead to the conclusion that in the absence of reliable borehole information a standard 25m buffer distance should be applied. This provides an indication of the potential for a zone of influence surrounding workings.

3.2.1.3 CHALK AND VEIN MINERALS

In processing the data for chalk and vein minerals, buffers are used to indicate the extent of workings. As a result, these two layers have not had zones of influence calculated separately as this would deliver an extent for which there was no evidence to sustain.

3.2.1.4 OTHER COMMODITIES

This input layer contains information relating to small scale localised mining activities such as jet, black marble, whetstone and talc. These individual workings are well documented and their location and extents recorded. They are usually identified as a rating of class C or less and therefore are not regarded as presenting a significant level of hazard.

3.2.1.5 BEDDED ORES

Whilst the bedded ores cover a significant area e.g. the ironstones. At the present time work has not begun on the development of zones of influence for these areas. They remain a work in progress.

3.3 SOURCE DATASETS

The Mining Hazard (not including coal) version 8 uses two key BGS' data resources:

BGS Geology 50k (formerly known as DiGMap GB -50) version 7

BritPits (October 2019 release)

4 Technical Information

The following section describes the key technical aspects of the Mining Hazard (not including coal) dataset.

4.1 SCALE

The Mining Hazard (not including coal) dataset is intended for use at 1:50 000 scale. All spatial searches of the maps should be undertaken using a minimum 50 m buffer. This is because the smallest detectable feature at this scale is 50 m.

4.2 COVERAGE

The dataset covers Great Britain (see Figure 1).

4.3 ATTRIBUTE DESCRIPTION

Attribute descriptions are shown in Table 1.

Attribute	Description
NAME	Site name where available. A significant number are shown as 'Not available'.
COMMODITY	Indicates the mineral commodity worked at the site. If more than one mineral was worked, the highest hazard is shown first.
CLASS	Mining Hazard categories on a scale of A (lowest) to E (highest)
LEGEND	Description of the A to E classes.
CLASS_ZOI	Zone of influence categories scale shows only Ez and Dz
LEGEND_ZOI	Description of the Ez and Dz classes used to define the zones of influence
VERSION	Current version number (v8)

4.3.1 Class Descriptors

4.3.1.1 UNCLASSIFIED

Areas where no underground mine workings are known. This may be because the rock types present are such that no commodities or metal ores have been worked by underground mining methods.

It should be noted, that there is always the possibility of the existence of other sub-surface excavations, such as wells, cesspits, follies, air raid shelters/bunkers and other military structures etc. These sub-surface excavations could affect surface ground stability but are outside the scope of this dataset. Furthermore, you should still consider a Coal Authority mining search for the area of interest.

4.3.1.2 CLASS A

Underground mine workings are uncommon, although the geology is similar to that worked elsewhere. Potential for difficult ground conditions are unlikely and are at a level where they need not be considered.

Hazards because of underground mine workings are uncommon, localised and of limited area. Although the geology present in this area is similar to that worked elsewhere there is no clear evidence of mineral working having occurred. Where for example, minor mineral veins may be present it is possible that there have been attempts to work these by underground methods. Whilst no evidence of working exists, undocumented trials or small-scale underground extraction may have occurred. All such occurrences are likely to be restricted in size and infrequent.

It should be noted, however, that there is always the possibility of the existence of other sub-surface excavations, such as wells, cesspits, follies, air raid shelters/bunkers and other military structures etc. that could affect surface ground stability but which are outside the scope of this dataset. Furthermore, you should still consider a Coal Authority mining search for the area of interest.

Class A examples include:

a) Areas where minor mineral veins may be present on which it is possible that there have been attempts to work these by underground methods
b) Areas of chalk where no evidence of working has been recorded

4.3.1.3 CLASS B

Underground mine workings may have occurred in the past or current mines may be working at significant depth to modern engineering standards. Potential for difficult ground conditions are unlikely and are at a level where they need not be considered.

Hazards because of underground mine workings may occur. The geology present in these areas has been worked elsewhere. Example localities include areas where small mineral veins may be present on which it is possible that small-scale mining has been undertaken and/or limited underground extraction of other materials may have occurred. Little or no documented evidence is available to indicate working has occurred, however, undocumented workings may have occurred. All such occurrences are likely to be of minor localised extent and infrequent.

Modern deep mines, built to recent engineering standards may also be included in class B where they are of sufficient depth that effects on the surface are unlikely.

It should be noted, however, that there is always the possibility of the existence of other sub-surface excavations, such as wells, cesspits, follies, air raid shelters/bunkers and other military structures etc. that could affect surface ground stability but which are outside the scope of this dataset. Furthermore, you should still consider a Coal Authority mining search for the area.

Class B examples include:

a) Areas where small mineral veins may be present on which it is possible that small-scale mining has been undertaken.
b) Sandstone (for building stone) areas where bedrock geological formation e.g. Elland Flags are present but no evidence of working is found at the location.
c) Salt (brine) workings, which have been recently abandoned. Areas of known working using controlled extraction methods.
d) Modern deep mines currently operating, built to modern engineering standards thus reducing hazard potential e.g. Boulby potash.

4.3.1.4 CLASS C

Underground mine workings may have occurred in the past or current mines may be operating to modern engineering standards. Potential for difficult ground conditions should be considered.

Hazards because of underground mine workings are possible. The geology present in these areas are such that for example mineral veins may be present on which it is possible that mining has been undertaken and/or it is possible that small scale underground extraction of other materials may have occurred. Occurrences are likely to be of localised extent and infrequent.

Currently operating shallow mines, built to modern engineering standards thus reducing hazard potential, may also be included in this class.

It should be noted, however, that there is always the possibility of the existence of other sub-surface excavations, such as wells, cesspits, follies, air raid shelters/bunkers and other military structures etc. that could affect surface ground stability but which are outside the scope of this dataset. Furthermore, you should still consider a Coal Authority mining search for the area of interest.

Class C examples include:

a) Chalk areas where the approximate location of workings rather than an exact location are known.
b) Slate workings e.g. Woodhouse Eaves (Leicestershire) where working is known to have occurred but exact location is not known.
c) Vein mineral areas of North Pennine orefield, which surround worked mineral veins but which contain no mapped veins and no actual evidence of underground working.

d) Currently operating, shallow mine works using modern engineering standards e.g. East Leake gypsum workings.

4.3.1.5 CLASS D

Underground mining is considered likely to have occurred within or close to the area. The location, extent and nature of mining should be considered in any site investigation. Potential for difficult ground conditions should be considered.

Hazards because of underground mine workings are probable. These are areas known or suspected to contain underground mining for minerals. In the case of mineral veins, these are areas within 500m of mapped mineral veins where mining activities may have occurred and subsidiary veins explored and exploited.

It should be noted, however, that there is always the possibility of the existence of other sub-surface excavations, such as wells, cesspits, follies, air raid shelters/bunkers and other military structures etc. that could affect surface ground stability but which are outside the scope of this dataset. Furthermore, you should still consider a Coal Authority mining search for the area of interest.

Class D examples include:

a) Mineral veins these are areas within 500m of mapped mineral veins, within which, it is likely that mining activities may have occurred and subsidiary veins explored and exploited.
b) Bedded ironstone workings where ironstone is extracted in association with coal but is not the primary mineral.
c) Historic brine pumping sites for the extraction of salt e.g. Stoke Prior.

4.3.1.6 CLASS E

Underground mining is known or considered likely within or very close to the area. The location, extent and nature of mining should be considered in any site investigation. Potential for difficult ground conditions should be considered.

Hazards because of underground mine workings are to be expected. These are areas known or suspected to contain underground mining for minerals. Workings are likely to be extensive. In the case of mineral veins, these are areas within 200m of mapped mineral vein. Where it is likely that mining activities may have occurred.

It should be noted, however, that there is always the possibility of the existence of other sub-surface excavations, such as wells, cesspits, follies, air raid shelters/bunkers and other military structures etc. that could affect surface ground stability but which are outside the scope of this dataset. Furthermore, you should still consider a Coal Authority mining search for the area of interest.

Class E examples:

a) Mineral veins areas within 200m of mapped mineral veins within which it is likely or known that mining activities may have occurred.
b) Areas where hydraulic limestone is known to have been worked at Barrow-on-Soar (Leicestershire)
c) Gypsum working at West Leake (Nottinghamshire) where the extent of workings has been mapped from published documents.

4.3.1.7 NA (NOT AVAILABLE)

Indicates areas where a zone of influence exists but no underlying Mining Hazard (not including coal) data occurs.

4.3.1.8 ZONE OF INFLUENCE CLASS EZ

Mining may not be known at site, however underground mining is known or likely in the vicinity that may affect location. Proximity, extent and nature of mining should be investigated. Potential for difficult ground conditions should be considered.

Hazards because of underground mine workings are to be expected in close proximity. These are zones close to areas known or suspected to contain underground mining for minerals. Workings are likely to be extensive and may affect the site. Further investigation may be required.

It should be noted, however, that there is always the possibility of the existence of other sub-surface excavations, such as wells, cesspits, follies, air raid shelters/bunkers and other military structures etc. that could affect surface ground stability but which are outside the scope of this dataset. Furthermore, you should still consider a Coal Authority mining search for the area of interest.

4.3.1.9 ZONE OF INFLUENCE CLASS DZ

Mining may not be known at site, however underground mining is considered likely to have occurred in the vicinity. Proximity, extent and nature of mining should be investigated. Potential for difficult ground conditions should be considered.

Close proximity to hazards because of underground mine workings are probable. These are zones close to areas known or suspected to contain underground mining for minerals and the locality lies within a distance, which may be impacted as a result. Further investigation may be required.

It should be noted, however, that there is always the possibility of the existence of other sub-surface excavations, such as wells, cesspits, follies, air raid shelters/bunkers and other military structures etc. that could affect surface ground stability but which are outside the scope of this dataset. Furthermore, you should still consider a Coal Authority mining search for the area of interest.

4.4 DATA FORMAT

The Mining Hazard (not including coal) dataset has been created as vector polygons and are available in ESRI shapefile format. Additional more specialist GIS formats may be available but may incur additional processing costs.

4.5 DATASET HISTORY

Mining Hazard (not including coal) has been through a series of iterations, described below. Each new release provides improved coverage and understanding of hazards arising from historic mining. Research in this area is ongoing with new releases expected on an ad hoc basis.

4.5.1 Version 1

Mining Hazard (not including coal) was originally released in 2009 as version 1. It provided a summary of known mining locations and represented release of BGS's first mining dataset.

4.5.2 Version 5

In 2014 BGS introduced a new versioning system whereby the version number applied to a dataset indicated the version of the geological base data (BGS Geology 50 formerly DiGMapGB-50) from which it was derived. For Mining Hazard (not including coal) this resulted in a jump from version 1 to version 5.

In 2010, the data was released as version 5 to include significantly more building stone locations; re-working of the chalk methodology to provide improved coverage and a

redesign of the vein minerals data processing to deliver a more representative spatial extent.

4.5.3 Version 5.1

Early in 2014, in response to the spate of climatic related sinkhole occurrences, a small number of changes were made to the representation of chalk resulted in the release of version 5.1. This release focussed mainly on the generalisation of a small number of chalk localities in South East England. Reference was included in the attribute table to indicate sites where only a general grid reference i.e. to the nearest 1km^2 could be given.

4.5.4 Version 7

In 2015, a fully updated version 7 of the Mining Hazard (not including coal) was released. Changes were made to the chalk methodology as a result of research into the 2014 sinkholes. Additional work had identified number areas from a variety of resources, which were also included.

4.5.5 Version 8

Version 8 released in 2021 contains a number of updates. For the first time the data is aligned to the published BGS BritPits dataset which has been used to identify previously unidentified sites. The extensive working of ironstone, much of which are worked in conjunction with coal have been included and a set of zones of influence have been calculated to indicate the close proximity of mine workings and the consequent potential for instability.

4.6 DISPLAYING THE DATA

Data is accompanied by an ArcGIS v9.3 layer file (compatible with all later versions of ArcGIS). Table 2 and Table 3 contain colour codes and example colour patch for use with other GIS software.

Table 2 Colour palette recommended for displaying Mining Hazard (not including coal) data

Data Classification	Red	Green	Blue	Hex	Looks like
A	215	194	158	D7C29E	
B	194	158	215	C29ED7	
C	245	205	122	F5CD7A	
D	102	205	171	66CDAB	
E	168	0	0	A80000	
Zone of influence only	225	225	225	E1E1E1	

Table 3 Zone of Influence data

Data Classification	Red	Green	Blue	Hex	Looks like
Dz	76	230	0	4C600	
Ez	0	112	215	0070D7	

5 Limitations

5.1 DATA CONTENT

The Mining Hazard (not including coal) data has been constructed based on expert knowledge, published literature and DiGMapGB version 7 (now known as BGS Geology 50k). Consequently, the values within this dataset are limited by the components on which they are based. Given the methodology described within this document (section 3), the value provided here are to the best of our knowledge and current data holdings.

The BGS Geology 50k component is a compilation of digital tiles derived from previously published and unpublished maps and archive information. The mapping, description and classification of rocks are based upon the interpretations and evidence available at the time of survey, or time of re-evaluation for modifications/correction.

Raw data may have been transcribed from analogue to digital format, or may have been acquired by means of automated techniques. Some processes were subjected to quality control to ensure reliability; however, some data may have been processed by automated means resulting in undetected errors.

Data maybe compiled from disparate sources of information at the BGS's disposal; including material donated to the BGS by third parties, and may not have been subject to any verification or other quality control.

Data, information and related records, which have been donated to the BGS, have been produced for a specific purpose, and that may affect the type and completeness of the data recorded and any interpretation. The nature and purpose of data collection, and the age of the resultant material may render it unsuitable for certain applications/uses. You must verify the suitability of the material for your intended usage.

The data, information and related records supplied by the BGS should not be taken as a substitute for specialist interpretations, professional advice and/or detailed site investigations. You must seek professional advice before making technical interpretations based on the materials provided.

Although there are a number of sites affected by underground mining where remediation has occurred, including parts of the Northwich salt field, Barrow-on-Soar, Coalbrookdale, Dudley, and Bury St Edmunds, the impact of this remediation work is not considered in this assessment, and all ratings are given as if localities are not remediated.

5.2 SCALE

The Mining Hazard (not including coal) dataset is published at 1:50 000 where one map unit equates to fifty thousand equivalent units on the ground.

Elements of the data are based on the BGS Geology 50k scale digital map data is generalised and the geological interpretation should be used only as a guide to the geology at a local level, not as a site-specific geological plan based on detailed site investigations. The scale of the data is indicated by the nominal scale attribute (1: 50 000) embedded in the data. Do not over-enlarge the data; for example, do not use 1:50 000 nominal scale data at 1:10 000 working scale. If more-detailed information is required, a site investigation should be commissioned to provide the more information.

5.3 ACCURACY AND UNCERTAINTY

The mapping accuracy associated with the BGS Geology: 50k dataset is nominally 1 mm, which equates to 50m on the ground at 1:50 000 map scale. This is only a measure of how faithfully the lines are captured. Consequently, do not use this dataset at viewing scales finer than 1:50 000. All geological classifications are based on geological interpretation for which no explicit uncertainty is provided. As a result, this measure of accuracy also applies to the Mining Hazard (not including coal) dataset.

A classification of hazard has been applied across a broad range of mining types, activities encompassing the long and complex mining history of Great Britain. Whilst every effort has been made to rationalise these independent factors minor inconsistences may have occurred.

5.4 ARTEFACTS

The Mining Hazard (not including coal) dataset represents data from different times and origins. This can result in disagreements between older and more recently gathered observations.

Re-evaluation of the hazard classification is undertaken with each release of the Mining Hazard (not including coal) data to resolve legacy inconsistencies; this may result in inconsistencies between published versions of the data.

5.5 DISCLAIMER

The use of any information provided by the British Geological Survey ('BGS') is at your own risk. Neither BGS nor the Natural Environment Research Council (NERC) or UK Research and Innovation (UKRI) gives any warranty, condition or representation as to the quality, accuracy or completeness of the information or its suitability for any use or purpose. All implied conditions relating to the quality or suitability of the information, and all liabilities arising from the supply of the information (including any liability arising in negligence) are excluded to the fullest extent permitted by law. No advice or information given by BGS, NERC, UKRI or their respective employees or authorised agents shall create a warranty, condition or representation as to the quality, accuracy or completeness of the information or its suitability for any use or purpose.

6 Frequently asked questions

Q: What does the BGS Mining Hazard (not including coal) dataset show?
A: The dataset shows areas where underground mining is known to have occurred. It does not include coal mining, for information relating to the extraction of coal please contact The Coal Authority.

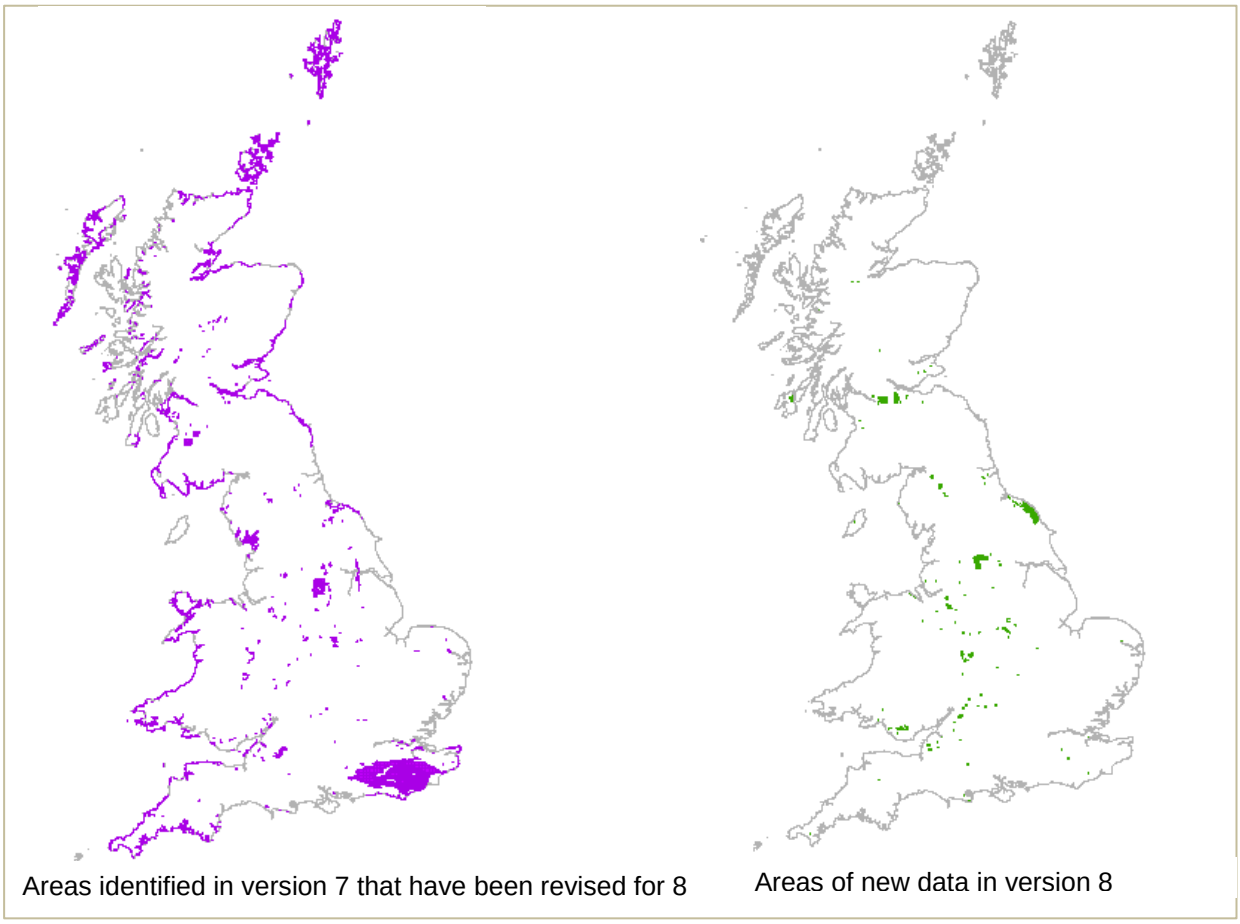
Q: How accurate is this dataset?
A: No uncertainty estimate is provided for the Mining Hazard (not including coal) dataset. The input resources are a combination of published documents, mine plans (published and unpublished) and published BGS Geology data; it is based on an interpretation process. The publication at 1: 50 000 scale is to mitigate some of the locational uncertainty in the source data therefore the data should not be used beyond this scale.

Q: How often will this dataset be updated?
A: This dataset is under on-going revision as new data resources are identified, as such, there are no specific update periods for this dataset.

Q: Can I use this dataset as part of a commercial application?
A: This dataset is licenced from BGS, please refer to the terms of your licence or contact iprdigital@bgs.ac.uk for further information

Appendix Changes between versions

AREA CHANGE BETWEEN VERSION 7 AND 8 OF MINING HAZARD (NOT INCLUDING COAL)



Areas identified in version 7 that have been revised for 8

Areas of new data in version 8

Figure 5 Change maps from version 7 and 8 of Mining Hazard (not including coal)

To identify areas of class change, a point in polygon analysis was carried out using a join based on class in version 7 and class in version 8. Locations where the two class values did not match are shown in the Table 4 and the map. The key reasons for these changes are listed in Table 5.

Table 4 Class changes between version 7 and 8 of Mining Hazard (not including coal)

Class change	Number of polygons
A to B	412
A to C	176
A to D	323
A to E	608
A to NA	7
B to A	12
B to C	388
B to D	903
B to E	969
B to NA	3
C to A	83
C to B	233
C to D	554
C to E	539
C to NA	10
D to A	3
D to B	86
D to C	38
D to E	108
D to NA	105
E to A	14
E to B	96
E to C	30
E to D	51

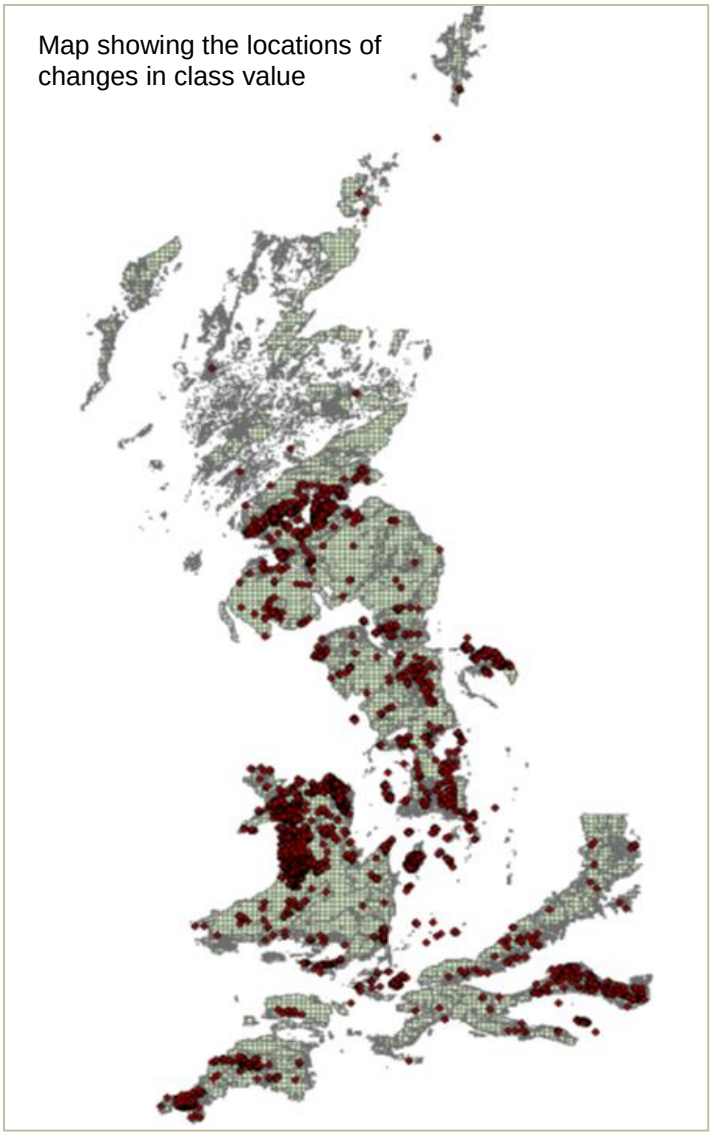


Table 5 Key causes of change between version 7 and 8 of Mining Hazard (not including coal)

Key causes of change between version 7 and 8 of Mining Hazard (not including coal)
Revision of the coastline the data is prepared against
Revision of existing data: • Ironstone areas reviewed and revised, including areas associated with coal extraction • Vein mineral methodology updated to give better representation • Evaporite data revised from published data resources
New BGS data sources identified and aligned to providing greater consistency between published BGS data resources and allowing the honing of previously published linework
Integration of newly generated zone of influence data
Class changes have occurred as a result of adding and subtracting of new data resulting in their subsequent reclassification

Glossary

Jargon	Explanation
ArcGIS	Geographic information system (GIS) software for working with maps and geographic information maintained by the Environmental Systems Research Institute (ESRI).
BritPits	An abbreviation of British Pits, and the word 'pits' is used here to include both surface and underground mineral workings. The BGS BritPits database holds information on names of mines, quarries, oil wells, gas wells, ash and desulphogypsum plants; geographic location; address; operator; mineral planning authority; geology; mineral commodities produced; end-uses where known.
Building stone	Naturally occurring rocks of igneous, sedimentary or metamorphic origin, which are sufficiently consolidated to enable them to be cut or shaped into blocks or slabs for use as walling, paving or roofing materials in the construction of buildings and other structures. The principal building stones include igneous rocks (such as granite), massive bedded sandstones, limestones and metamorphic rocks (such as marble and slate). Also known as Dimension stone.
Chalk	A sedimentary rock formed from the accumulation up of the shells marine microorganism comprised of calcium carbonate.
ESRI	Environmental Systems Research Institute (ESRI) is an international supplier of geographic information system (GIS) software, web GIS and geodatabase management applications.
Evaporite	A sedimentary rock composed mainly of minerals produced by evaporation, normally from an enclosed body of seawater or a salt lake. Minerals formed in this way include gypsum, rock salt, and various nitrates and borates.
Fault	Plane or zone of displacement. An area where bodies of rock have been displaced relative to each other by geological forces. Faults are commonly represented on maps as lines, but may represent zones and volumes of failed materials.
Geographical Information System	Geographic Information Systems (GIS) provides accurate information, assistance, support, and maintains and creates information to aid in the development of maps and data analysis.
Geohazard	Geological and environmental conditions, involving long and short-term processes which may lead to widespread damage. There are many different types of geohazard with different natural and artificial processes causing them to occur. All have the potential to create problems for development of the human environment and threats to the safety and well-being of people. Geohazards can develop quickly (seconds or minutes) in response to the processes that drive them, or take tens, hundreds, or thousands of years to develop to a point where they pose a danger. They are found in most parts of the world, including marine and fluvial environments.
Hazard rating	Scale or classification used to indicate low to high degree of identified threat.
Limestone	Any sedimentary rock consisting mostly of carbonates (calcite and/or dolomite).

MapInfo	A desktop geographic information system software product produced by Pitney Bowes Software and used for mapping and location analysis. MapInfo Pro allows users to visualize, analyse, edit, interpret, understand and output data to reveal relationships, patterns, and trends.
QGIS	A free and open-source cross-platform desktop geographic information system (GIS) application that supports viewing, editing, and analysis of geospatial data. QGIS was until 2013 known as Quantum GIS.
Scale	The relation between the dimensions of features on a map and the geographic objects they represent on the earth, commonly expressed as a fraction or a ratio. A map scale of 1/100,000 or 1:100,000 means that one unit of measure on the map equals 100,000 on the earth.
Shapefile	The shapefile format is a geospatial vector data format for geographic information system software. It is developed and regulated by Esri as a mostly open specification for data interoperability among Esri and other GIS software products.
Spatial data	Data describing anything with spatial extent; i.e. size, shape or position. In addition to describing things that are positioned relative to the Earth, spatial data may also describe things using other coordinate systems that are not related to position on the Earth, such as the size, shape and positions of cellular and sub-cellular Spatial Things described using the 2D or 3D Cartesian coordinate system of a specific tissue sample.
Topographic	The physical features of the Earth. A topographic map's principal purpose is to portray and identify the features of the Earth. These features might include the cultural landscape, but normally refer to the terrain and its relief.
Union	ESRI tool, which computes a geometric union of the input, features. All features and their attributes will be written to the output feature class.
Vector	A representation of the spatial extent of geographic features using geometric elements (such as point, curve, and surface) in a coordinate space.
Workings	The current or past underground or surface openings and tunnels of a mine. More specifically, the area where the ore has been extracted.
Zone of Influence	Area surrounding an underground mine working where subsidence may occur

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at https://envirolib.apps.nerc.ac.uk/olibcgi

BROWN T.J., LINLEY K.A. 2020. Mining Hazard (not including coal) Methodology Revision 8. *British Geological Survey Internal Report*, IR/20/022.

REN, G. AND LI, J. 2008. A Study of Angle of Draw in Mining Subsidence Using Numerical Modelling Techniques. Electronic Journal of Geotechnical Engineering, Vol. 13, Bundle F.