Inventory of closed mine waste facilities in Northern Ireland - Phase 1 Data collection and categorisation

Minerals and Waste Programme

Progress Report CR/13/119N

BRITISH GEOLOGICAL SURVEY

MINERALS AND WASTE PROGRAMME

PROGRESS REPORT CR/13/119N

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Foreword

This mid-project report is a required deliverable for a BGS project commissioned by the Northern Ireland Department of the Environment (DoENI) to assist in their implementation of the EU Mine Waste Directive (MWD) with regards to Article 20 - Inventory of closed waste facilities. The objective of this project is to address the requirement of the Directive for an inventory of closed waste facilities, including abandoned facilities, which cause or could potentially cause serious negative environmental impacts or are a serious threat to human health. This report describes the approach taken and provides project progress evidence.

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Summary

This mid-project report is a required deliverable for a BGS project commissioned by the Northern Ireland Department of the Environment (DoENI) to assist in their implementation of the EU Mine Waste Directive (MWD) with regards to Article 20 − Inventory of closed waste facilities. The objective of this project is to address the requirement of the EU Directive for an inventory of closed waste facilities, including abandoned facilities, which cause or could potentially cause serious negative environmental impacts or are a serious threat to human health. The report describes the approach taken and project progress to date.

For the purposes of this project the term "closed mine waste facilities" should be considered to include "abandoned mine waste facilities".

The EU Directive requires the application of risk assessment methods in the inventory of closed waste facilities that are either known or have the potential of impacting the environment or human health, i.e. there must be a link between the source of a hazard in the waste facility and an identified receptor. Our approach to developing the inventory is based on: Annex III of the MWD, which refers to the "*Criteria for determining the classification of waste facilities*", and the EC 2011 *"Guidance document for a risk-based pre-selection protocol for the inventory of closed waste facilities*". The latter provides guidance to Member States on the methodology for producing a precautionary list of waste facilities that would be candidate sites for the inclusion in the inventory. We also consider the methodology devised by the Environment Agency in England and Wales (EA, 2012) and similar work undertaken by the Geological Survey of Ireland when creating an inventory of historic mine sites for the Republic of Ireland.

A phased approach is being followed, consisting of an initial qualitative study (Phase 1), aimed at data collection and categorisation. This will be followed by a more quantitative data assessment phase (Phase 2), which appraises potential environmental impacts of the closed mine waste facilities. Both phases are desk-based studies and, do not require fieldwork-based activities. The Phase 2 output will identify and rank potential inventory sites and will seek to establish spatial linkages between the mine sites and water and/or sediment geochemical data for stream water and sediment data values that exceed specified chemical quality assessment criteria. Phase 2 will use data held by the GSNI and BGS. The most impacted sites should then be investigated through field visits and further sampling and testing. This assessment does not address physical hazards, which also require consideration under the Directive. The project outputs should be complemented by information sourced from relevant authorities on known concerns about risks to human or animal health, stability, and fire or air pollution.

The second part of the report describes the results of the Phase 1: data collection and categorisation.

The GSNI Abandoned Mines database of Northern Ireland (~1,700 records of mine shafts and adits) and the BGS BRITPITS database of Mines and Quarries (~2,100 records of closed mineral sites in Northern Ireland) represent the primary baseline data for creation of the inventory. The following issues were identified during the compilation of source data:

- The data collated refer to sites defined as "location of mining or quarrying activity; the site may be a surface quarry, the location of an underground shaft or adit or a mine spoil or a tailings lagoon. Consequently, a record does not necessarily constitute proof of the existence of a mine waste facility, i.e. an area designated for the accumulation or deposit of extractive

waste. During the compilation of source data, available information on the presence of waste tips has been gathered from a range of sources, including field slips and the 1: 10 000 scale digital geological map artificial ground layer, however this data does not provide comprehensive coverage.

- The existing catalogues include references to individual mine entrances or workings rather than a centroid or single point location to represent a mine location; this will result in over estimation of the number of workings.

These issues will, where possible, be addressed during Phase 2 of the project.

The majority of waste, if present, associated with the closed mine waste facilities in Northern Ireland is likely to be non-hazardous waste and substantially inert. Providing there is no evidence of physical instability, these facilities should not be included in the inventory. Exceptions comprise the waste associated with coal/lignite, metal base and iron and bauxite extraction, which should be further assessed in a more quantitative way.

On this basis, of the 3686 entries, a selection of 1806 (bauxite, copper, iron ore, lead, coal, lignite and barytes) will be subjected to the geochemical assessment in Phase 2 of the project.

The current assessment does not address physical stability of closed mine waste facilities, which forms an integral part of the assessment for the classification of closed waste facilities. Should any data that relate to evidence of harm to human health, instability and combustion associated with a known closed mine waste facility become available, the site should be included in the inventory.

1 Introduction

1.1 SCOPE OF THE PROJECT

This project was commissioned by the Northern Ireland Department of the Environment (DoENI) to assist their implementation of the EU Directive 2006/21/EC on the Management of Waste from the Extractive Industries, often referred to as the Mine Waste Directive (MWD), with regards to Article 20 - Inventory of closed waste facilities. This project will provide the information required to create an inventory of closed and abandoned mining waste facilities which may be causing or have the potential to cause serious negative environmental impacts or are a serious threat to human health. For the purposes of this project the term "closed mine waste facilities" should be considered to include "abandoned mine waste facilities".

This report describes the approach taken and provides the evidence for progress of Task 1 as detailed in Figure 1.

	October 2013				November 2013				December 2013				January 2014			
Task 1. Identification and categorisation of closed mine waste facilities																
Task 2. Quantitative data assessment, report and map production																
Task 3. Deliver draft report and maps to DoE for comment																
Task 4. DoE review of draft report and maps																
Task 5. Deliver final report and maps																

Figure 1 Project Gantt chart

1.2 THE MINE WASTE DIRECTIVE

The European Mine Waste Directive (MWD) seeks to mitigate the environmental effects of mine waste facilities, to prevent the occurrence of major accidents associated with tailings ponds and other waste containment structures, and encourage the reuse and minimisation of mine waste. A mine waste facility is defined as "any area designated for the accumulation or deposit of extractive waste".

The current project is concerned with Article 20 – of the Directive – Inventory of closed waste facilities. Article 20 states that '*Member States shall ensure that an inventory of closed waste facilities, including abandoned waste facilities, located on their territory which cause serious negative environmental impacts or have the potential of becoming in the medium or short term a serious threat to human health or the environment is drawn up and periodically updated. Such an inventory, to be made available to the public, shall be carried out by 1 May 2012, taking into account the methodologies as referred to in Article 21, if available.*'

Therefore the Directive requires the application of risk assessment methods in the inventory of closed waste facilities that are either known or have the potential of impacting the environment or human health, i.e. there must be a link from the source of a hazard in the waste facility to an identified receptor.

1.3 CRITERIA FOR THE CLASSIFICATION OF WASTE FACILITIES

The criteria set out in the following documents will guide our assessment:

Annex III of the MWD refers to the "Criteria for determining the classification of waste facilities" as follows:

A waste facility shall be classified under Category A if:

— a failure or incorrect operation, e.g. the collapse of a heap or the bursting of a dam, could give rise to a major accident, on the basis of a risk assessment taking into account factors such as the present or future size, the location and the environmental impact of the waste facility; or

— it contains waste classified as hazardous under Directive 91/689/EEC above a certain threshold; or

— it contains substances or preparations classified as dangerous under Directives 67/548/EEC or 1999/45/EC above a certain threshold.

Subsequent Commission Decision 2009/359/EC and Commission Decision 2009/337/EC complete the definition, respectively, of inert waste and of the criteria for the classification of waste facilities in accordance with Annex III of the Directive.

In addition, the **EC 2011** "Guidance document for a risk-based pre-selection protocol for the inventory of closed waste facilities as required by article 20 of the Directive 2006/21/EC" provides guidance to Member States on the methodology to use to produce a precautionary list of waste facilities that would be candidate sites for the inclusion in the inventory. As indicated in the previous section, the inventory should be risk-based, i.e. consider the probability of an event occurring and the impact of such an occurrence. It should address the source, pathway and receptor components. The guidance protocol was presented as a flowchart and includes four sections addressing: 1. Any known serious impacts; 2. Sources; 3. Pathways; and 4. Receptors. Following the pre-selection protocol leads to two endpoints for the evaluation of the waste facility, either NO NEED TO EXAMINE FURTHER, or EXAMINE FURTHER. A description of the protocol and flow chart is given in Appendix 1.

The EC 2011 document also provides useful guidance on how to interpret various terms in Article 20 of the Directive and further elucidates the interpretation defined in Commission Decision 2009/337/EC1 on how to define "serious negative environmental impacts or the potential of becoming in the medium or short term a serious threat to human health or the environment" as follows:

- Serious in the context of human health includes loss of life, disability or prolonged states of ill-health.

- Serious in the context of environment includes: i) intensity of the potential contaminant source strength is not decreasing significantly within a short time; ii) the failure leads to any permanent or long-lasting environmental damage; iii) affected environment cannot be restored through minor clean-up and restoration efforts.

The methodology devised by the Environment Agency in England and Wales (**EA, 2012**) further defines criteria for assessing serious environmental impacts for specific hazards such as water pollution, contaminated land, instability, particulates, suspended solids, and fire hazards. For example, serious environmental impact on water courses is considered to occur when failure of environmental quality standards (EQSs) in surface waters is measured over a distance of more 500 metres from the site. Further details are reported in Appendix 2.

1.3.1 Source, Pathway and Receptor components of the risk-based assessment

Within the context of "source characterisation", two criteria require consideration prior to inclusion of the mine waste facility in the inventory: one addresses **the chemical content** of the facility (i.e. the character of the waste in terms of presence of sulphides and hazardous substances above certain thresholds), while the second addresses the **physical stability** of the facility, distinguishing between tailings lagoons and waste heaps.

In order to further elucidate the components of the risk assessment, Table 1 illustrates the potential linkages to consider in assessing the environmental impacts of closed mine waste facilities used by the Environmental Agency in England and Wales (Environment Agency, 2012).

Table 1 Hazard- pathway-receptor linkages at closed mine waste facility

Hazard	Pathway	Receptor
Pollution	Leaching	Rivers, streams (surface water quality) Groundwater
	Erosion	Rivers, streams (surface water quality) Ecology (surface water) Ecology (protected sites) Crops, livestock
	Windblown dust	Human Health Ecology (protected sites) Crops, livestock
	Dermal contact, ingestion	Human Health Livestock
Instability	Heap, dam or tailings pond failure	Rivers, streams (surface water quality) Ecology (surface water) Ecology (protected sites) Human Health
Flammability	Smoke, heat, dust, gas	Human Health Property

Source Environment Agency, 2012

1.4 OUTLINE OF APPROACH

The methodology used in this project to develop the inventory considers both the European Commission guidance protocol (EC, 2011), and the criteria devised by the Environment Agency in England and Wales (EA, 2012) in the preparation of their inventory, to which the British Geological Survey contributed (Palumbo-Roe and Colman, 2010). It also takes cognisance of similar work undertaken by the Geological Survey of Ireland when creating an inventory of, and undertaking an associated risk classification for, historic mine sites in the Republic of Ireland.

A phased approach is followed. An initial qualitative study (Phase 1) involves data collection and categorisation. This is followed by a more quantitative data assessment phase (Phase 2), which appraises potential environmental impacts of the closed mine waste facilities comparing mine site locations with geochemical data for stream water and sediment samples held by the GSNI and BGS. Both phases are desk-based studies and, therefore, no fieldwork-based activities are carried out. Phase 2 identifies and ranks potential inventory sites by spatially linking the mine sites and water and/or sediment data that exceed specified chemical quality assessment criteria. The most impacted sites should then be investigated through field visits, further sampling and testing. This assessment does not address physical hazards, which also require consideration under the Directive. The project outputs should be complemented by information sourced from relevant authorities on known concerns about risks to human or animal health, stability, and fire or air pollution.

2 Phase 1- Qualitative identification and categorisation of closed mine waste facilities in Northern Ireland.

2.1 DATA COLLECTION

Data on the location and type of mines and quarries are derived from the GSNI Abandoned Mines database of Northern Ireland and the BGS BRITPITS database of Mines and Quarries. These data sources represent the primary baseline data for creation of the inventory. Whilst there is overlap between the two data sources, information contained within both has allowed a comprehensive assessment to be undertaken.

2.1.1 Abandoned Mines database of Northern Ireland

This database locates and identifies all mine shafts, adits and collapses currently known to the Geological Survey of Northern Ireland. The records held in the database have been derived from a wide range of map and written sources, and not all have been validated on site. Consequently a record does not necessarily constitute proof of the existence of a mine opening.

The database contains approximately 2000 records each representing an individual site of a shaft, adit or surface expression; it should be recognised that a mine or working may be represented by more than one site within this dataset. Details of the minerals worked and location are included in the dataset and some work has been done by GSNI to 'group' the data to associate records based on an individual mine name.

In validating this dataset some positions have been corrected where more up-to-date information has been used to locate the working.

2.1.2 BRITPITS

The BGS BRITPITS database contains information on active, inactive, closed and abandoned mineral extraction sites. It is continually modified to take into account changes in industry and new sites, but can never be absolutely up-to-date. The data is updated from BGS's own extensive records, a wide range of contacts within the minerals industry and Mineral Planning Authorities and by both formal and informal (visits, enquiries, trade journals, etc.) means.

For the purpose of this project 3439 records were identified in BRITPITS relating to mineral workings in Northern Ireland. Of the 3439 records, 708 were categorised as either active (sites which are actively extracting mineral products), inactive (sites which are not currently extracting minerals, but have valid mineral planning permission to do so and can restart at any time) or yet to being (sites which have been notified by operators of mineral planners but have not yet started extracting mineral). Due to their status they have been excluded from the analysis.

Some sites were considered as duplicates of the GSNI data due apparently to the use of differing map series as source information in the creation of the separate databases. Work has been undertaken to identify and remove obvious duplicates from the analysis where possible through validation against field slips and other available data sources. However, all duplicates will not have been removed, as their spatial locations are not necessarily coincident due to different source documents being used.

2.1.3 Preliminary identification of waste tips

There is little comprehensive information of the quantities of waste produced by mineral workings, as it has generally been of no interest to the statistical or planning community, having by definition no commercial value. Mine and quarry waste is not classified as ‘controlled waste’ and is, therefore, not regulated by the controlled waste legislation.

During the compilation of source data, available information on the presence of waste tips has been gathered from a range of sources. These include field slips and the 1: 10 000 scale digital geological map artificial ground layer, i.e. those areas where the ground surface has been significantly modified by human activity. These data sources do not provide comprehensive coverage, but, where available, have been used to identify the presence of spoil tips.

A set of geo-referenced mine abandonment plans are also available for a small number of mines and these have been used to provide site specific data.

2.2 LIMITATIONS

Variation between primary data sources will have produced duplicated data points which cannot be identified and removed without revising all original capture documents. This is beyond the scope of this project. Furthermore, it is important to note that existing catalogues include references to individual mine entrances or workings rather than a centroid or single point location to represent a mine location; this will result in over estimation of the number of workings.

We do not have complete information at this stage to differentiate between waste piles/tailings pond and other features such as shafts and adits. Therefore the data collated refer to sites defined as “location of mining or quarrying activity; may be a surface quarry, the location of an underground shaft or adit or a mine spoil or a tailings lagoon”.

2.3 CLASSIFICATION OF MINERAL WORKING TYPES

Using the data collated as described in previous sections, the closed sites in Northern Ireland have been extracted and classified according to mineral working type. The classification of mineral working types is that used in the BGS Directory of Mines and Quarries publication based on mineral commodity worked. This provides a discrimination between the main classes of minerals worked, i.e. construction minerals, industrial minerals, energy minerals and metals. For the first three of these classes, the specific mineral worked is also identified, e.g. industrial minerals are sub-divided into, for example, barytes, clay, chalk, etc.. The results of this classification are shown in Table 2. Many of the sites work more than one mineral, for example iron ore and bauxite or coal and fireclay. Details of primary and secondary minerals worked and the number of sites are summarised in Appendix 3. Figures 2-12 show the locations of the individual mines and quarries summarised in Table 2.

Table 2 Summary of closed mineral extraction sites in Northern Ireland

Mineral Class	Commodity	No of closed sites
Construction minerals	Basalt	301
	Igneous & Metamorphic	206
	Sand & Gravel	418
	Sandstone (including gritstone)	325
Energy minerals	Coal	843
	Lignite	28
Industrial minerals	Barytes	1
	Chalk	131
	Clay	122
	Diatomite	9
	Dolomite	1
	Feldspar	9
	Fireclay	45
	Kaolin	2
	Limestone	217
	Peat	20
	Perlite	8
	Porcellanite	2
	Salt	24
	Silica Sand	2
	Slate	39
Metallic minerals	Bauxite	317
	Copper	15
	Iron ore	495
	Lead	107

Source: GSNI MS Access database NIShafts2000Data.mdb and BGS BRITPITS Database

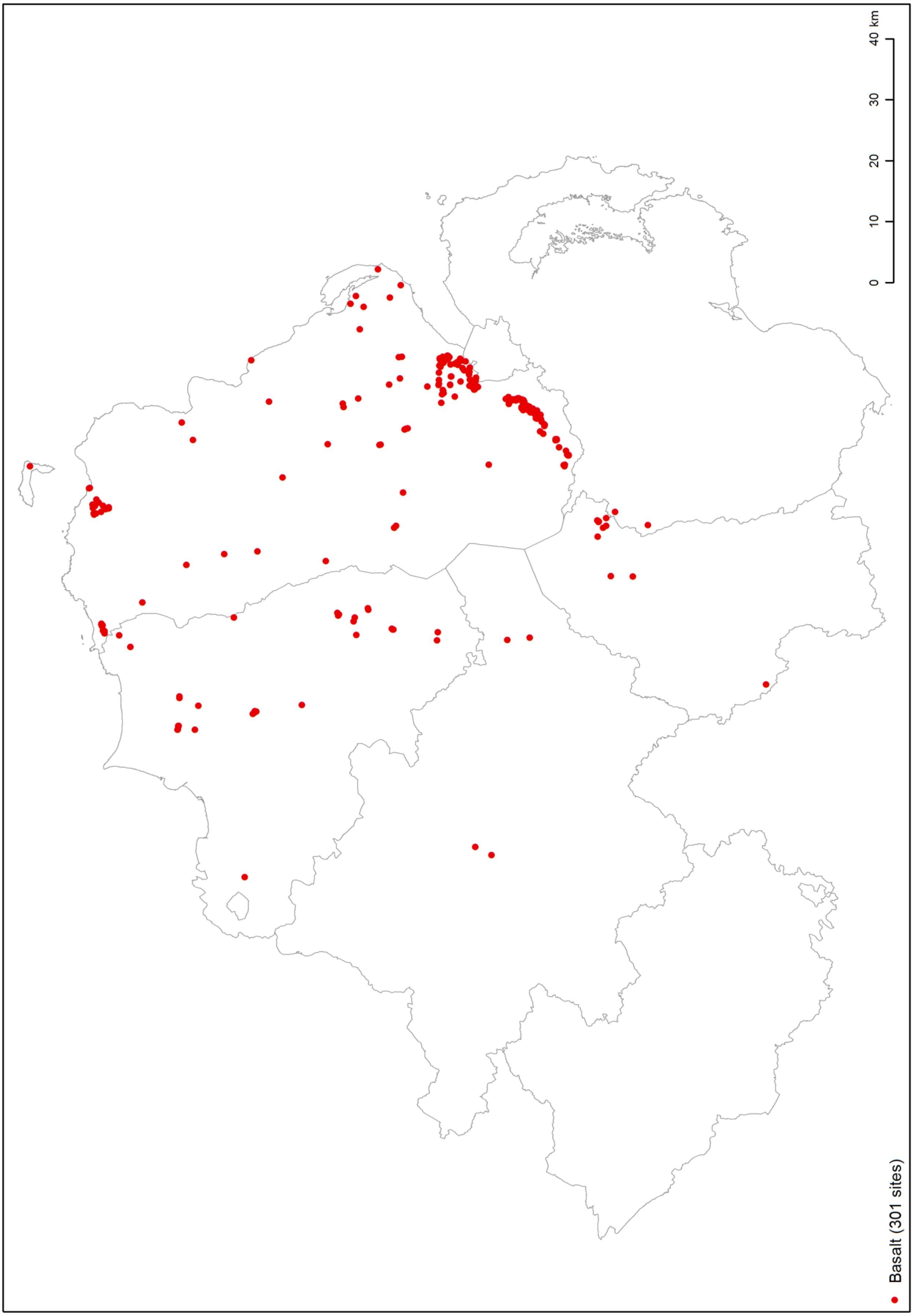

Figure 2 Basalt sites

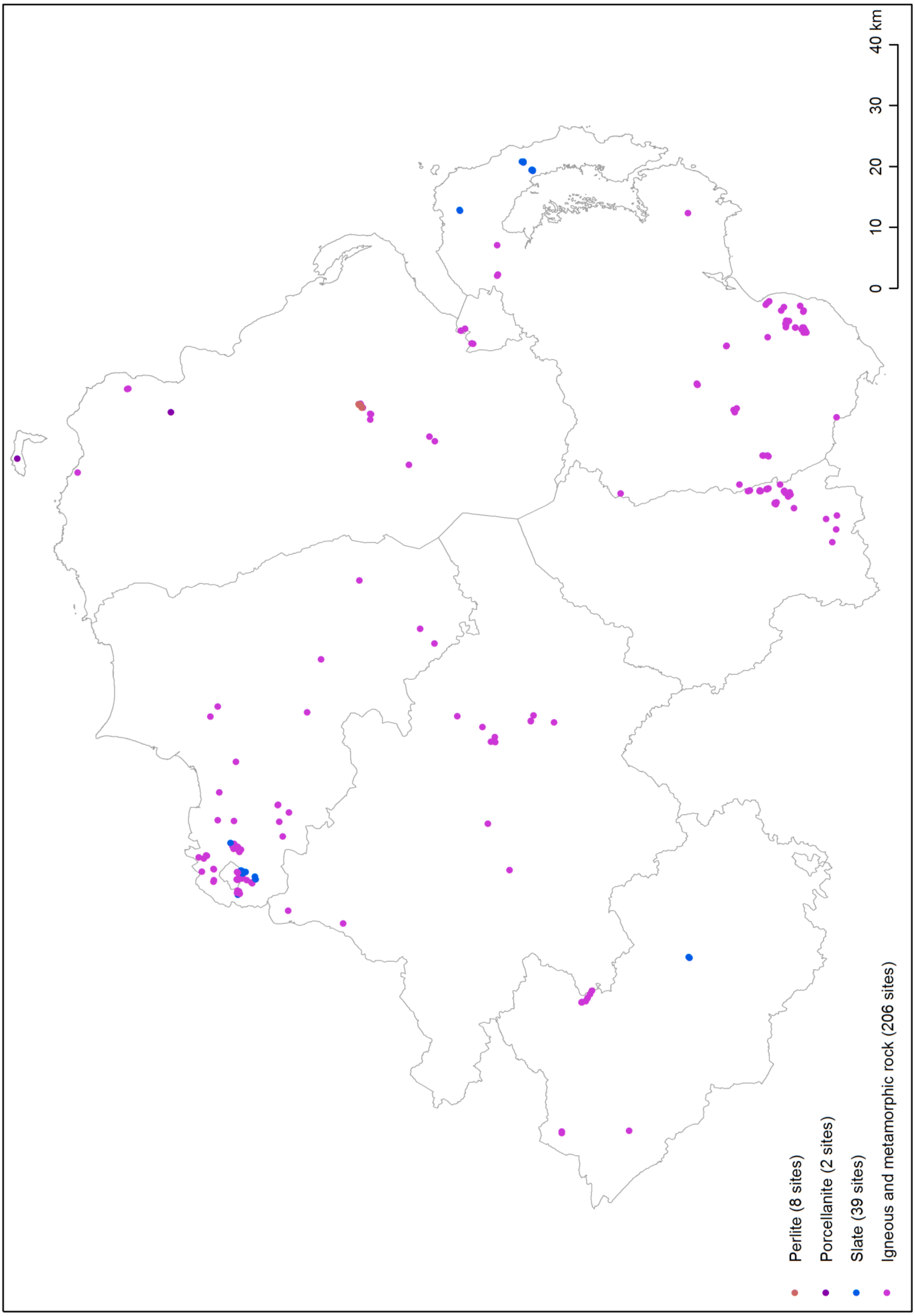

Figure 3 Igneous and metamorphic rock, slate, perlite and porcellanite sites

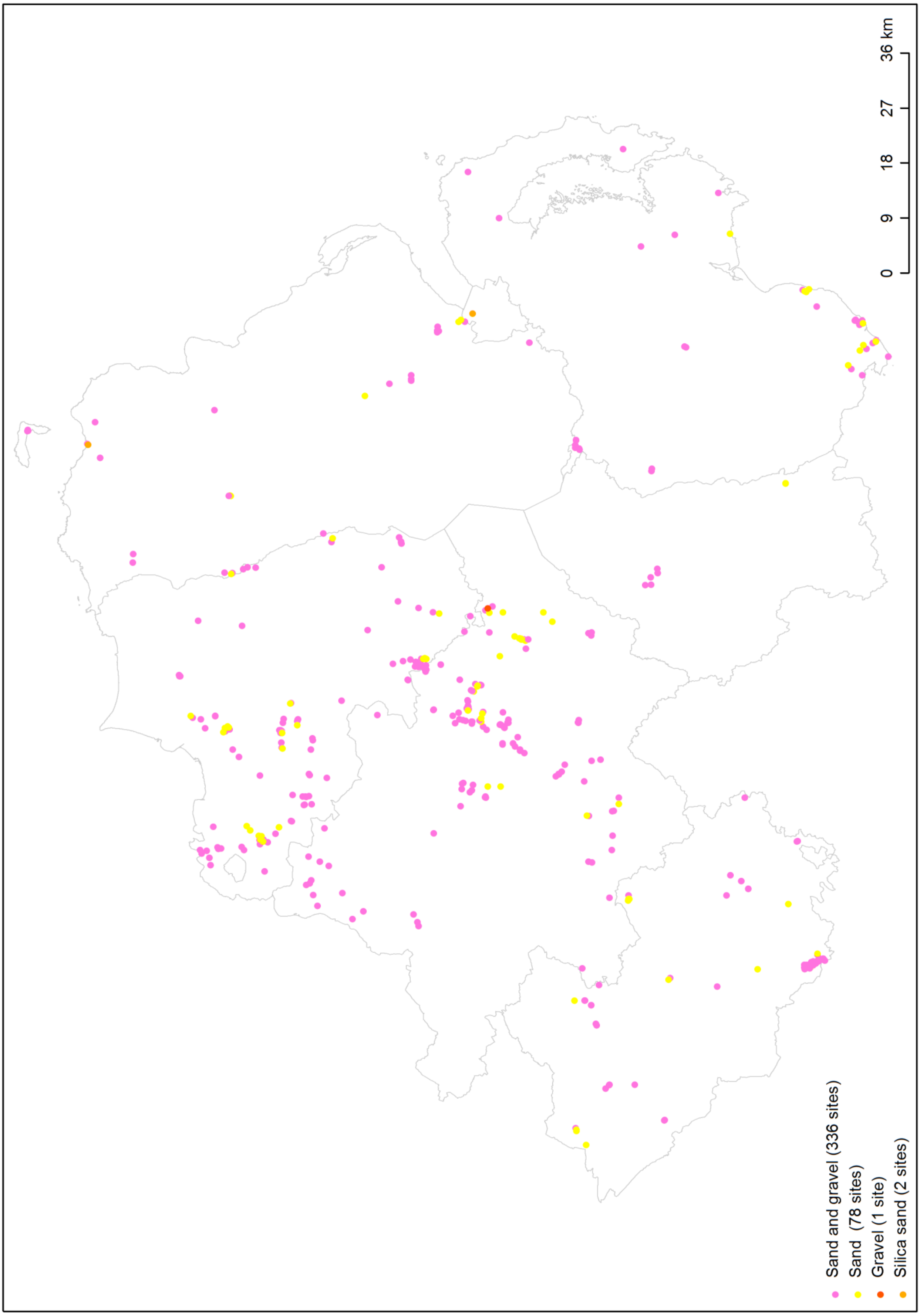

Figure 4 Sand and gravel and silica sand sites

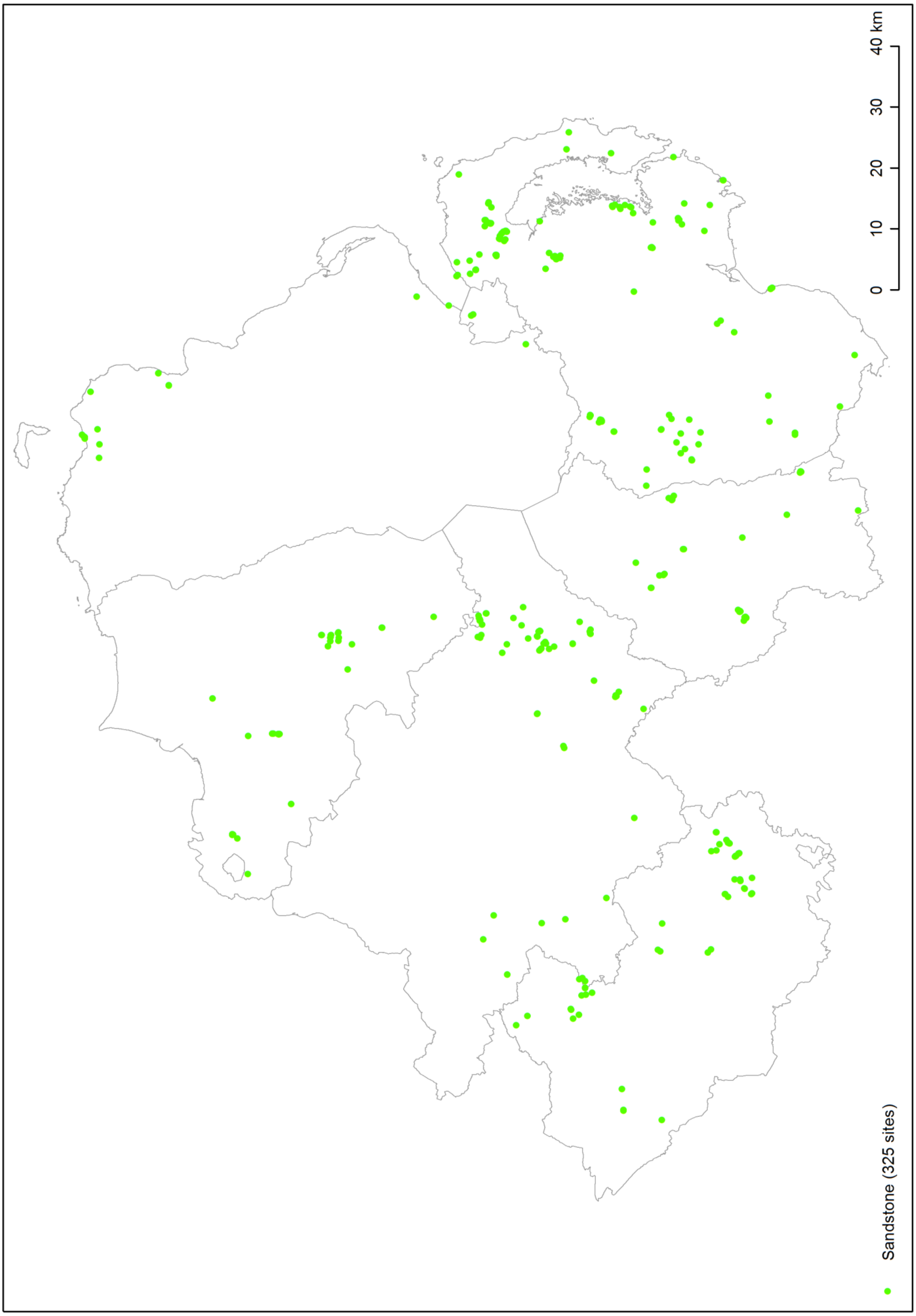

Figure 5 Sandstone (including gritstone) sites

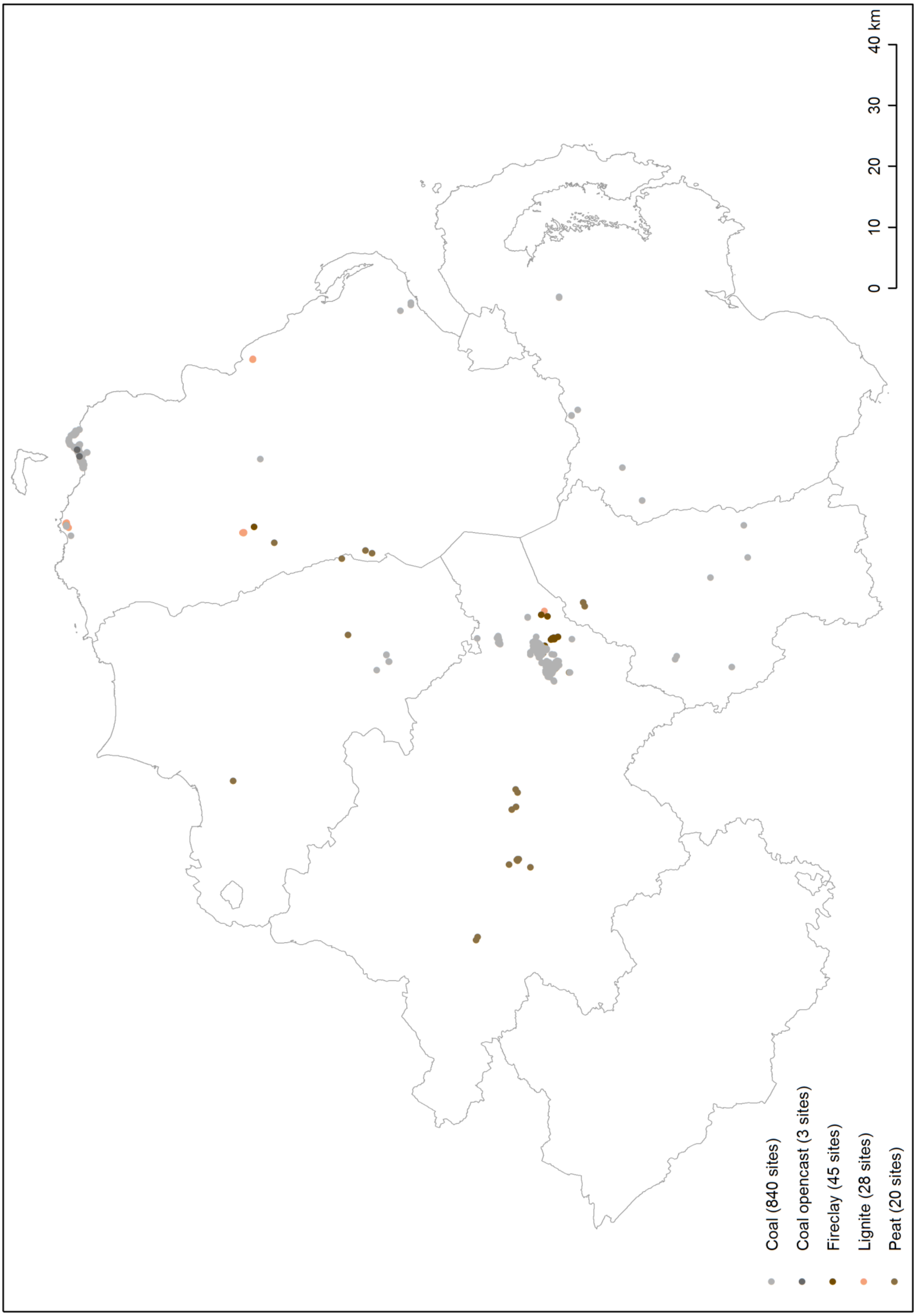

Figure 6 Coal, lignite, fireclay and peat sites

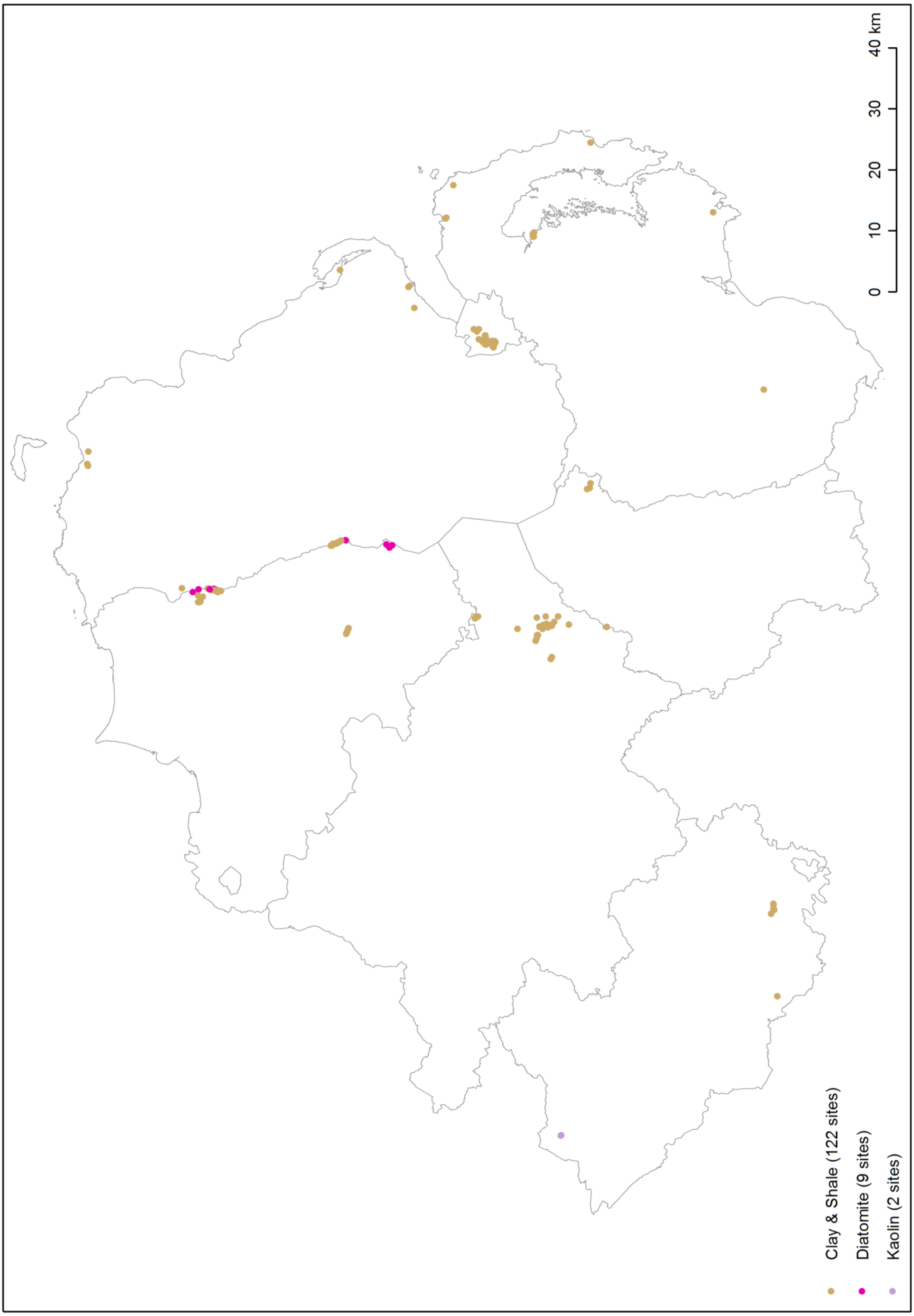

Figure 7 Clay, shale and kaolin sites

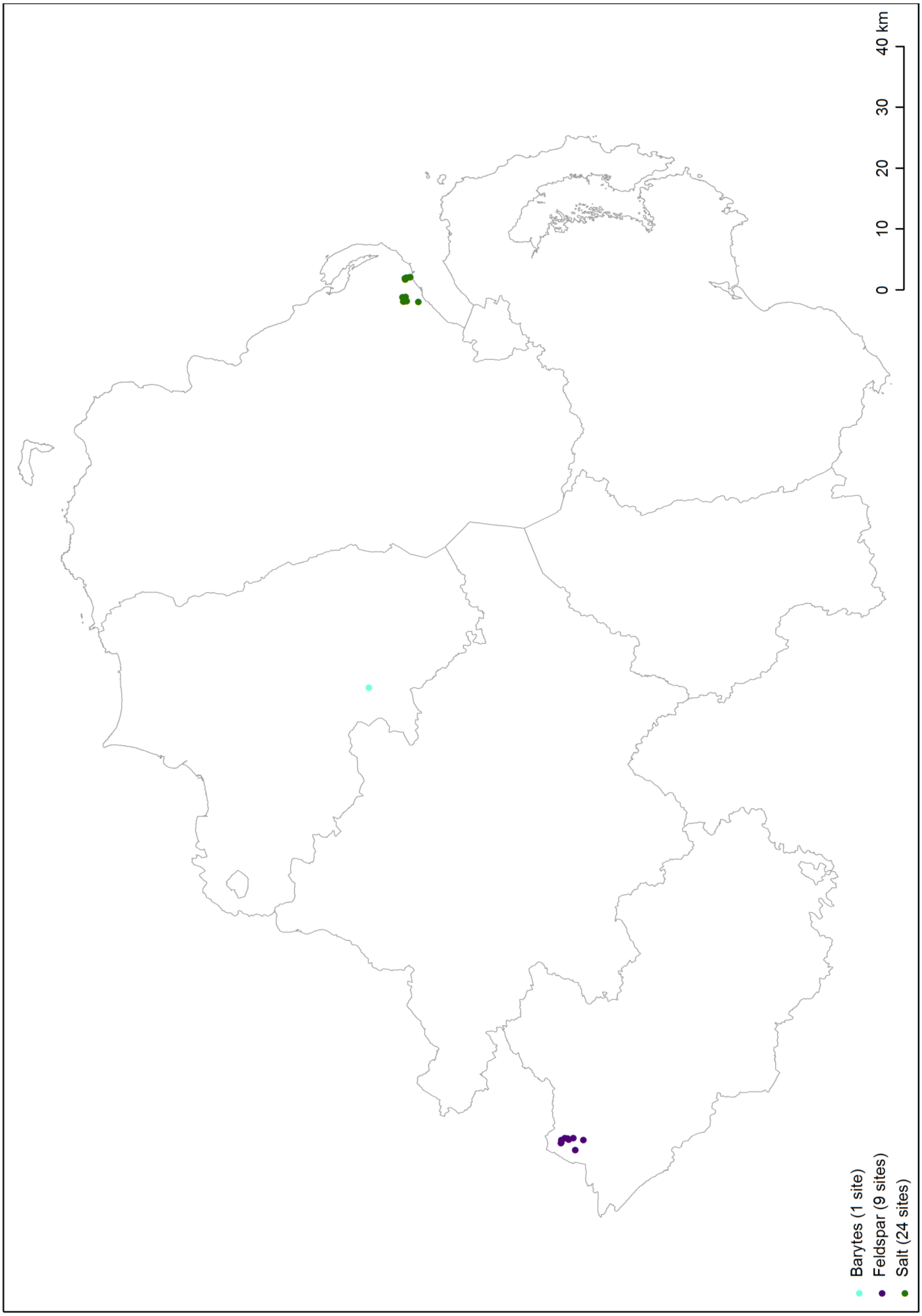

Figure 8 Barytes, feldspar and salt sites

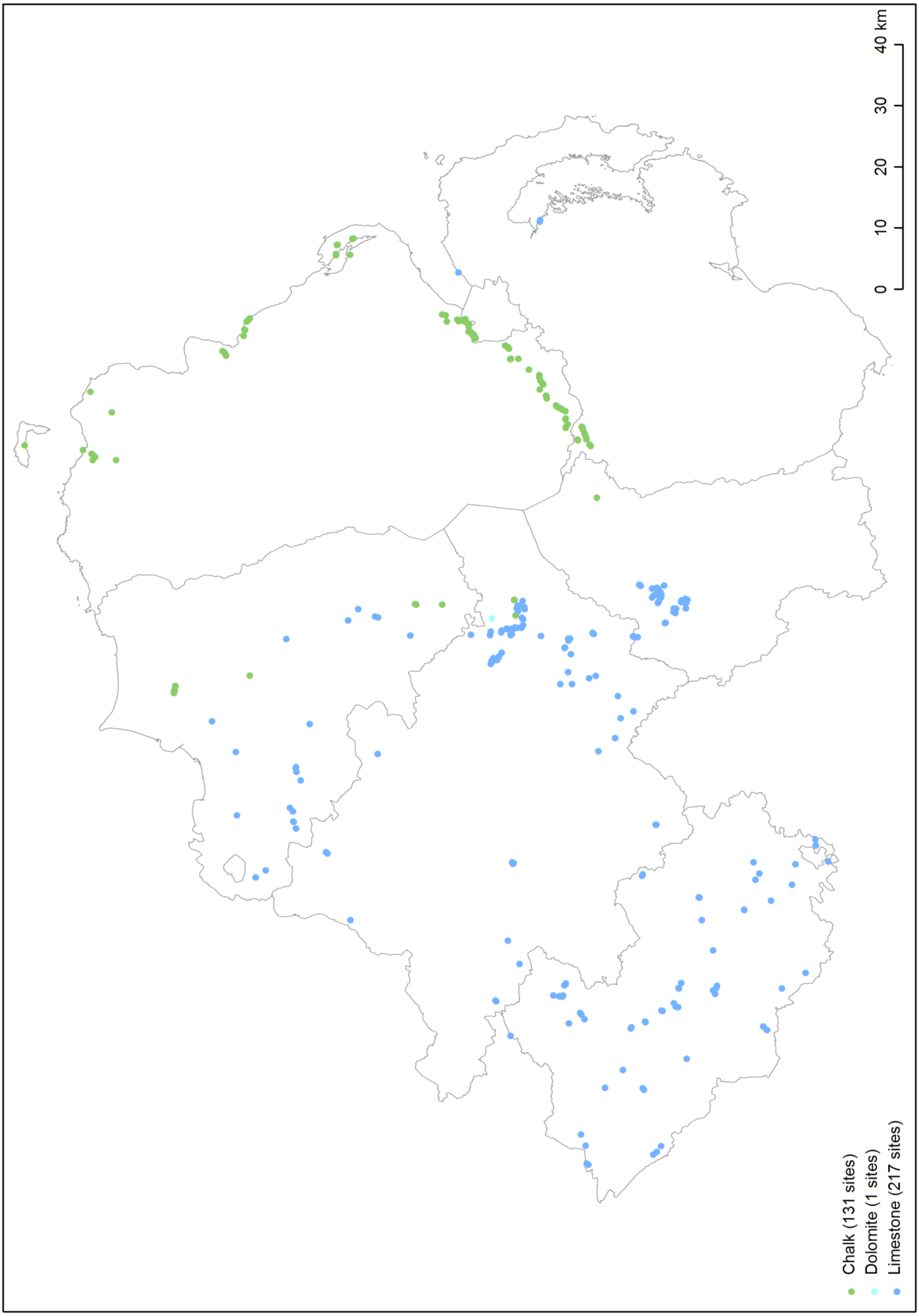

Figure 9 Chalk, dolomite and limestone sites

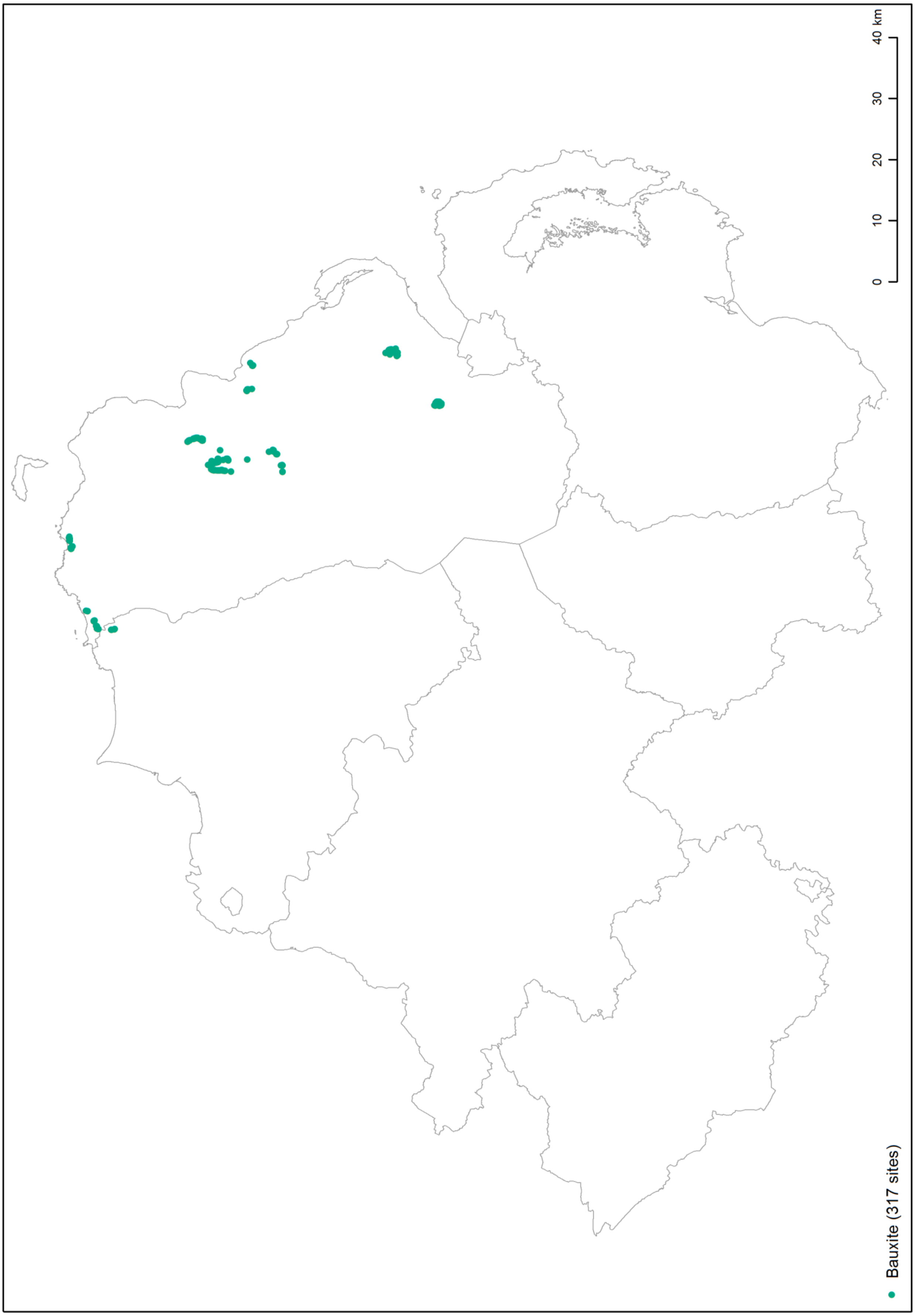

Figure 10 Aluminium (bauxite) sites

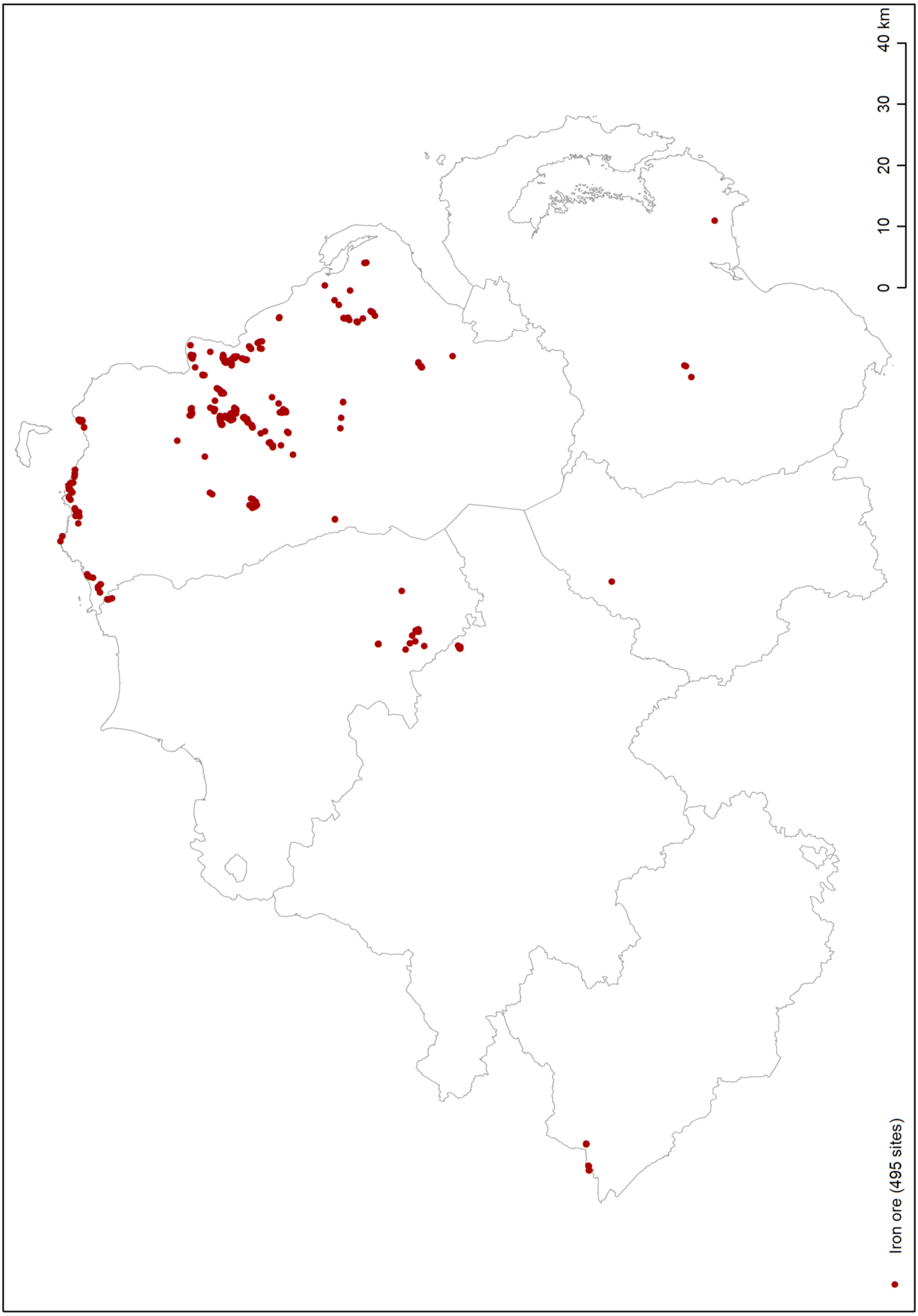

Figure 11 Iron ore sites

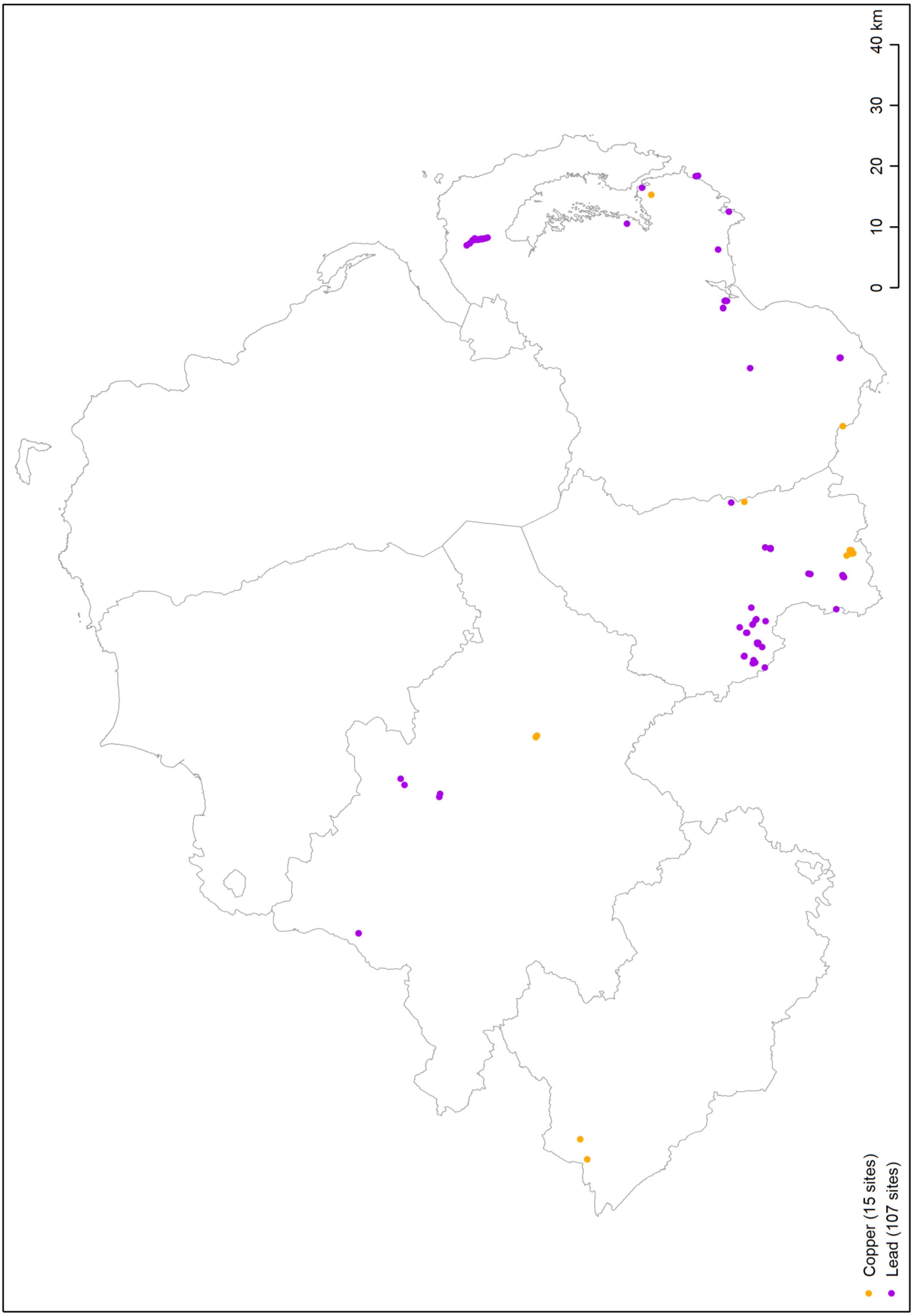

Figure 12 Copper and lead sites

2.4 Qualitative assessment for preliminary screening of closed mine sites

This assessment builds upon the information on non-metalliferous sites contained in studies of waste from active mineral workings (Colman et al., 2006) and metalliferous abandoned mine sites in England and Wales (Palumbo-Roe and Colman, 2010) and it is guided by the criteria set out in the Directive and related documents described in the previous sections.

The waste produced by the extraction of minerals consists principally of naturally occurring materials, such as overburden, interburden (rock interbedded with the useful mineral) and the residues left after the initial processing of the extracted mineral to produce a saleable product. Extraction and processing waste thus consists essentially of:

a) Overburden and waste rock, including soil;

b) Fine-grained materials derived from mineral processing and separation techniques to remove unwanted material, such as unmineralised waste rock, silt and clay.

It is important to note that the waste material, although composed of the same mineral substances as the soil and solid rock from which it is derived, is not in the same physical condition. It may have been disaggregated, mixed and moved to a different location under different hydrological conditions. The surface area of the material will be increased by reducing the particle size and some dense minerals may concentrate in certain areas of settling ponds or lagoons. The material may also have been exposed to the atmosphere and to surface and/or groundwater. This can cause chemical and physical transformations, some of which may be detrimental to the environment.

In the past mine wastes were not subject to any regulation and may have been dumped on any convenient adjacent piece of land to the mine or quarry. These dumps may have been used at intervals, following the mine or quarry closure, as a convenient source of cheap aggregate or fill.

2.4.1 Approach for generic assessment of character of mine waste

The MWD Directive details the information required for the characterisation of waste for active mine waste facilities. A summary is provided below. This may guide the assessment and collection of data related to the closed mine waste facilities, as the aim of both is the same, i.e. prevention of major accidents and harm to human health and the environment.

Waste characterisation in accordance with Annex II of the MWD for active mine waste facilities requires that the waste to be deposited in a facility shall be characterised in such a way as to guarantee the long term physical and chemical stability of the structure of the facility and to prevent major accidents. Also "*The waste characterisation shall include, where appropriate and in accordance with the category of the waste facility, the following aspects:*

(1) description of expected physical and chemical characteristics of the waste to be deposited in the short and the long term, with particular reference to its stability under surface atmospheric/meteorological conditions, taking account of the type of mineral or minerals to be extracted and the nature of any overburden and/or gangue minerals that will be displaced in the course of the extractive operations;

(2) classification of the waste according to the relevant entry in Decision 2000/532/EC, with particular regard to its hazardous characteristics;

(3) description of the chemical substances to be used during treatment of the mineral resource and their stability;

(4) description of the method of deposition;

(5) waste transport system to be employed".

Details on Decision 2000/532/EC, the European Waste Catalogue (EWC 2002), to which Annex II (2) of the Directive refers for the classification of waste, are given in Appendix 4. The EWC 2002 lists waste materials according to generic industry, process or waste type using a six-digit code, ad example code 01 01 01 for "wastes from mineral metalliferous excavation" or code 01 03 04* for "acid-generating tailings from processing of sulphide ore". The asterisk (*) attached to the six-digit code is used to mark the waste as "hazardous waste". Appendix 4 also reports all the EWC codes used for wastes resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals. As a result of the EWC classification, mine waste can be attributed to the "hazardous waste" or "non hazardous waste" category. The non-hazardous waste category includes the "inert" class as defined in Article 3 (1) of the Directive.

The Colman et al. (2006) and Palumbo-Roe and Colman (2010) reports provide useful descriptions of the waste associated with active and former workings in terms of presence of inert or hazardous material (e.g. presence of sulphides, toxic metals, and dangerous substances) and a classification of the waste according to the relevant entry in Decision 2000/532/EC. To enable the current report to be read as a "stand alone" document, the "Waste characterisation" descriptions of the Palumbo-Roe and Colman (2010) report are reproduced in the following paragraphs (2.5 to 2.8) with modifications as necessary to be valid in Northern Ireland.

2.5 CONSTRUCTION MINERALS

2.5.1 Basalt

Mode of occurrence

Basalt is an igneous rock formed as a result of molten rock solidifying at the surface. Basalts of the Palaeogene (62-59 Ma) Antrim lava group are used as a general aggregate where they are quarried from lava flows up to 10 metres thick. High quality basalt for use in road and concrete aggregate is produced from several large quarries where care is taken to avoid extensively altered zones and the poorer quality tops and bottoms of lava flows.

There are approximately 380 surface basalt sites, of which 301 are closed (Figure 2).

Character of waste

The overall amount and character of waste varies widely between quarries. The two main waste products are very large oversize blocks and very fine undersize particles. The actual properties and amounts of these depend on the products of the individual quarry. The waste from all the workings is non-hazardous and likely to be inert.

2.5.2 Igneous and metamorphic

Mode of occurrence

A variety of different types of igneous rocks of various ages have been quarried as a source or aggregate. These include Palaeogene dolerite dykes (worked in Fermanagh and Armagh) and the Tyrone Igneous Complex which includes a wide range of plutonic, volcanic and volcanoclastic rock types which are worked as an aggregate resource.

Metamorphic rocks, having generally been derived from sedimentary rocks, tend to occupy larger areas, within which there may be selected sections, which posses the right characteristics for a particular product.

There are approximately 250 surface igneous and metamorphic sites of which 206 are closed (Figure 3).

Character of waste and classification

The overall amount and character of waste will vary widely between quarries. The two main waste products are very large oversize blocks and very fine undersize particles. The actual properties and amounts of these depend on the products of the individual quarry.

The waste from all the workings is non-hazardous and likely to be inert, with codes 01 04 10 - Dusty and powdery wastes other than those mentioned in 01 04 07, and 01 04 08 -Waste gravel and crushed rocks other than those mentioned in 01 04 07.

2.5.3 Sand and gravel

Mode of occurrence

Sand and gravel deposits are accumulations of the more durable rock fragments and mineral grains, which have been derived from the weathering and erosion of hard rocks mainly by glacial and river action. The sand and gravel is composed of durable particles and rich in silica (quartz, quartzite and flint).

Sand and gravel are defined on the basis of particle size rather than composition. In current commercial practice, following the introduction of the European standards in 2004 (BS EN 12620), the term ‘gravel’ (or more correctly coarse aggregate) is used to define particles between 4 and 80 mm, and the term ‘sand’ (or more correctly ‘fine aggregate’) for material that is finer than 4 mm, but coarser than 0.063 mm.

The principal uses of sand are as a fine aggregate in concrete, mortar and asphalt and the main use of gravel is as coarse aggregate in concrete. Substantial quantities of sand and gravel may also be used for constructional fill.

There are 782 sand and gravel sites in Northern Ireland of which 418 are closed (Figure 4), with only two sites working underground.

Character and amount of waste

Waste from working these deposits consists of a) overburden and b) ‘fines’ comprising clay and silt. The amount of waste produced varies considerably depending on the specific character of the site, but will range from a few per cent up to around 30% of the total material quarried. The fine material is stored in lagoons that are generally restored to some form of productive use by covering with soil.

Classification

The waste from the vast majority of sand and gravel facilities is non-hazardous and inert and can be classified to the EWC 2002 entry: 01 04 12- Tailings and other wastes from washing and cleaning of minerals other than those mentioned in 01 04 07 and 01 04 11.

2.5.4 Sandstone

Mode of occurrence

Sandstones are sedimentary rocks consisting of sand-sized particle composed predominantly of quartz. Sandstones and their metamorphic equivalents can be found across Northern Ireland. They vary widely across their distribution in both thickness and physical properties and thus in their end use. The sandstones and coarser gritstones are mostly used for crushed rock aggregates for example the Gala and Hawick Groups (Ordovician & Silurian). There are however, a number of important sources of building stone for example Early Carboniferous Sandstones of the Tyrone and Omagh groups including the thickly bedded Carland Sandstone Member and the Carrickaness Sandstone Formation. Both of which were widely used as freestone or dimension stone.

There are 447 surface sandstone and gritstone sites of which 325 are closed (Figure 5).

Classification of waste

Waste generally consists of overburden and oversize and undersize sandstone blocks and particles. Waste from all sites is non-hazardous and is likely to be inert, classified with codes 01 04 10 - Dusty and powdery wastes other than those mentioned in 01 04 07, and 01 04 08 - Waste gravel and crushed rocks other than those mentioned in 01 04 07.

2.6 INDUSTRIAL MINERALS

2.6.1 Barytes

Mode of occurrence

Barytes is frequently associated with base metal mineralisation, commonly occurring as gangue associated with the metallic mineral veins in the Dalradian (700-500 Ma) rocks of the Sperrin Mountains. It also occupies post-tectonic irregular tension gashes, joints and fractures in the Dalradian rocks, frequently in association with quartz and calcite. Barytes also occurs with quartz and calcite as a gangue mineral in many of the lead veins in the Silurian beds of the Longford-Down Lower Paleozoic massif which were mined in the 19th Century. Only one trial site has been identified where Barytes was worked underground as the main mineral (Figure 8).

Classification of waste

Waste associated with mining of baryte occurring as a gangue in metalliferous veins may be similar to the waste from metalliferous veins and therefore potentially containing hazardous substances.

2.6.2 Clay and Shale

Mode of occurrence

'Brick clay' is the term used to describe clay and shale used predominantly in the manufacture of bricks and to a lesser extent roof tiles and clay pipes. The suitability of the raw material depends principally upon its behaviour during shaping, drying and firing. There are a range of clays which have been worked in Northern Ireland including the Rossmore Mudstone Formation in Co. Tyrone and the Castle Espie Limestone Formation in Co. Down; both have been worked for brick manufacture.

The late Oligocene (28.4 – 23.0 Ma) Lough Neagh lignite-bearing clays occur in a belt around the western, southern and eastern shores of Lough Neagh. The clays are interbedded with up to 400 meters of flat lying or shallow dipping sands, silts and lignite within small fault-bounded basins.

Although the Lough Neagh clay deposits show similar qualities to ball clay, they are of variable quality. The clays consist of illite and kaolinite, with variable amounts of silica and iron. In the past they have been extensively worked to make coarse pottery and tiles. The presence of silica and iron means that without beneficiation Lough Neagh Clays are only suitable for production of coarse ceramic ware and modelling clay.

There are 139 clay and shale sites of which 122 are closed. The majority are surface workings with only one underground working identified (Figure 7).

Classification of waste

The waste consists of sand and lignite overburden and interburden, together with variable amounts of inferior quality clay and interbedded sand. Waste products from these operations are likely to be mainly inert and falling into the EWC category 01 01 02.

2.6.3 Chalk

Mode of occurrence

Chalk is a relatively soft, very fine grained white limestone consisting mainly of the debris of planktonic algae.

The late Cretaceous Ulster White Limestone Formation, which is exposed around the margins of the Antrim Plateau andhas been baked and recrystallised by the overlying plateau basalts, is an extremely hard, high purity product (>97% $CaCO_3$) which has been extensively worked in Counties Antrim and Londonderry for the manufacture of cement (and concrete), agricultural lime and white filler as well as limestone aggregates. It has also furnished building stone.

There are 136 chalk sites of which 131 are closed (Figure 9).

Classification of waste

The waste is mainly flint nodules, chalk fragments and clay. The waste is classified as inert with codes 01 04 08-Waste gravel and crushed rocks other than those mentioned in 01 04 07, and 01 04 09-Waste sand and clay.

2.6.4 Diatomite

Mode of occurrence

Diatomite or diatomaceous earth diatomite was deposited in freshwater lakes during the early post-glacial times and consists of microscopic siliceous skeletons of diatoms. Diatomite extraction in the Toomebridge area ceased in the early 1980s.

There were 9 surface sites, all of which are now closed (Figure 7).

Classification of waste

The waste associated to diatomite deposit mining and processing consists of overburden and waste resulting from the crushing and milling/drying processing of the diatomite and can be classified as 01 01 02 - Wastes from non metalliferous mineral excavation and 01 04 10 - Dusty and powdery wastes other than those mentioned in 01 04 07. We have no available data on the presence and nature of any waste in the sites in Northern Ireland. If waste is present, the primary pollutant of concern would be the particulate matter less than 10 μm (PM-10) from the processing. The presence and concentrations of trace elements potentially hazardous such as selenium, nickel, lead, chromium in this fraction should be evaluated.

2.6.5 Feldspar

Mode of occurrence

Feldspar veins were found within an area of metamorphic gneissose rocks in the north of Belleek and Castle Caldwell in Fermanagh. The feldspar occurs as the main component in irregular veins or dykes of pegmatite within the crystalline gneisses and in some cases penetrates some of the coarser quartz veins. Occurrences vary from 1 to 2 metres in thickness.

Where worked the veins have a definite hade (angle of inclination from vertical), resulting in workings of any depth requiring structural support or removal of overlying material. The feldspar in this area is high in potash and low in iron but varies from each locality. Material was worked to supply the needs of the local pottery and china clay works.

There are 9 known sites both surface and underground all of which are closed (Figure 8).

Classification of waste

Site specific information on the waste or the presence of a processing plant associated to each site is not available. Conventional open-pit mining methods include removal of overburden, drilling and blasting; a froth flotation process is used for most feldspar ore beneficiation. The associated waste generally consists of overburden/ sand/ any unsaleable product from the processing. Most of the waste would be used for backfilling of the open pit or underground voids. The waste can be considered substantially non-hazardous and inert.

2.6.6 Fireclay

Mode of occurrence

Fireclays are non-marine sedimentary mudstones that occur as ‘seatearths’ that underlie coal seams and consist essentially of the clay mineral kaolinite with varying proportions of hydrous mica (illite) and quartz together with impurities such as ironstone nodules and carbonaceous matter. Fireclays are typically thin (normally <1 m, although rarely >3m). Their composition is similar to ball clay but it is not as plastic and not light-firing.

In the past the uses of fireclay stemmed from its refractory nature, that is the ability to withstand high temperatures without deforming or becoming chemically unstable. These properties are dependent on the alumina content which is generally between 40 and 45 per cent. The value of the raw material depended on the content of alkalis, iron oxides and carbon. Traditionally these clays were used for the manufacture of fire bricks, crucibles, furnace lining and flue pipes. However, fireclays are now valued chiefly as a raw material for the manufacture of high-quality, weather-resistant, buff/cream-coloured facing bricks.

Fireclays occur almost exclusively in association with Carboniferous 'Coal Measures'. Fireclay was an important by-product of the coal industry and was formerly worked in the Ballycastle area of northern Co. Antrim and Coalisland area of Co. Tyrone in the manufacture of refractory bricks.

There are 45 sites (mainly records of shafts) where fireclay is the primary commodity all of which are closed (Figure 6).

Classification of waste

The waste consists of overburden, together with variable amounts of inferior quality clay and interbedded sand. Waste products from these operations are likely to be mainly inert and falling into the EWC category 01 01 02.

2.6.7 Kaolin

Mode of occurrence

White halloysite china clay is a weathering product of the igneous rocks (rhyolites) of the Tardee Rhyolite Complex of the Antrim Lava Group. The halloysite is admixed with quartz or cryptocrystalline silica and the clay has an average composition of 58% SiO_2, 26% Al_2O_3, 1.7% Fe_2O_3 and 0.7% TiO_2. Hallosite clay can be used to produce the highest quality tableware china including porcelain and bone china.

There are two closed sites known (Figure 7).

Classification of waste

The waste is considered to be inert and classified with a code 01 04 12 - Tailings and other wastes from washing and cleaning of minerals other than those mentioned in 01 04 07 and 01 04 11.

2.6.8 Limestone and dolomite

Mode of occurrence

Limestones are sedimentary carbonate rocks composed mainly of calcium carbonate ($CaCO_3$). With an increase in magnesium carbonate ($MgCO_3$) they grade into dolostone consisting mainly of the mineral dolomite [$CaMg(CO_3)_2$]. Limestones containing 5-10% dolomite are generally referred to as magnesian limestones; those with 10-50% dolomite are called dolomitic limestones.

Metalimestone is a limestone that has undergone metamorphism and when strongly recrystallised may be referred to as marble and dolomitic marble. Most limestones and dolostones are durable and, therefore, useful for building stones and general aggregates.

Limestones occur in three main stratigraphic divisions within Northern Ireland: the Late Neoproterozoic (630-590 Ma), Upper Paleozoic (359-251 Ma) and Late Mesozoic (85-70 Ma) eras.

The Late Neoproterozoic Dalradian Supergroup, and particularly the Argyll Group, that form the Sperrin Mountains in the northwest of the country contain units of metalimestones or marbles which are commonly interbedded with pelites and psammites. The metalimestone units are up to 100 metres thick and are locally quarried for aggregates and agricultural lime. They were formerly used for building stone and have dimension stone potential.

The most widespread and important limestone resource is of Carboniferous age. Limestones are represented in the Tyrone and Armagh groups but by far the most important of these is the Tyrone Group (345-340 Ma) which mainly comprises upper and lower limestone formations up to 400 metres thick separated by a clastic sedimentary succession. The limestones of the lower Ballyshannon Formation (200-345 metres thick) and upper Maydown Formation (160-300 metres thick) and its lateral equivalents in Co. Fermanagh are quarried for crushed rock aggregate, lime production and derivative pre-cast concrete products, building stone and constructional fill.

Bodies of dolomitised limestone with 27-43 per cent $MgCO_3$ occur within the Dartry Limestone Formation in Co. Fermanagh. This dolomite is locally worked for crushed rock aggregate and the production of lime.

Limestones and argillaceous limestones of the younger Armagh Group (340-333 Ma) are primarily used as a local source of crushed rock aggregate. Armagh Group limestone, which was formerly also used for building stone, is currently worked for a range of products including agricultural lime. The Rockdale Limestone Formation (100 metres thick) is worked for cement manufacture. The Kildress Limestone Member of the Derryloran Formation contains a workable unit of dolomitic limestone with a $MgCO_3$ content of 30 to 40 per cent.

The 'Magnesian Limestone' unit of the Belfast Group of Late Permian age (260-251 Ma), which crops out sporadically around the margins of the sedimentary basins beneath the Antrim plateau, contains resources of dolomitic limestone (average $MgCO_3$ content 36.6%).

The youngest limestones are a dense variety of Late Cretaceous (83.5-65.5 Ma) chalk which is the stratigraphic equivalent to the English Chalk Group. The Ulster White Limestone Formation which is exposed around the margins of the Antrim Plateau and has been baked and recrystallised by the overlying plateau basalts, is an extremely hard, high purity product (>97% $CaCO_3$) which worked for the manufacture of cement (and concrete), agricultural lime and white filler as well as aggregate.

There are 263 limestone sites (open workings) of which 217 are closed (Figure 9).

Classification of waste

The waste from the vast majority of limestone quarries can be classified as inert. The EWC 2002 codes are 01 04 10 - Dusty and powdery wastes other than those mentioned in 01 04 07, and 01 04 13 - Waste from stone cutting and sawing other than those mentioned in 01 04 07.

2.6.9 Perlite

Mode of occurrence

Perlite is the industrial name for felsic volcanic glass, with sufficient water content to cause it to expand when heated. The perlite, when fused froths up and forms an inert, lightweight and porous granular products with a wide range of uses in construction, insulation, packaging and agricultural industries. It forms part of the Tardee Rhyolite Complex (ca. 61 Ma) within the Palaeogene Antrim Lava Group, which was worked for perlite between 1952 and 1968. There are 8 former surface sites (Figure 3).

Character of waste

Site specific information on the presence of a processing plant associated to each site is not available. Crude perlite ore is mined, crushed, dried in a rotary dryer, ground, screened, and shipped to expansion plants. The associated waste, if any, can be classified as 01 01 02 - Wastes from non metalliferous mineral excavation and 01 04 10 - Dusty and powdery wastes other than those mentioned in 01 04 07. It is substantially non-hazardous and inert.

2.6.10 Porcellanite

Mode of occurrence

Porcellanite is a hard, dense close textured rock, similar to chert, with a conchoidal fracture containing clay and calcareous matter. Porcellanite was formed where a weathered inter-basaltic layer has been baked at high temperatures in contact with an igneous\extrusive sequence. Its use is limited to Neolithic stone axe production, and of the two known sources in Co. Antrim, north-east Ireland, the mainland site at Tievebulliagh has traditionally been considered the more important, with the site at Brockley on the offshore Rathlin Island seen as a minor source.

There are 2 known location both of which are closed (Figure 3).

Character of waste

Site specific information is not available. The waste products, if present, composed of the same mineral substances as the mineral deposit worked, are likely to be non-hazardous and inert.

2.6.11 Salt

Mode of occurrence

Salt (sodium chloride: NaCl), formed by evaporation of shallow hypersaline water bodies, occurs in nature in solid form as rock salt (halite) or in solution as brine. It is mainly used for de-icing roads, as a flavour enhancer/preserver, an additive for animal feeds and as a basic feedstock for the inorganic chemical industry.

Rock salt forms beds of variable thickness within the Triassic age (248–205 Ma) Mercia Mudstone Group which crops out predominantly around the periphery of the Antrim Plateau, with salt-bearing strata extending from Carrickfergus to Larne, in the south-east corner of Co. Antrim. The Triassic salt is thickest in the Larne area (three seams with an aggregate thickness of 400 metres) adjacent to the Six Mile Water Fault and thins south to the Carrickfergus area (40 metres). In the Carrickfergus salt field the salt beds have been exploited continuously for about 150 years.

There are 31 salt sites (shaft entries) of which 24 are closed. All the salt workings are underground (Figure 8).

Classification of waste

Mining of rock salt and subsequent processing, which involves crushing and treating the salt to keep it free-flowing, does not produce any waste. The brine produced by brine pumping requires purification before it can be used either as a chemical feedstock or for the production of white salt by an evaporation process. The purification process involves precipitating out calcium sulphate, magnesium hydroxide and calcium carbonate. These insoluble wastes are disposed of into worked out salt cavities.

The waste if any is classified as non-hazardous non-inert with the entry 01 04 11 - Wastes from potash and rock salt processing other than those mentioned in 01 04 07.

2.6.12 Silica Sand

Mode of occurrence

Silica (industrial) sands contain more than 95% silica (SiO_2) in the form of quartz and are used for purposes other than as construction aggregate. They are essential raw materials for the glass and foundry castings industries, but also have a wide range of other industrial applications. This includes ceramic and chemical manufacture, for water filtration media and in sport and horticulture. Silica sands are produced from loosely consolidated sand deposits and by crushing weakly cemented sandstones.

There are no known superficial deposits of silica sand in Northern Ireland but there are poorly consolidated bedrock sandstone resources that have been worked. These include silica sandstones of Carboniferous age (330–300 Ma) that were formerly worked for glass manufacture in north Co. Antrim, and the Triassic age (250–200 Ma) Sherwood Sandstone Group which was worked in the Lagan Valley for use as moulding sand. There are 2 known former silica sand sites (Figure 4).

Character of waste

Site specific information is not available. The associated waste, if present, generally consists of fine sand, with a silt or clay fraction and any unsaleable product which is disposed in heaps. It is non-hazardous and inert.

2.6.13 Slate

Mode of occurrence

Slate is a very fine grained sedimentary or volcanic rock, which has been altered by heat and pressure (metamorphism) to produce a slaty cleavage, whereby it splits easily along a particular direction. It is used for roofing and, increasingly, slate powder is used as a filler and insulating material.

Metamorphic rocks of the Dalradian Supergroup that have been widely worked for local building stone include pelites (slates). Within the Southern Highland Group the Ballykelly Formation pelites and Londonderry Formation pelites have been worked for building stone and roofing slates. Other examples include slates extracted from interbedded mudstone units in the Gala Group (e.g. the Tullykevin Formation).

There are 39 former surface slate sites (Figure 3).

Classification

The composition of the waste is essentially the same as the slate produced which is valued for its durability and resistance to weathering. It is inert and classified mainly as 01 01 02 - Wastes from mineral non-metalliferous excavation and, also, as 01 04 13 - Waste from stone cutting and sawing other than those mentioned in 01 04 07.

2.7 ENERGY MINERALS

2.7.1 Coal

Mode of occurrence

Coal (‘black coals’ or ‘hard coals’) and lignite (‘brown coal’) are fossil fuels derived from dead plant material which has been transformed by burial and compression at elevated temperatures over a long period of time into combustible sedimentary rocks.

Coal consists of ‘macerals’ (organic equivalent of minerals), minerals and water. The organic matter is sequentially altered by the process of ‘coalification’ resulting in an increase in carbon content through ‘brown coal’ (lignite and sub-bituminous) to ‘black coal’ (sub-bituminous to bituminous coal). A coal seam (layer) is formed by the alteration of dead plant material which is consolidated between other sedimentary rocks, notably fireclay, mudstone, siltstone and sandstone. As a result of subsequent faulting and folding of the coal-bearing strata, coal seams occur at varying depths from the surface.

Northern Ireland has some very restricted resources of ‘black coals’. All onshore coal resources in Northern Ireland occur in rocks of Late Carboniferous age (330 – 300 Ma) and the main strata containing coal seams at fairly regular intervals are referred to as ‘Coal Measures’.

Coal seams vary in thickness from a few centimetres up to rarely 2.6 metres. The Coalisland and Annaghone coalfields in Co. Tyrone and the Ballycastle coalfield in Co. Antrim comprise the coalfields in Northern Ireland. The Coalisland and Annaghone coalfields are largely worked out.

There are 843 coal sites (mainly shafts record entry type) all of which are closed; three sites were surface workings (Figure 6). 307 of those sites have a flagged hazard in the GSNI record.

Classification of waste

The waste mainly consists of clay, shale and sandstone, rocks composed of mostly inert silicate minerals. However, there is usually up to 2 or 3 % pyrite within the coal and some of this will occur in the waste.

Due to the ubiquitous presence of pyrite (FeS_2) any coal waste tips may generate acid drainage, though the amount will vary with local conditions and the original concentration of pyrite within the tip. The waste is classified according to the EWC 2002 codes as 01 04 07* - Waste containing dangerous substances from physical and chemical processing of non metalliferous minerals with a hazardous mirror entry. However, the risk posed by individual tips cannot be determined due to the lack of detailed information on the chemistry and the interaction of the tips with the environment.

2.7.2 Lignite

Mode of occurrence

Extensive deposits of lignite (or brown coal) occur within the Oligocene Lough Neagh Group (28-23 Ma) where individual beds range to tens of metres thick within a succession up to 400 metres thick of sandy clays and silts. Lignite beds are flat lying or shallow dipping within small fault-bounded basins.

Lignite bearing sediments occur in around and beneath Lough Neagh with lignite deposits found near Crumlin, Co. Antrim and Stewartstown and Coagh in Co. Tyrone. Individual beds of lignite are up to 43 metres thick. Around Lough Neagh this group occurs across an area of 500 km^2, of which about 300 km^2 occur below the Lough. The largest deposits of lignite, however, are found in the Ballymoney basin on the north side of the Tow Valley Fault within northwest Co. Antrim. Within the Ballymoney succession lignite seams locally form a workable thickness up to 100 metres.

There are 28 sites all of which are closed, only one site was an opencast working (Figure 6). Eight of those sites have a flagged hazard in the GSNI record.

Classification of waste

As with coal waste, the same considerations should be applied to the waste associated with lignite mining, therefore classified as as 01 04 07* - Waste containing dangerous substances from physical and chemical processing of non metalliferous minerals with a hazardous mirror entry.

2.8 METALLIC MINERALS

2.8.1 Copper and lead

Disseminated and vein-hosted copper, lead and zinc occurrences are found throughout the Dalradian metamorphic rocks. Shear zone-associated quartz-calcite vein mineralisation, containing lead and copper with the potential for associated gold and silver occurs in the Argyll Group of the Dalradian metamorphic basement (e.g. Milltown Cu-Pb mine). Stratabound mineralisation (up to 9.8 per cent zinc and 2.9 per cent lead over one metre intervals) has been reported at Glenlark in Co. Tyrone, and to the north other Dalradian formations have the potential to host stratabound lead-zinc mineralisation. Baryte is frequently associated with base metal mineralisation, commonly occurring as gangue associated with the metallic mineral veins in the Dalradian rocks of the Sperrin Mountains. It also occupies post-tectonic irregular tension gashes, joints and fractures in the Dalradian rocks, frequently in association with quartz and calcite.

The Tyrone Igneous Complex, and most notably the Tyrone Volcanic Group, is host to copper, lead and zinc (± gold) vein mineralisation. Geochemical base metal anomalies associated with siliceous (jaspilitic) ironstones and iron-rich chert of probable exhalative origin within the Tyrone Volcanic Group indicate potential for volcanogenic massive sulphide mineralisation.

Lead-zinc-copper occurrences are scattered throughout the Lower Palaeozoic rocks of the Southern Uplands-Down-Longford Terrane. The mineralisation occurs in vertical veins and breccia zones of variable orientation in association with quartz, calcite and baryte. The Conlig-Whitespots Mines were worked intermittently from at least 1780 until 1899.

In the South Armagh-Monaghan Mining District a few veins were worked on a relatively large scale by the standards of the 1800s.

The geological environment of Lower Carboniferous (about 320 million years ago) shallow water sediments, in close proximity to a basin margin fault is analogous to sites of mineralisation in the major lead-zinc orefield of the Irish Midlands. Extensive exploration has taken place in southwest Northern Ireland, and particularly the Clogher Valley area, with the focus on identifying this style of carbonate-hosted base metal mineralisation. Extensive sub-economic mineralisation occurs at two main levels in the succession: (i) the basal dolomitic rocks as disseminations and breccia infillings, and (ii) thickly bedded limestones. Mineralisation also occurs, but to a lesser extent, in sandstones and siltstones as occasional patches within thin calcite veins and along joint planes. Copper and lead have been worked historically on a small scale.

There are 15 former copper sites and 107 former lead sites (including both open and underground workings (Figure 12). 49 of all sites have a flagged physical hazard in the GSNI record.

Classification of waste

The chemical hazard represented by the mine waste associated with metalliferous deposits is dependent on the sulphide mineral content and related acid mine drainage potential together with the presence of harmful elements. A conservative assessment is to classify the waste as potentially hazardous waste (01 03 wastes from physical and chemical processing of metalliferous minerals).

2.8.2 Iron ore and aluminium (bauxite)

Historically, by far the most important occurrences of iron and aluminium that have been worked are hosted within the Antrim Lava Group. Lateritic iron and bauxite or bauxitic clay (the principal ore of aluminium) occurrences are associated with either the Port Na Spaniagh Member or the Ballylagan Member of the Interbasaltic Formation. Lateritic iron ores along with bauxite or aluminous laterite are sub horizontal strata bound deposits formed by alteration and chemical weathering of basalt lava of the Antrim Lava Group. The iron-rich laterite also contains up to 5 per cent titanium dioxide.

The iron ore beds commonly comprise a thin (ca. 30 cm) higher grade layer, the ‘pisolitic ore’, overlying a thicker and lower grade ‘pavement’ (up to 2 metres). The higher grade ore is 30–60 per cent total iron oxides, while the lower grade ore is about 25 per cent iron oxides. The deposits were worked in open-cast or room-and-pillar underground operations. Antrim iron ore was extensively worked from at least the 18th Century up to the 1920s.

The bauxite is a residual clay deposit comprising a mixture of kaolin, gibbsite (aluminium hydroxide) and boehmite (aluminium oxide hydroxide), with variable proportions of quartz, iron oxides and minor titanium minerals. The bauxite is more restricted in distribution than the iron-rich laterite. The bauxite is variable in thickness (average 90 centimetres) and in composition with some very high grades (over 60 per cent aluminium oxide) reported. Bauxite containing in excess of 50 per cent aluminium oxide with low silica and iron would generally be considered metallurgical grade.

A wide range of sub-ore grades are also recorded including ‘lithomarge’ (kaolinised basalt), ferruginous red bauxite with 20–30 per cent iron oxide, and siliceous grey bauxite in which iron oxide seldom reaches 10 per cent, but silica frequently exceeds 20 per cent. Bauxite was discovered and first mined in Antrim about 1870. Production continued until about 1934 in association with the much larger iron ore mining industry.

Late Carboniferous strata bound or bedded ironstones with an iron content of 21–35 per cent were worked in the nineteenth century. Clay ironstone bands and nodules occur within the Namurian shales and are associated with hard coals, shales and fireclays of the Coal Measures Ore thicknesses were in the range 60-75 centimetres. The so-called ‘blackband ironstone’, a variety of clay-rich sideritic ironstone associated with the coal, generally contains sufficient carbonaceous matter to make it self-calcining (without the addition of extra fuel).

Bog iron, formed when acid water leaches iron oxides from boulder clay and deposits iron as a thin crust within the soil profile, was extensively worked in the last century.

There are 317 aluminium (bauxite) sites (Figure 10) and 495 iron ore sites (Figure 11), both opencast and underground, all of which are closed. 49 of all sites have a flagged physical hazard in the GSNI record.

Classification of waste

At this stage information on the composition of both iron and bauxite ore in terms of potentially harmful elements and on the nature of the waste (tailings or waste rocks) associated with historical mining of these deposits is not available for review. If present, red mud, the waste from bauxite ore processing, would represent the main hazard as it is highly caustic and may contain hazardous substances. Using a precautionary approach, all sites are classified as potentially hazardous (01 03 07* other wastes containing dangerous substances from physical and chemical processing of metalliferous minerals and 01 03 09 red mud from alumina production other than the wastes mentioned in 01 03 07).

3 Summary of findings and overall progress

Phase 1 of the project comprised two steps: i) data collection and ii) categorisation of closed mine waste facilities in Northern Ireland.

Data Collection

Data Source

The GNSI Abandoned Mines Database of Northern Ireland (~1,700 records of mine shafts and adits) and the BGS BRITPITS database of Mines and Quarries (~2,100 records of closed mineral sites in Northern Ireland), the two main sources of data, were subject to a preliminary screening for inclusion in the inventory of closed mine waste facility in Northern Ireland as required by Article 20 of the MWD.

Data Limitation

The data collated refer to sites defined as "location of mining or quarrying activity; the site may be a surface quarry, the location of an underground shaft or adit or a mine spoil or a tailings lagoon". Consequently, a record does not necessarily constitute proof of the existence of a mine waste facility, i.e. an area designated for the accumulation or deposit of extractive waste.

During the compilation of source data, available information on the presence of waste tips has been gathered from a range of sources, including field slips and the 1: 10 000 scale digital geological map artificial ground layer, however this data does not provide comprehensive coverage.

Furthermore, it is important to note that existing catalogues include references to individual mine entrances or workings rather than a centroid or single point location to represent a mine location; this will result in over estimation of the number of workings.

These issues, where possible, will be addressed during Phase 2 of the project.

Categorisation

Of the 3686 entries, 1971 are surface, 1705 underground and 10 are described as both surface and underground workings; 1248 are construction mineral sites, 633 industrial mineral sites, 871 are energy mineral sites, and 934 are metallic mineral sites (see Table 2). Guided by the relevant criteria set out in the MWD directive and related documents, and informed by a similar assessment carried out in England and Wales, we consider the majority of the closed waste facilities in Northern Ireland to contain non-hazardous waste and substantially inert; providing there is no evidence of physical instability, they should not be included in the inventory. Exceptions comprise the waste associated with coal/lignite, metal base and iron and bauxite mines, which should be further assessed in a more quantitative manner.

On this basis, of the 3586 entries, a selection of 1806 (bauxite, copper, iron ore, lead, coal, lignite and barytes) will be subjected to the geochemical assessment in Phase 2 of the project.

The current assessment does not address physical stability of closed mine waste facilities. Physical hazards associated with a mine site are principally safety hazards and ground instability related to mine workings, buildings and processing areas. As such the physical hazards are likely to include: shafts, adits and open stopes; unstable buildings; unstable ground; tanks, channels and ponds containing water.

In the past, before the advent of more effective and efficient tipping procedures and coal preparation plants, many coal tips contained enough fine coal and oxidising pyrite that they commonly caught fire, releasing large amounts of smoke into the environment. Gathering this type of information is outside the remit of the project. Therefore, the physical stability assessment, which forms integral part of the assessment for the classification of closed waste facilities, is not considered in this study. Sources of this information should be accessible through local authorities. Should any data that relate to evidence of harm to human health, instability and combustion associated to a known closed mine waste facility become available, the site should be included in the inventory.

The next step of Phase 2 is now commencing. In a GIS platform we will compare the locations of sites selected in Phase 1 with existing chemical analyses of stream waters and sediments. The objective is to identify potential inventory sites by spatially linking water and/or sediment data that exceeded specified chemical quality assessment criteria with the mining location. During this phase we will also address the evidenced issue of multiple entries per mine by following up the work undertaken by GSNI to ‘group’ associated records based on an individual mine name.

Appendix 1 "Guidance document for a risk-based pre-selection protocol for the inventory of closed waste facilities as required by Article 20 of the Directive 2006/21/EC", European Commission 2011

The European Commission "Guidance document for a risk-based pre-selection protocol for the inventory of closed waste facilities as required by Article 20 of the Directive 2006/21/EC" provides guidance to Member States on the methodology to use to produce a precautionary list of waste facilities that would be candidate sites for the inclusion in the inventory. The inventory should be risk-based, i.e. consider the probability of an event occurring and the impact of such an occurrence. It should address the Source, Pathway and Receptor components. The guidance protocol is presented as a flowchart and includes four sections: 1. Any known serious impacts; 2. Sources; 3. Pathways; and 4. Receptors (Figure 13). For Section 1 there are two possible answers – either YES or NO. If YES then the waste facility under question is immediately assigned to the EXAMINE FURTHER endpoint, while if NO is the answer the assessor is directed to Sections 2, 3 and 4 of the protocol. Then, for each further section, there are three possible answers – YES, NO or UNKNOWN, which will bring the assessor an end result, to classify the waste facility as either to EXAMINE FURTHER (if there is at least a YES or UNKNOWN answer) or NO NEED TO EXAMINE FURTHER (if all the answer in a section are NO). In the NO NEED TO EXAMINE FURTHER class the waste facility is excluded from any further consideration, while the EXAMINE FURTHER class implies that the waste facility should be examined further to determine if it meets the criteria for inclusion in the inventory.

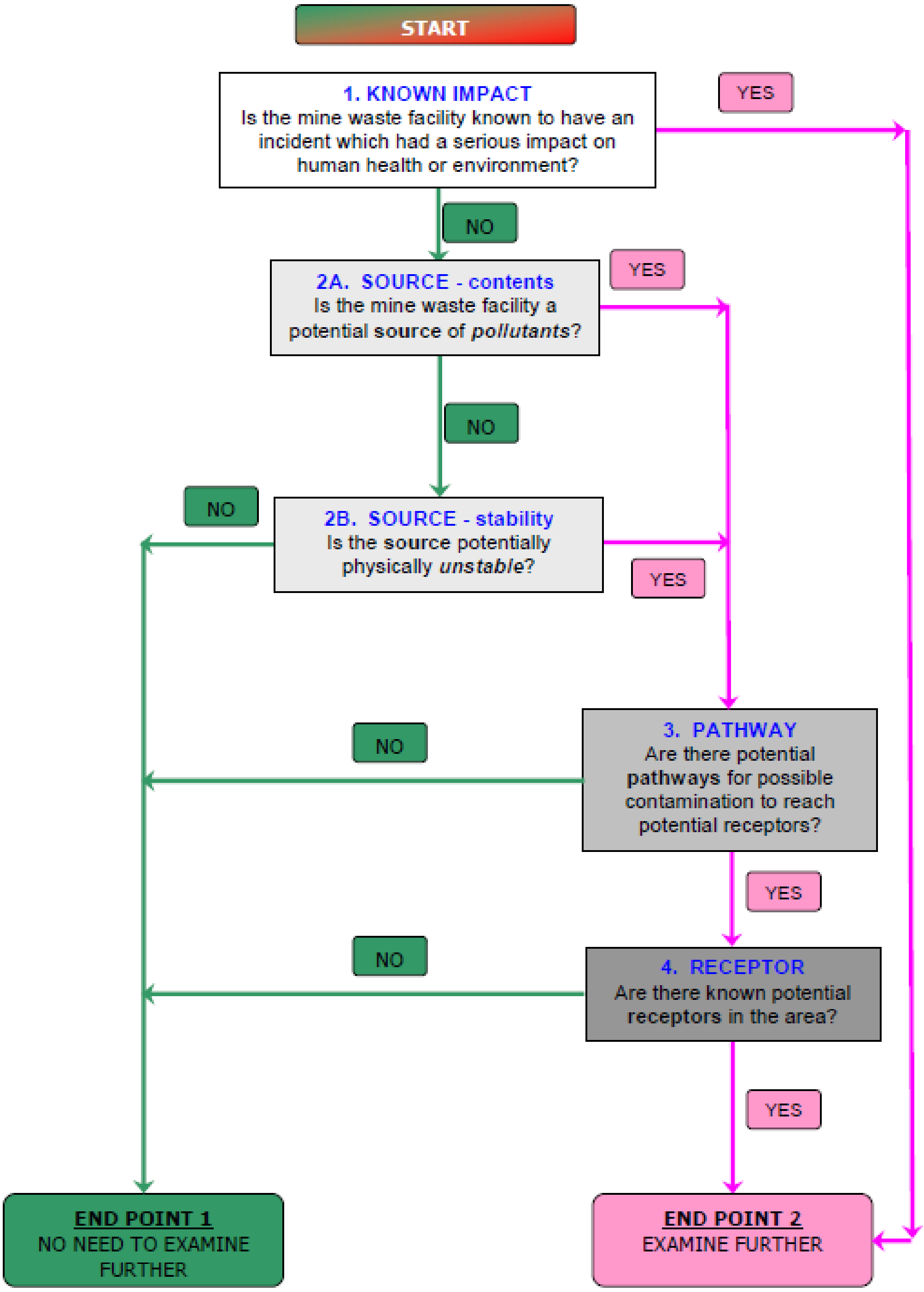

Figure 13 Annex I Pre-selection protocol flowchart from European Commission (2011)

Appendix 2 Environment Agency criteria for assessing serious environmental impacts

Hazard	Magnitude
Water pollution	Site causes failure of Environmental Quality Standard (EQS[1]) in surface water over a distance of more than 500 metres, or Site causes pollution of groundwater extending more than 50 metres in a principal aquifer or 250 metres in a secondary aquifer
Contaminated land	Site determined as "contaminated land" for Part 2A due to "significant harm" or "significant possibility of significant harm" to defined receptors: Human health Ecology Buildings, services, crops Livestock, pets, wild animals
Instability	Stability risk assessment or inspection has indicated a risk of instability and receptors present
Particulates	Site causes local air quality to fail to meet Air Quality Objective for PM[2]2.5 or PM10
Suspended solids	Site causes surface water to fail to achieve "good ecological status" due to suspended solids
Fire	Combustion of wastes identified within the past 10 years and not permanently remediated, and any of following receptors present: Human health Ecology Buildings, services, crops Livestock, pets, wild animals

Source EA 2012

[1] EQS defined by UK or EU legislation. Values used: cadmium = 0.08 - 0.25 µg/l (hardness-related); copper = 1 - 28 µg/l (hardness-related); iron = 1,000 µg/l; lead = 7.2 µg/l; zinc = 0.08 - 0.25 µg/l (hardness-related); dissolved concentrations except for zinc.

[2] PMX = particulate matter which passes through a size-selective inlet at X µm aerodynamic diameter

Appendix 3 Summary of number of sites by commodity and secondary commodities produced

Commodity	Other commodities worked	No. of sites
CONSTRUCTION MINERALS		
Basalt		**301**
	Basalt	272
	Basalt, Chalk	27
	Basalt, Clay & Shale	3
	Basalt, Sand & Gravel	1
	Basalt, Schist	1
Igneous and Metamorphic		**206**
	Igneous & Metamorphic Rock	147
	Igneous & Metamorphic Rock, Schist	1
	Schist	56
	Schist, Clay & Shale	1
	Schist, Slate	1
Sand and Gravel		**418**
	Sand & Gravel	336
	Sand and Gravel	1
	Sand	78
	Gravel	1
Sandstone		**325**
	Sandstone	194
	Gritstone	129
	Gritstone, Igneous & Metamorphic Rock	1
	Gritstone, Schist	1
ENERGY MINERALS		
Coal (all types)		**843**
Underground		**840**
Opencast		**3**
	Coal	25

Commodity	Other commodities worked	No. of sites
	Coal, Bauxite	1
	Coal, Deep or Clay	2
	Coal, Deep	793
	Coal, Deep, Fireclay	13
	Coal, Deep, Iron Ore	1
	Coal, Deep, Ironstone	3
	Coal, Iron Ore, Sulphur	1
	Coal, Salt	1
	Coal, Surface Mined	2
	Coal, Opencast	1
Lignite		28
	Lignite	26
	Lignite, Bauxite	2
INDUSTRIAL MINERALS		
Barytes		**1**
Chalk		**131**
	Chalk	113
	Chalk, Flint	1
	Chalk, Sandstone	1
Clay		**122**
	Clay & Shale	113
	Clay & Shale, Fireclay	3
	Clay & Shale, Gypsum	4
	Clay & Shale, Limestone	1
	Clay, Coal, Deep	1
Diatomite		**9**
Dolomite		**1**
Feldspar		**9**
	Feldspar	8
	Feldspar, Copper, Iron Ore	1
Fireclay		**45**
	Fireclay	43
	Fireclay, Coal, Deep	2
Kaolin		**2**
	Kaolin, Feldspar	2

Commodity	Other commodities worked	No. of sites
Limestone		**217**
	Limestone	211
	Limestone, Sandstone	5
	Limestone, Schist	1
Peat		**20**
Perlite		**8**
Porcellanite		**2**
Salt		**24**
Silica Sand		**2**
Slate		**39**
METALLIFEROUS MINERALS		
Bauxite		**317**
	Bauxite	107
	Bauxite, Fireclay, Iron Ore	2
	Bauxite, Iron Ore	164
	Bauxite, Lateritic Iron Ore	35
	Bauxite, Lateritic Iron Ore, Lignite	4
	Bauxite, Lignite	5
Copper		**15**
	Copper	11
	Copper, Iron Ore	1
	Copper, Iron Pyrites	1
	Copper, Lead	2
Iron Ore		**495**
	Hematite (Iron Ore)	5
	Iron Ore	408
	Iron Ore, Bauxite	50
	Iron Ore, Bauxite, Coal	1
	Iron Ore, Coal, Deep	2
	Iron Ore, Lignite	9
	Iron Pyrites, Lead	1
	Ironstone	7
	Ironstone, Coal, Deep	3
	Lateritic Iron Ore	5
	Lateritic Iron Ore, Bauxite	1
	Lateritic Iron Ore, Fireclay, Lignite	3

Commodity	Other commodities worked	No. of sites
Lead		**107**
	Lead	102
	Lead, Copper	1
	Lead, Iron Pyrites	4

Appendix 4 Decision 2000/532/EC, the European Waste Catalogue (EWC 2002)

The EWC 2002 defines wastes according to their known hazard characteristics, any waste whose six-digit code is marked with an asterisk (*) is a hazardous waste; however, there are two types of hazardous waste entries in the catalogue:

i) “Absolute entries”: those entries with an asterisk (*) and without a specific or general reference to “dangerous substances”. Wastes covered under these entries are hazardous waste regardless of the concentration of any “dangerous substance” within the waste.

ii) “Mirror entries”: those entries with an asterisk (*) and with a specific or general reference to “dangerous substances”, which are generally identified by the word “containing” in the description. These “mirror entries” cover wastes that have the potential to be either hazardous or nonhazardous depending on their actual composition and the concentrations of “dangerous substances” within the waste.

For the purpose of EWC 2002 *‘dangerous substance’ means any substance that has been or will be classified as dangerous in Directive 67/548/EEC and its subsequent amendments*; *‘heavy metal’ means any compound of antimony, arsenic, cadmium, chromium(VI), copper, lead, mercury, nickel, selenium, tellurium, thallium and tin, as well as these materials in metallic form, as far as these are classified as dangerous substances* (Decision 2000/532/EC, Annex, point 5). Decision 2000/532/EC also states that *if a waste is identified as hazardous by a specific or general reference to dangerous substances, the waste is hazardous only if the concentrations of those substances are such (i.e. percentage by weight) that the waste presents one or more of the properties listed in Annex III to Council Directive 91/689/EEC*.

Among the constituents of the wastes which render them hazardous, “heavy metals “, inorganic sulphides, inorganic fluorine compounds excluding calcium fluoride (the Fluorite mineral), inorganic cyanides, acidic solutions, basic solutions, phosphorus compounds excluding mineral phosphates are of relevance for the extractive industry.

In the EWC only “acid-generating tailings from processing of sulphide ore” with the code 01 03 04* is classified as absolute hazardous waste, regardless of any threshold concentrations. Other tailings (code 01 03 05*) or waste (code 01 03 07*) containing dangerous substances from physical and chemical processing of metalliferous minerals, or wastes (code 01 04 07*) containing dangerous substances from physical and chemical processing of non-metalliferous minerals have mirror entries and are classified as hazardous waste if dangerous substances are present above threshold concentrations.

The EWC 2002 codes for wastes from the extractive industry are reported in Table 3.

Table 3 The EWC 2002 codes for wastes from the extractive industry EWC CODE 01 - Wastes Resulting from Exploration, Mining, Quarrying, and Physical and Chemical Treatment of Minerals

01 01 wastes from mineral excavation

01 01 01 wastes from mineral metalliferous excavation

01 01 02 wastes from mineral non-metalliferous excavation

01 03 wastes from physical and chemical processing of metalliferous minerals

01 03 04* acid-generating tailings from processing of sulphide ore

01 03 05* other tailings containing dangerous substances

01 03 06 tailings other than those mentioned in 01 03 04 and 01 03 05

01 03 07* other wastes containing dangerous substances from physical and chemical processing of metalliferous minerals

01 03 08 dusty and powdery wastes other than those mentioned in 01 03 07

01 03 09 red mud from alumina production other than the wastes mentioned in 01 03 07

01 03 99 wastes not otherwise specified

01 04 wastes from physical and chemical processing of non-metalliferous minerals

01 04 07* wastes containing dangerous substances from physical and chemical processing of non-metalliferous minerals

01 04 08 waste gravel and crushed rocks other than those mentioned in 01 04 07

01 04 09 waste sand and clays

01 04 10 dusty and powdery wastes other than those mentioned in 01 04 07

01 04 11 wastes from potash and rock salt processing other than those mentioned in 01 04 07

01 04 12 tailings and other wastes from washing and cleaning of minerals other than those mentioned in 01 04 07 and 01 04 11

01 04 13 wastes from stone cutting and sawing other than those mentioned in 01 04 07

01 04 99 wastes not otherwise specified

01 05 drilling muds and other drilling wastes

01 05 04 freshwater drilling muds and wastes

01 05 05* oil-containing drilling muds and wastes 01 05 06* drilling muds and other drilling wastes containing dangerous substances

01 05 07 barite-containing drilling muds and wastes other than those mentioned in 01 05 05 and 01 05 06

01 05 08 chloride-containing drilling muds and wastes other than those mentioned in 01 05 05 and 01 05 06

01 05 99 wastes not otherwise specified.

Glossary

Site	Location of mining or quarrying activity. May be a surface quarry or the location of an underground shaft or adit.
Superficial deposit	Deposits formed on or close to the present land surface by processes (e.g. glaciation) usually of Quaternary age. Their distribution and thickness are related essentially to surface relief and not the structure of the underlying bedrock.
Waste facility	Any area designated for the accumulation or deposit of extractive waste.

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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: http://geolib.bgs.ac.uk.

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