

CONSIDERATION OF SUBSIDENCE IN LAND USE PLANNING POLICIES AND PROCEDURES IN  
ENGLAND<sup>1</sup>

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Abstract. A widespread potential for subsidence requires consideration within a planning system which aims to control development in the public interest. A research strategy involving review at the national level of causes of subsidence followed by specific studies to develop techniques for use by planners provides the basis for planning guidance on the development of unstable land. This is now being taken forward with specific respect to subsidence to enable proper consideration in development plans and in considering applications for planning permission.

Introduction

England has a long history of mining dating from prehistoric times, although the principal period of activity was from the late 18th to the middle of the 20th century. Natural underground cavities due to dissolution of soluble rocks (chalk, limestone, gypsum, halite) are also widely distributed. In consequence there is a widespread potential for subsidence which may pose a threat to public safety and to property and land use.

When events occur, sub-editors have a field day with headlines such as:-

- "Crater fright for family" (Hitchen & Stewart 1995)
- "Falling apart at the coal seams" (Prior 1989)
- "Mine of information needed as homes face collapse" (Porter 1992)

Such events often represent a historical legacy of the time when little was known about the potential for subsidence and there was little, if any, control over the location of development. There are, however, a number of examples

where recent development has been affected by subsidence. If the developer and those controlling development had taken account of the potential for subsidence most of these events could have been avoided. Whilst recognising that the responsibility for safe development and secure occupancy of a site rests with the developer and the landowner, we need to look at existing controls over development, how they have been exercised in practice and the improvements that can be made.

Controls on Development

The main controls over development and land use in England are through the operation of the planning system and the building regulations.

The Planning System

The legislation is now contained in the Town and Country Planning Act 1990, as amended by subsequent acts. The fundamental requirement is that development may not be undertaken without planning permission.

Development is defined in the 1990

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Act as :- "The carrying out of building, engineering, mining or other operations in, on, over or under land, or the making of any material change in the use of any buildings or other land." However, certain works and uses do not constitute development (eg the use of land for the purpose of agriculture or forestry) and the Town and Country Planning General Permitted Development Order 1995 gives general permission in advance for certain defined classes of development, mainly of a minor character (eg small extensions and alterations to dwelling houses).

Subject to these exceptions, specific planning permission is required for development upon application to the local planning authority (lpa). The Secretary of State for the Environment (SoS) has call-in powers to require in exceptional circumstances that applications be referred to the SoS for decision and aggrieved applicants may appeal to the SoS against the lpa's decision, ie against refusal of permission, against conditions imposed on the grant of permission or against failure to determine an application. There is no provision for appeal by other parties, though decisions may be challenged in the courts on legal grounds.

The lpa's decision on an application must "have regard to the provisions of the development plan, so far as material to the application, and to any other material consideration." Other material considerations are not defined and they can cover a wide field. They must, however, be genuine planning considerations, ie they must relate directly to the physical development and use of land. Permission may be granted subject to such conditions as the lpa or the SoS think fit, provided that they are necessary, relevant to planning, relevant to the development to be permitted, enforceable, precise and reasonable in all other respects. There is a presumption in favour of allowing applications for development, having regard to all material considerations,

unless the development would cause demonstrable harm to interests of acknowledged importance. A developer is not required to prove the case for the development proposed and, if the lpa consider it necessary to refuse permission or to impose conditions, the onus is on them to give reasons for permission being refused or conditions imposed.

Development plans, as prescribed by the Acts, provide the framework for the control of development. They are intended to provide a firm basis for rational and consistent decisions on planning applications and a means of coordinating the needs of development and the interests of conservation. Where the development plan is material to a development proposal, the Planning and Compensation Act 1991 requires an application or appeal to be determined in accordance with the plan unless material considerations indicate otherwise. The system is thus essentially plan-led.

Structure Plans and Part I of Unitary Development Plans (UDPs) provide the broad strategic framework based on a written statement which may be accompanied by diagrams. Local Plans and Part II of UDPs are more specific, develop the strategic policies in the local context and contain land-use proposals which are map-based. Development plans are mandatory and are required to be consistent with national planning policies, with any regional planning guidance issued by the SoS and with each other.

#### The Building Regulations

The Building Regulations 1991, made under the Building Act 1984, provide an additional means of controlling built development. They are concerned primarily with the safe construction of a building and the provision of services to and from it so as to secure "the health, safety, welfare and convenience

of persons in and about the building." The regulations apply to building work in general, control of services and fittings and material change of use. However, there are exemptions such as greenhouses and agricultural buildings, temporary buildings, some small detached buildings and extensions.

The building regulations authority has a duty to see that building work complies with the regulations. If the work fails to comply, the developer may be required to alter or remove it. However, the submission of detailed plans for checking of compliance with the approved document is not compulsory and works may commence two days after the submission of a building notice.

#### Relevance of planning and building regulations to subsidence

Subsidence is not specifically mentioned in the Town and Country Planning Acts. It is clear, however, that planning matters are related to the physical development and use of land. This relates to the content of development plans, to decisions in individual cases and to the imposition of planning conditions.

The preparation of development plans requires lpas to undertake a survey of their area which must include "a review of the principal physical characteristics of the area" and the plan must contain statements on "measures for the improvement of the physical environment." In principle, there is as much justification for including policies on subsidence as a material planning consideration as there is to include other commonly accepted planning constraints such as Sites of Special Scientific Interest, Ancient Monuments, areas of high landscape value or high quality agricultural land.

Similarly, the physical characteristics of a site are relevant to the development and use of that site

and can be considered as material considerations when deciding a planning application. The relevance of subsidence to planning decisions was recognised by the Ministry of Town & Country Planning (1949) when arrangements were announced for lpas to obtain the advice of the mineral valuers of the Valuation Office of the Board of Inland Revenue where any question of subsidence is involved.

In 1961, the Minister of Housing and Local Government gave his opinion that "decisions should not be taken to permit surface development without giving due weight to what is known or can be conjectured about the stability of the site" (Ministry of Housing & Local Government 1961). Whilst this advice was directed specifically to lpas in coal mining areas, it is clearly a general principle which is more widely applicable to other mining and other forms of land instability. There had also been a long-standing procedure for consultation with the nationalised coal industry. With privatisation of the coal industry, the Town and Country Planning (General Development Procedure) Order 1995 requires a lpa to consult the Coal Authority before granting planning permission for "development which involves the provision of a building or pipe-line in an area of coal working notified by the Coal Authority to the local planning authority."

Despite these provisions, it was clear by 1990 that the potential for subsidence was often not considered by lpas when deciding planning applications. Many planners regarded subsidence as a matter for the developer alone, or for the building regulations. At that time, the building regulations covered specific causes of ground movement such as swelling, shrinkage or freezing but there was dispute as to whether they covered subsidence due to mining, except in so far as the subsidence was caused by the weight of the building itself. Concern had also been expressed about the liabilities of lpas granting planning

permission for developments which were subsequently affected by subsidence.

In consequence, the Department of the Environment (1990) issued Planning Policy Guidance Note (PPG) 14 - *Development on unstable land* to clarify the position with respect to all forms of ground instability. This explained the responsibilities of the various parties to development and stressed the lpa duty to take all material considerations into account when reaching decisions on development proposals. The stability of the ground, in so far as it affects land use, is a material consideration and should be taken into account when deciding a planning application. Ways in which instability might be treated in development plans and in considering applications for planning permission were outlined and the role of expert advice was emphasised.

PPG 14 explained that it is the function of the planning system to determine, taking account of all material considerations, of which instability is only one, whether a proposed development should proceed. Having made that decision, for certain types of development, it is the function of the building regulations to determine whether the detailed design of buildings and their foundations will allow the buildings to be constructed and used safely.

Subsequently, the Building Regulations 1991 drew attention to potential problems caused by land instability in requiring that "The building shall be constructed so that ground movement caused by (a) swelling, shrinkage or freezing of the subsoil; or (b) landslip or subsidence, in so far as the risk can be reasonably foreseen, will not impair the stability of any part of the building."

Minerals Planning Guidance Note (MPG) 12 (Department of the Environment 1994) has taken forward the general principles in PPG 14 to advise lpas,

landowners and developers of the specific consideration which needs to be given to the problem of disused mine openings and to demonstrate the need to compile information on mined ground in readily accessible, well organised data systems. Particular attention was given to the need for and operation of planning control over the treatment of mine openings in different circumstances (eg on closure of a mine, for public safety reasons, to safeguard conservation interests and to facilitate development) and to the consideration which needs to be given to mine entries and mine openings in determining planning applications and in development plans.

#### Department of the Environment Research on Subsidence

The planning guidance that has been issued has been based on a solid foundation of research on land stability issues which proceeded in line with a well defined strategy. This involved, firstly, reviews on a national scale of individual causes of land instability to determine what work had been done and what was needed. The second element of the strategy was to conduct specific area and topic-studies to develop techniques for the investigation and management of particular problems which would be more generally applicable.

#### The National Reviews of Land Instability

The general objectives of all the reviews were to examine the geographical and geological distribution of problems, causes and mechanisms, effects on the land surface and on development, methods of investigation, risk assessment and remedial measures, the legislative and administrative provisions for dealing with problems and priority topics for further research.

Review of Mining Instability in Great Britain. Carried out by Arup Geotechnics (1992), this involved the compilation

and interpretation of data from readily available publications and documentary records. For the purposes of the review, minerals were classified into five types :- metalliferous (non-ferrous) ores; rocks (eg sandstone, limestone, chalk); coal and associated minerals (eg fireclay, Coal Measures ironstone); iron ore outside coalfields; and evaporites (eg rock salt, gypsum).

Mining has been found to have taken place throughout England and Wales, although in some counties it is of only minor extent, and in all Scottish Regions except Western Isles (figure 1). Extensive coalfield mining covers more than 20 per cent of the areas of 16 counties in England and Wales and 3 Scottish Regions. Mining methods include both partial extraction (primitive shafts and headings such as bell pits or chalk wells, pillar and stall mines and brine pumping and solution mining) and total extraction methods (pillar and stall, stoping, longwall extraction and sub-level or block caving). The principal types of mining instability which may affect the ground surface are:-

- collapse of mine entries (shafts and adits);
- crown holes (localised collapses into mine voids); and
- general subsidence (also called areal subsidence, a wide saucer-shaped depression of the land surface without the massive discontinuities associated with crown holes).

The results of the review are presented in 3 volumes comprising:-

- Ten regional reports describe the extent of mining for the 5 mineral types on a county and district basis and contain advice to planners to be used in conjunction with PPG 14. Comprehensive schedules of mining areas indexed by reference codes, mine names and National Grid references provide a link to the associated 1:250,000 scale maps showing areas where mining is known or suspected to have taken place and, therefore, should be regarded as a planning consideration.

- Five technical reports consider the effects of mines, investigation methods, preventive and remedial measures, monitoring methods and procedures for locating disused mine entries. Guidance is given on the procedures that should be adopted, their fitness for purpose, procurement and the priorities for further research as a basis for better technical guidance.

- Eleven case study reports, which provided the basis for the technical reports illustrate the variety of subsidence problems experienced due to mining instability. Each outlines the characteristics of mining and associated subsidence events in a specific area and summarises the site investigations and preventive and remedial measures which were used to deal with the problems.

- A separately published summary report and an executive summary provide a brief outline of the findings of all elements of the work undertaken for this review together with two summary maps, for northern and southern Britain respectively, at 1:625,000 scale of areas of mining consideration.

Review of Natural Underground Cavities in Great Britain. This review was carried out by Applied Geology Ltd (1993). Natural cavities were classified into 4 categories based on the mode of formation :- by dissolution (limestone, chalk, gypsum, salt and calcareous sandstone); by cambering (of competent cap-rock overlying less competent mud-rocks associated with past glacial and periglacial episodes); by marine erosion (sea caves in coastlines composed of competent rocks); and by other processes (eg soil piping, scour hollows resulting from periglacial processes and erosion of natural discontinuities).

Natural cavities were found to be widespread but not uniformly distributed throughout Great Britain (figure 2); 20,000 occurrences are recorded in the project database. The most significant concentrations are dissolution cavities in the Chalk of south east England and

East Anglia and the Carboniferous Limestone of the Yorkshire Dales, Derbyshire, north and south Wales and Avon and Somerset, with lesser concentrations due to cambering in the Permian, Jurassic and Cretaceous sequences of North Yorkshire, the East Midlands, Gloucestershire and Dorset. The cavities may be filled with air, water or unconsolidated deposits. Most instability is related to the downward movement of cover deposits rather than the cavity host rock. It may be sudden where air-filled voids are destabilised or occur more slowly with consolidation of loose infill deposits. The most common subsidence trigger involves water, often related to human activities.

The results of this review are presented in a similar format to those of the mining review with:-

- 10 regional reports (with accompanying 1:250,000 scale maps and a computerised database) describing the types and spatial distribution of natural cavities related to administrative areas and assessing them as constraints and amenities. Particular attention is given to regional experience of cavities affecting construction and engineering works, mining and tunnelling, mineral extraction, waste disposal, water resource development and public open space. Brief case histories are included within the regional reports.
- 3 technical reports discussing the nature and occurrence of natural cavities and their influence on planning and development, the range of site investigation techniques which may be appropriate for cavity detection and the ground treatment and structural design techniques available to overcome potential problems.
- A summary report with accompanying 1:625,000 scale maps of northern and southern Britain.

#### Techniques for Use by Planners.

Four examples are given below of the specific area- and topic-studies

which have been carried out to assist planners in giving consideration to the problems of subsidence.

Development Advice Maps for Mining Subsidence. This project aimed to develop a method for preparing development advice maps (DAMs) giving advice to planners on abandoned shallow mining in the South Wales coalfield. A pilot study in the Ebbw Vale area (Ove Arup & Partners 1985) was followed by a further study in the Borough of Islwyn (Scott & Statham 1995) to confirm the methodology and to devise procedures enabling the maps to be used in the planning process.

Both studies were supplemented by a detailed review of subsidence incidents in the South Wales coalfield (Statham & Treharne 1991). This showed that 75 per cent of the 400 subsidence events recorded in about 35 years were collapses into workings at outcrop or mine entrances. The remainder were crownholes with an upper limit of migration of 8 to 12 times void height. Almost 70 per cent occurred in open land and less than 20 per cent caused damage to buildings or structures; only one example of injury to people was traced. Overall the risk of subsidence in the South Wales coalfield is very low, though it is higher at mine entrances and near to seam outcrops.

Preparation of the DAMs involved a detailed desk study from geological, mining, historical and other archival records to establish workable seams and their seam reputation for subsidence. Working maps showing modified geology, mining records, rock cover to seams and drift cover were then used to prepare maps showing zones where:-

- abandoned shallow mining is known or anticipated;
- abandoned shallow mining is possible;
- abandoned shallow mining is unlikely; and
- positions of mine entrances.

Draft "Planning guidelines" and "Guidance notes for potential applicants" were incorporated in the planning process by Islwyn Borough Council and the operation of this system was monitored for a year to assess the accuracy and worth of the DAMs and their usefulness in the planning process. It was concluded that the maps are a valuable tool, that their development should be extended to other areas of the South Wales coalfield and that the techniques could be applied to other coalfield areas in the United Kingdom.

Subsidence in Norwich. Following a number of fairly spectacular incidents in the late 1980s, a thorough survey of the causes of subsidence in Norwich was undertaken (Howard Humphreys & Partners Ltd 1993). This involved an examination of the records of subsidence and their causes, determining the extent and finding ways of managing the subsidence problem.

The study showed that not all of Norwich suffers from subsidence problems. Where they have occurred they have often been of a relatively minor nature, though there have been a number of severe subsidence events. The majority of subsidences were found, somewhat surprisingly, not to be associated with underground chalk mines, though the most severe ones were. A high proportion of the subsidences are associated with damaged or leaking water pipes and many of the subsidence problems have been exacerbated by poor construction and maintenance of property. The study concluded that the risk was relatively low, despite the many factors which contribute to the subsidence problem (chalk mines, cellars, undercrofts and wells, natural underground cavities in the chalk, collapse of sewers and leakage from services and the presence and nature of backfills and infills).

Most of the subsidences can be dealt with by simple preventive or remedial works provided appropriate

investigations are made by developers and good practice is observed in construction and alteration of buildings. Dealing with subsidence is an integral part of Norwich City Council's local plan and account is taken of potential instability when considering development proposals and planning applications.

The recommendations for similar studies elsewhere emphasise the importance of a comprehensive data collection exercise, the importance of and requirements for underground inspection of old mines and the value of using a computerised database and geographic information system.

Assessment of Subsidence Hazard due to Gypsum Dissolution. The review of natural underground cavities had identified as a priority for further work the gypsum-bearing strata on the eastern side of the Pennines. In furtherance of this a study was commissioned to assess the working of the planning system in reducing hazards due to subsidence related to gypsum dissolution and to prepare a draft framework of advice suitable for use by planners, developers, land and property owners, insurers and others.

The study was focused on the Ripon area of North Yorkshire, where such subsidence was well known through the work of the British Geological Survey (Cooper 1995), but also covered the wider extent of the outcrop of gypsum-bearing strata. The geological, geomorphological and hydrogeological controls on gypsum dissolution and associated subsidence were examined and a conceptual model of gypsum dissolution in the Ripon area was established as a basis for assessment of the subsidence hazard. Recommendations were made on the engineering and planning responses to gypsum-related subsidence (Thompson & others 1995). The wider area study enabled confirmation of the conceptual model and conclusions to be drawn on the wider applicability of the framework of

advice for planners and others.

Treatment of Disused Mineshafts. Because of concern over the incidence of subsidence damage associated with disused mine opening, the Local Authority Associations and the Royal Institution of Chartered Surveyors made separate representations to the DOE about the need for advice. A Working Group was established and a program of research was undertaken on the treatment of disused mine openings and on the information base on mined ground (Freeman Fox Ltd 1988a,b).

Existing practice and methods of treatment were reviewed, classified according to their function and evaluated in respect of the most significant factor, depth to bedrock, and cost. Based on the concept of treatment objectives as a prime starting point for determining treatment policy, procedure, practice and selection of treatment method, a draft framework of advice was presented to indicate the most appropriate and cost-effective measures covering the majority of situations.

Similarly, the need for information on mined ground was examined along with information sources and types. Mining activity on which information is required was classified into shafts, roadways and workings and storage and retrieval options, including current practice in those authorities who already had information systems, were examined and recommendations made.

These two research programs provided the basis for MPG 12.

#### The Way Forward.

The need for consideration of potential subsidence in land-use planning has long been recognised but there have been some deficiencies in practice. A number of initiatives have been taken in recent years founded on a solid basis of research into the types of problems, their

distribution and significance to planning and development and the appropriate planning responses.

Advice which makes it clear to lpas that subsidence and other forms of instability are material planning considerations which should be considered when preparing development plans and determining applications for planning permission has been issued in PPG 14. This advice has been augmented in respect of the treatment of disused mine openings and the availability of information on mined ground in MPG 12. It may yet be too early to see the direct benefits of this advice but a number of other initiatives are being taken forward.

Recent and current research is providing the basis for the planning guidance to be taken further in respect of subsidence from mining, natural underground cavities and other causes of subsidence and settlement. The aim is to reach a wider audience than the technical expert so that awareness is raised amongst land use planners, developers and financial institutions, enabling proper consideration to be given to the issues that arise. The DOE has started to prepare guidance which will advise planners and others on how they can identify and assess the potential for subsidence in order to take it into account in their everyday planning decisions. It will also advise on the information requirements for sound planning and as a basis for investment by developers. This will be based on the research described above.

Proper consideration of subsidence in the planning process will assist in reducing the impact of subsidence on the economy and on people. Whilst the risk has, in most cases, been found to be generally low to very low, when subsidence occurs the results can be spectacular and costly. They cannot be ignored by decision-makers. There will undoubtedly be some impacts due to the historical legacy of development in areas which are



prone to subsidence but it should be possible to avoid these impacts in most new development and redevelopment. It is also recognised that most forms of subsidence can be mitigated by appropriate engineering but that this is generally more cost-effective when undertaken in advance of development rather than as a result of incidents occurring during or after the development has taken place.

It is important to emphasise that the development of policies on subsidence and planning is not aimed at preventing development, though in some cases that may indeed be the appropriate response. Rather it is to ensure that development is suitable, that any risk is mitigated by appropriate engineering and that both natural and human-induced physical constraints on the land are considered at all stages of planning. Proper consideration of the potential for subsidence will thus contribute to the broad objectives of the planning system to achieve economy and efficiency in the use of land and the protection of the environment.

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#### References.

- Applied Geology Ltd, 1993. Review of instability due to natural underground cavities in Great Britain. Vol. 1, Regional Reports with 1:250,000 scale maps; Vol. 2, Technical Reports; Summary Report with 1:625,000 scale maps. Royal Leamington Spa, Rust Environmental.
- Arup Geotechnics, 1992. Review of mining instability in Great Britain. Vol. 1, Regional Reports with 1:250,000 scale maps; Vol. 2, Technical Reports; Vol. 3, Case Study Reports; Executive Summary; Summary Report with 1:625,000 scale maps. Newcastle-upon-Tyne, Arup Geotechnics.
- Cooper, A., 1995. Subsidence hazards caused by the dissolution of Permian gypsum in England: Geology, investigation and remediation. p. 457-466. In Maund, J., Penn, S. and M. Culshaw (Editors) Geohazards and engineering geology: International hazard assessment, mitigation and remediation. Preprints of papers for the 31st Ann. conf. Geol. Soc. Engineering Group, Coventry, U.K., 10-14 September, 1995.
- Department of the Environment, 1990. Development on unstable land. Planning Policy Guidance Note 14. London, H.M.S.O., 25p.
- Department of the Environment, 1994. Treatment of disused mine openings and availability of information on mined ground. Minerals Planning Guidance Note 12. London, H.M.S.O., 31p.
- Freeman Fox Ltd, 1988a. Treatment of disused mine openings. London, H.M.S.O., 182p.
- Freeman Fox Ltd, 1988b. Methods of compilation, storage and retrieval of data on disused mine openings and workings. London, H.M.S.O., 132p.
- Hitchen, A. and F.-Stewart, 1995. Crater fright for family. Ripon Gazette, 17 February, 1995.

- Howard Humphreys & Partners Ltd, 1993. Subsidence in Norwich. London, H.M.S.O., 112p.
- Ministry of Housing & Local Government, 1961. Town & Country Planning Acts, 1947-59: Surface development in coal mining areas. Ministry of Housing & Local Government Circular No. 44/61. London, H.M.S.O., 3p.
- Ministry of Town & Country Planning, 1949. Consultation on proposals for development by local authorities and statutory undertakers. Ministry of Town & Country Planning Circular No. 65. London, H.M.S.O., 2p.
- Ove Arup & Partners, 1985. South Wales mining subsidence desk study. Report No. 85/1100 to Department of the Environment and Welsh Office. Open-file report.
- Porter, R., 1992. Mine of information needed as homes face collapse. Sunday Telegraph. 28 June, 1992.
- Prior, G., 1989. Falling apart at the coal seams. Construction News. 20 April, 1989.
- Scott, M.J. and I. Statham, 1995. Development advice maps - mining subsidence. p. 482-490. In Maund, J., Penn, S. and M. Culshaw (Editors) Geohazards and engineering geology: International hazard assessment, mitigation and remediation. Preprints of papers for the 31st Ann. conf. Geol. Soc. Engineering Group, Coventry, U.K., 10-14 September, 1995.
- Statham, I. and G. Treharne, 1991. Subsidence due to abandoned mining in the South Wales coalfield, U.K.: causes, mechanisms and environmental risk assessment. p. 143-152. In Johnson, A.I. (Editor) Land subsidence. Proc. 4th Int Sympos. on Land Subsidence, Houston, TX, 12-17 May, 1991. Int Assoc Hydrological Sciences Publication No. 200, Wallingford, IAHS Press.
- Thompson, A., Hine, P., Peach, D., Frost, L. and D. Brook, 1995. Subsidence hazard assessment as a basis for planning guidance in Ripon. p. 491-505. In Maund, J., Penn, S. and M. Culshaw (Editors) Geohazards and engineering geology: International hazard assessment, mitigation and remediation. Preprints of papers for the 31st Ann. conf. Geol. Soc. Engineering Group, Coventry, U.K., 10-14 September, 1995.

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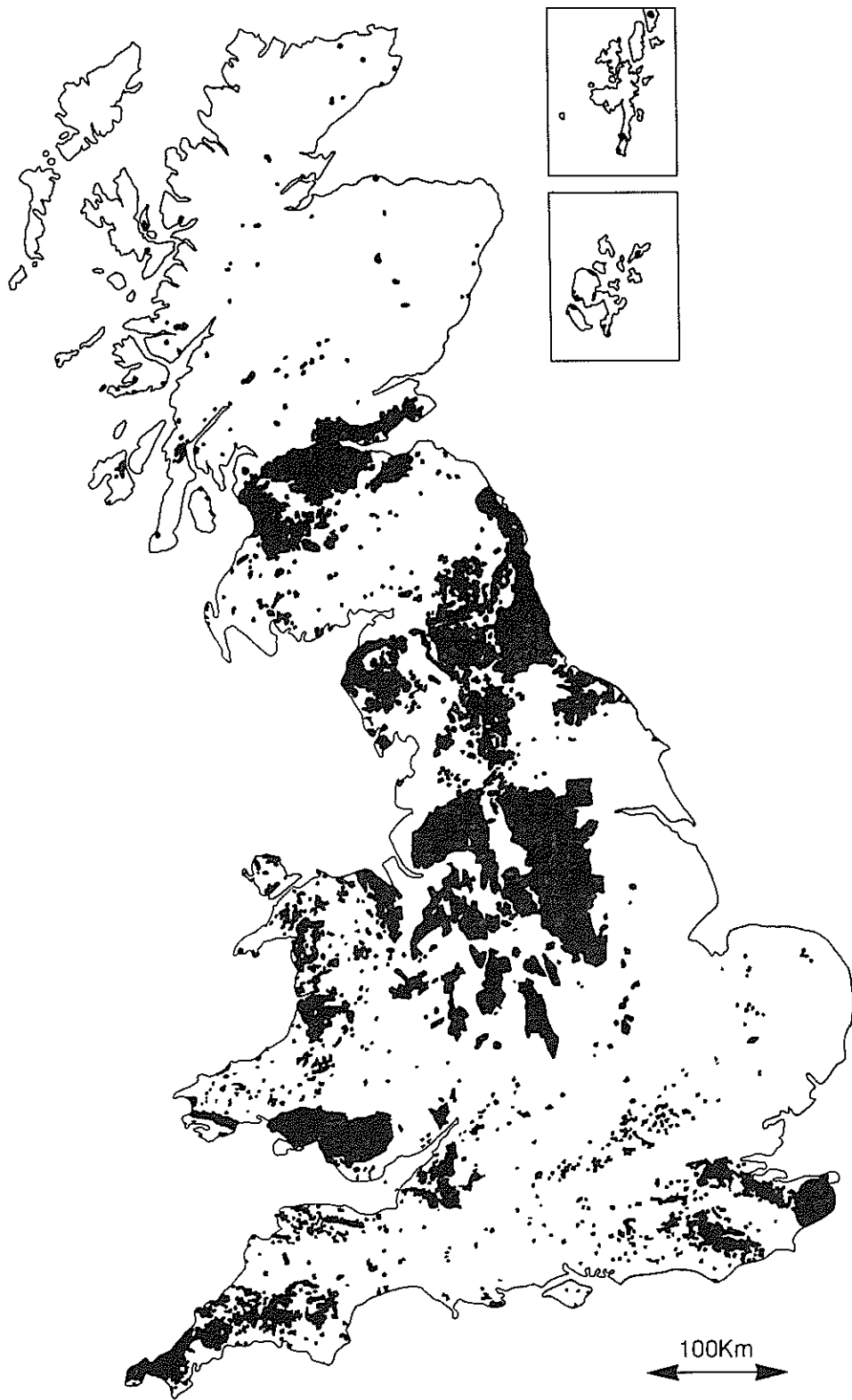


Figure 1. Mining areas in Great Britain (after Arup Geotechnics, 1992)

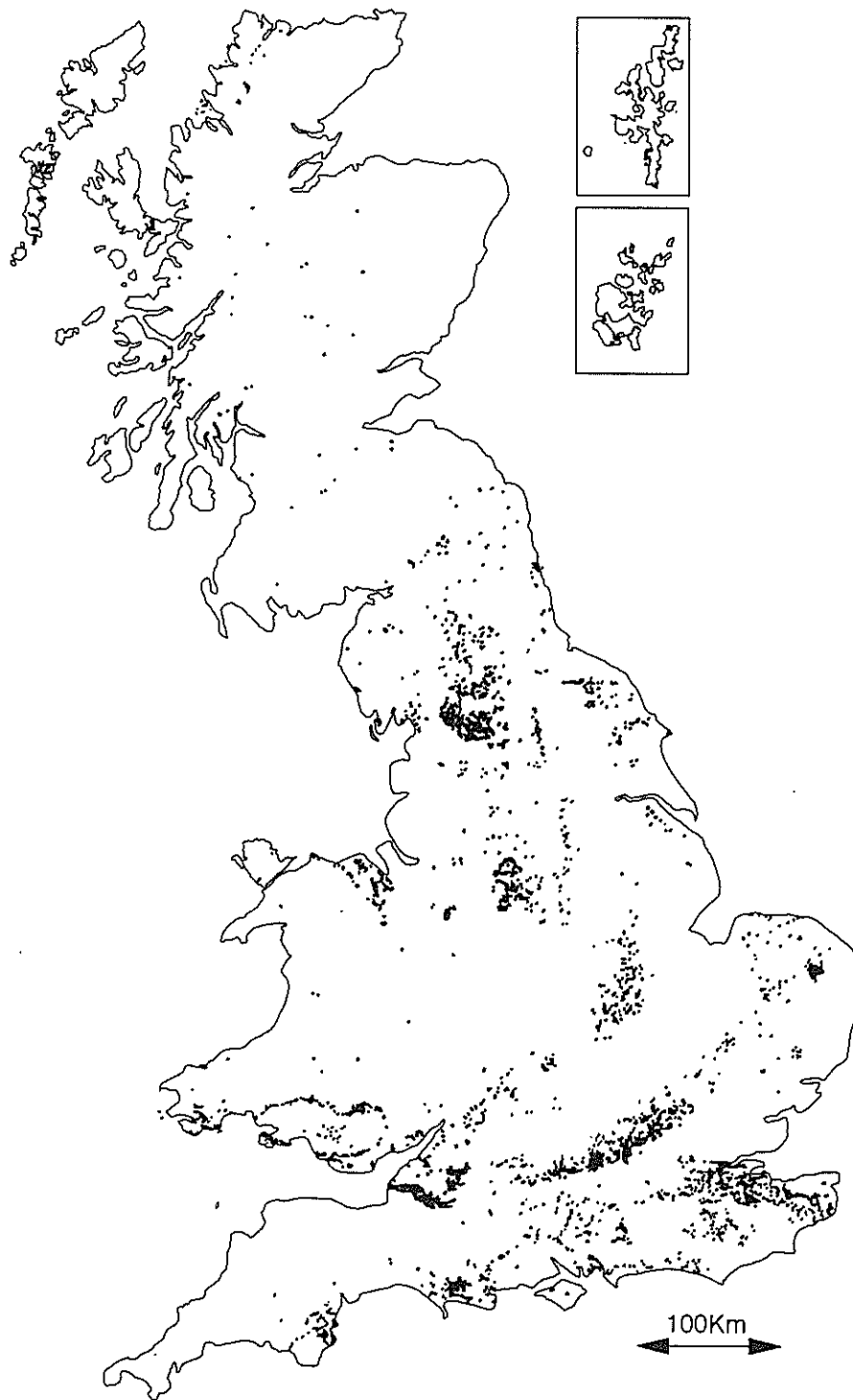


Figure 2. Distribution of natural underground cavities in Great Britain (after Applied Geology Ltd, 1993)