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PROBLEMS OF LIMESTONE QUARRYING IN AND ADJACENT TO THE PEAK DISTRICT NATIONAL PARK

by

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(1 figure and 2 tables)

RESUME. - Problèmes d'extraction du calcaire dans le Peak District (Derbyshire) et les environs.
Le Calcaire carbonifère forme comme un grand dôme dans le Peak District (Derbyshire) et les régions adjacentes du Staffordshire, où il affleure sur quelque 450 km^2. Les carrières et les activités connexes emploient environ 8.000 personnes et la matière première produite est estimée à plus de 100 millions de livres sterling par an. Cependant, le paysage karstique du Calcaire carbonifère est extrêmement attrayant et sa valeur est grande pour les loisirs. En 1951, 81 °/o de l'affleurement calcaire a été inclus dans le Parc national du Peak District (le premier des parcs nationaux britanniques) dont il représente le tiers de la superficie. A l'extérieur du parc, le calcaire était déjà intensément exploité et, les 30 années suivantes, l'aire d'extension possible des carrières fut progressivement diminuée. Ceci fut à l'origine de pressions croissantes pour le développement des carrières à l'intérieur même du Parc, où l'on extrait maintenant 40 °/o de la production totale. Les autorités du Parc essaient de concilier les multiples problèmes de sauvegarde du milieu rural, de l'agriculture traditionnelle, de l'emploi et du tourisme locaux avec les besoins nationaux en matière première. Comme les carrières impliquent la modification ou la destruction de certaines formes karstiques et la création d'un relief artificiel, ainsi que la pollution et/ou la rupture de l'écoulement souterrain, un vaste champ d'action s'ouvre aux karstologues et aux spécialistes des ressources.

ABSTRACT. - In the Peak District of Derbyshire and adjacent parts of Staffordshire the Carboniferous Limestone forms an extensive dome-like structure with an outcrop of some 450 km^2. Quarrying and related activities such as haulage provide employment for about 8,000 people and the value of the raw material produced is thought to be in excess of £ 100 million/a. However, the karst scenery on the Carboniferous Limestone is extremely attractive and of high value for amenity and recreation. In 1951, 81 °/o of the limestone outcrop was included in the Peak District National Park (Britain's first national park) forming about one third of its total area. The area of limestone outside the Park was already heavily quarried; during the succeeding 30 years the area available for expansion outside the Park has been progressively reduced and this has led to increasing pressures for expansion of quarries within the Park which now produce about 40 °/o of the annual output from the Peak District. The Peak Park Joint Planning Board attempt to reconcile the multiple problems of countryside conservation, traditional forms of land use such as farming, employment needs and amenity pressures at the regional level with a national demand for raw materials. As quarrying involves the modification or destruction of some karst landforms and the creation of new, artificial landforms together with the pollution and/or disruption of underground drainage lines there is considerable scope for applied research by karstologists and resource specialists.

INTRODUCTION

In 1951 some 1400 km^2 of Derbyshire and adjacent parts of Staffordshire were designated as Britain's first national park, the Peak District National Park (P.D.N.P.). About a third of the Park is underlain by Carboniferous Limestone and 81 °/o of the Peak District karst lies within the Park boundaries (figure 1). The Peak District is also the most important region in Britain for the production of limestone accounting for over 25 °/o of annual output, valued at over £ 100 million (Harris, 1982). The conflicts between quarrying and alternate land uses, particularly recreation and tourism, have placed the planning authorities and particularly the Peak Park Joint Planning Board (P.P.J.P.B.) under considerable pressure. This paper seeks to examine the problems and conflicts and particularly to assess the potential for applied karst research.

THE PEAK DISTRICT KARST

In the Peak District the Carboniferous Limestone forms part of an extensive dome-like structure and is

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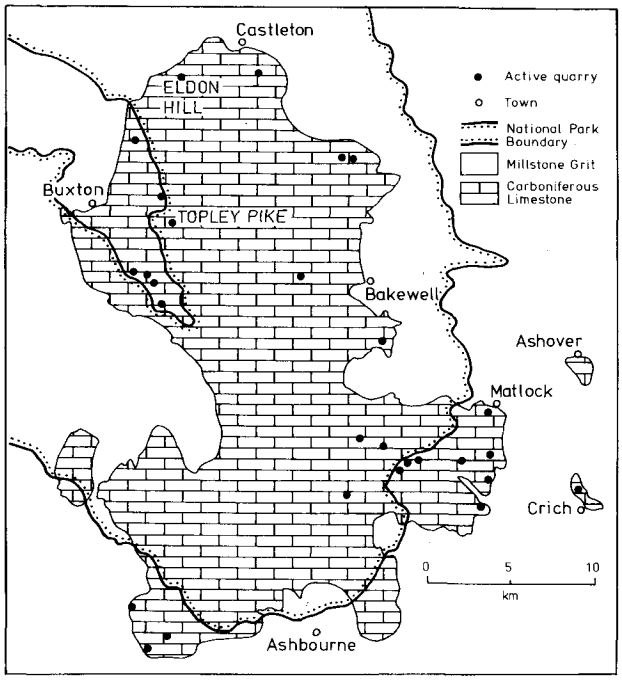

Figure 1. - Limestone Quarries in the Peak District karst.

surrounded by impermeable lithologies (fig. 1). The outcrop is almost 40 km long (north-south) and up to 20 km wide and has a total area of some 450 km^2. The environment of deposition varied across the area and the limestones fall into three main lithological groups : bioclastic limestones formed in a lagoonal "shelf" environment which prevailed over most of the area; massive fine grained reef limestones which formed at the fringes of and less commonly within the lagoons; and thinly bedded, fine grained calcisiltites and calcilutites, often associated with siliceous cherts, which were formed in basinal or gulf environments. The overall thickness of the limestone sequence is uncertain as the underlying strata are nowhere exposed and the only two boreholes to penetrate to basement did so at depths of 274 m and 1803 m, the former having been drilled from river level with at least 150 m of limestone above its top. In general it would appear that the basement is sufficiently deep to have had little influence on karstification, particularly since the limestones are surrounded by impermeable lithologies forming a ponded karst (karst barré). In the south Mio-Pliocene fluvial sediments preserved in solution collapse pockets provide evidence of early stages in the evolution of the Peak District karst (Walsh *et al.*, 1972, Ford, 1977) but the most widespread superficial deposits overlying the limestones are of Quaternary age and comprise remnants of a glacial till or tills (Burek, 1977) together with a more extensive veneer of loam and chert gravel composed largely of a silty loess which is often mixed with insoluble limestone residue (Pigott, 1962; Burek & Cubitt, 1979).

The karst landscape of the Peak District is essentially a soil covered, gently undulating limestone plateau surface which ranges in altitude from 275-450 m and is devoid of residual hills. The plateau surface is dissected by a complex network of sinuous valleys most of which are permanently dry and only two of which carry perennial surface streams (Warwick, 1964; Ford & Burek, 1976). There are few areas of bare limestone and those karren which have been described have suffered considerable degradation (Warwick, 1975). Solution dolines and alluvial dolines are common but collapse dolines are rare and there are no uvalas or poljes. There are over 100 caves with a combined length of about 30 km (Ford & Gill, 1979), the major systems being located at the margins of the limestone outcrop where allogenic streams provide point sources of aggressive recharge. Nearer the centre of the karst recharge is entirely autogenic but includes both diffuse inputs and more concentrated inputs from closed depressions. Total hardness values for karst risings range from 140-440 mg/l ($CaCO_3$ + $MgCO_3$) and site-mean values range from 180-285 mg/l (Gunn, in press). As yet hydrochemical budgeting techniques have not been used to obtain reliable estimates of solutional erosion rates but more crudely derived rates for individual basins lie in the range 20-100 $m^3/km^2/a$ while net erosion over the whole outcrop is probably around 45-65 $m^3/km^2/a$ (Gunn, in press). Taking the average limestone density to be 2.7 g/cm^3 and the outcrop area as 450 km^2 this is equivalent to 54,675-78,975 t/a.

LIMESTONE QUARRYING IN THE PEAK DISTRICT

The Peak District has a long tradition of mineral working which stretches back about 2,000 years and has been one of the mainstays of the local economy. Limestone quarrying also has a long history and is now the dominant extractive industry in the Peak District providing employment for about 2,000 people (including related activities such as haulage). In 1951 when the P.D.N.P. was designated 19 °/o of the limestone outcrop was deliberately excluded on the grounds that it was already a "degraded landscape", heavily scarred by quarrying. At that time this small area accounted for over 80 °/o of limestone production but this has now dropped to less than 70 °/o, the remainder being produced within the Park. In addition the period 1951-1971 saw a dramatic increase in the demand for limestone so that by 1971 production from within the Park was approaching that quarried outside the Park in 1951 (tab. 1). In preparing a structure plan for the Park the P.P.J.P.B. (1974) noted that if the previous 6 °/o per annum growth rate in limestone production was maintained then a quantity of limestone equivalent to a layer 30 m thick over the whole limestone outcrop would have been removed by the year 2050. This would have represented an erosion rate several thousand times that under natural conditions but fortuitously the projected

Table 1. - Limestone Quarries in the Peak District

	Number		Output (Mt)	
	Inside PDNP	Outside PDNP	Inside PDNP	Outside PDNP
1951	23	30	1.4	6.3
1971	12	22	5.4	14.0
1980	10	19	4.5	12.0

growth rate has not been sustained, due to the mid-1970's industrial recession, and between 1975 and 1979 production stabilised at 17-18 Mt/a (Harris, 1982). However, even this is 200-300 times the natural erosion rate.

As limestone outcrops over a wide area of the Peak District the early quarries were small units providing local supplies of building stone and quicklime for agriculture. However, the last 30 years has seen a rationalisation of the industry towards a smaller number of larger units (tab. 1) and this has been accompanied by the takeover of locally based companies by larger national or even multinational undertakings. At the same time there has been a change in the dominant economic use of the limestone from chemical to aggregate (tab. 2) and this is particularly significant as the Peak District limestones are noted for their high chemical purity, often over 99 °/o $CaCO_3$.

Table 2. - Economic use of Peak District Limestones (expressed as a percentage of annual limestone production)

	1954	1971	1978	1980
Aggregate	20.6	51.7	52.7	50.3
Chemical	47.6	25.0	23.0	
Iron & Steel & Cement	23.8	21.1	22.6	49.7
Agriculture	7.9	2.2	1.7	

COMPETING LAND USES IN THE PEAK DISTRICT KARST

The land use conflicts in the Peak District karst stem from the needs of quarrying, the water industry, formal and informal recreation pursuits, nature conservation, agriculture, forestry, scientific interests, special quality landscapes and the living conditions of the local inhabitants (Blunden, 1975, Harris, 1975). Problems arise where two or more of these make claims for the same area or alternatively where they exist adjacent to each other. The primary need of the quarrying industry is limestone and some conflict is inevitable given that the majority of the economic resource lies within the P.D.N.P., a designated amenity area. Proposals to extend existing quarries within the Park boundaries or to allow new quarries within the Park are perforce highly controversial as exemplified by the Old Moor extension near Buxton (MacEwen & MacEwen, 1982) and by the Eldon Hill and Topley Pike proposals considered in the present paper. To date, there have been surprisingly few conflicts between the quarrying and water industries although sporadic pollution of river water has occurred, notably on the Wye an important angling river. Approximately 20 million people (about 40 °/o of the population of England and Wales) are within an easy day's drive of the Peak District and some of the most attractive landscapes are located within the Carboniferous Limestone outcrop. In particular a survey by the P.P.J.P.B. (1974) indicated that the limestone valleys ranked equal highest of a range of landscape types in terms of attractiveness to visitors. However, these valleys are also the locations at which limestone is most accessible for quarrying and in many cases the communication lines along which quarried material is transported. The conflicts been agriculture and quarrying are somewhat more difficult to assess as the financial benefits accruing to a landowner who sells agricultural land for quarrying are very much higher than those which could be obtained by farming. In addition the majority of the land is Grade 3 or worse and therefore not eligible for protection on the grounds of productivity. However, the visual attractiveness of the limestone plateau (the "White Peak") is in part a result of the pattern of farmland with dry-stone walls enclosing small fields, providing a link between agriculture and tourism interests as land uses in conflict with quarrying. Conflicts between quarrying and scientific interests are particularly active where sites in close proximity to quarries have been designated as Nature Reserves or as Sites of Special Scientific interest (S.S.S.I.) as is the case at Eldon Hill and Topley Pike. Finally,

land use conflicts are also involved in the question of re-use of abandoned quarries. In the Peak District former quarries have been utilised for tipping (Taddington Quarry), as a site for small industries (un-named quarry near Matlock) as picnic areas (e.g. Tideswell Dale Quarry) as nature trails (e.g. Millers Dale Quarry), as a caravan site (Grin Quarry, Buxton) and as a motor-cycle scambling track (Peak Dale Quarry, Dove Holes).

POTENTIAL FOR APPLIED KARST RESEARCH

Two main areas in which limestone quarrying directly impacts on karst systems may be identified :

1.- GEOMORPHOLOGICAL IMPACTS

Quarrying results in the destruction of some landforms such as caves, closed depressions, and sometimes whole hills, and in the substantial modification of other landforms particularly valley systems. At the same time new, artificial landforms are created such as large closed depressions with steep, sometimes benched, sides and extensive flat floors. Little is presently known of the scale of landform destruction, modification or production and this could provide an interesting area for future karst research particularly since the director of the Institute of Quarrying is of the opinion that : " It is, incidentally, ironical that a rock face caused by some past geological upheaval is often regarded as an attractive feature, while a rock face created by man is an unmitigated evil. The two finish up looking much the same" (Fish, 1983). A further area of geomorphic interest is the extent to which quarrying has altered rates of solutional erosion (Dearden, 1963).

2.- HYDROLOGICAL IMPACTS

Quarrying may result in the destruction or disruption of underground drainage lines, changes in the pattern of underground water movement and changes in the quantity and quality of water flowing through the karst system. These aspects have received more attention from karst researchers, particularly in the Mendip Hills (Stanton, 1968; Atkinson *et al.,* 1973). However, there is scope for further work involving both qualitative and quantitative water tracing experiments together with studies of the hydrogeochemistry of karst risings.

CASE STUDIES : TOPLEY PIKE AND ELDON HILL QUARRIES

During 1983 and 1984 applications were made to extend the Topley Pike and Eldon Hill Quarries which lie within the P.D.N.P. (fig. 1). Both applications have been rejected by the P.P.J.P.B. but there is a possibility of appeals by the companies concerned and consequent planning enquiries. Hence it is only possible at this stage to outline the issues and the potential for applied research.

1. Topley Pike Quarry is situated 5 km east of Buxton and about 1 km within the Park Boundary (fig. 1). Limestone has been quarried at this site for over sixty years and the present operation provides direct employment for 49 people and indirect employment for 25-100 more in haulage and related activities. Consented reserves still accessible at present working depths have a life of about six years and the proposed extension would sustain production for a further ten years after which time new schemes are envisaged (Tarmac, 1983). The proposals are extremely well presented and show considerable regard for environmental impact. In terms of karst landforms the "destructive" impact would be small as there are no known cave systems in the proposed expansion area and no significant closed depressions on the plateau surface. However, the "constructive" impact could be large as the plans envisage creation of a new valley from the quarry extension with irregular cliffs and scree formed by final blasting and accelerated weathering techniques (Tarmac, 1983). More significant in the short term is the hydrological impact of the proposed extension as the quarry is adjacent to Deepdale a major valley and a Site of Special Scientific Interest (S.S.S.I.) on account of its rich and varied flora. The upper reaches of the valley are generally dry but springs supply flow to the lower valley for much of the year. The proposed extension would be worked to a depth of 10-15 m below the valley floor and concern has been expressed that this could dry up the springs and de-water the valley side with consequent impacts on the flora. Water tracing experiments are currently in progress to determine the regional hydrogeology and these will be followed by more detailed studies of slope hydrology.

2. Eldon Hill Quarry is situated 4 km south-west of Castleton and lies well within the National Park boundaries (fig. 1). In contrast to Topley Pike it is highly visible and has a history of landform destruction, principally cave passage. Moreover it is located in an area of extensive cave systems which include the longest and deepest in the Peak District and is dangerously close to Eldon Hill, the highest point on the limestone plateau and a S.S.S.I. In this instance the role of the karst researcher is to clearly state the value of the landforms, to carry out accurate surveys (particularly of the cave systems in order to show their relationship to surface topography), and to assess the possibility of disruption or pollution of underground drainage lines. There is also an important role for resource specialists in evaluating whether the extension is really necessary in pure economic terms.

CONCLUSIONS

The main task facing the P.P.J.P.B. inside the National Park and Derbyshire County Council (D.C.C.) outside it is to attempt to reconcile the economic arguments for and the environmental arguments against the extraction of limestone. The aim of D.C.C. (1977) is "to strike a careful balance between the essential demand for the mineral, the limited resources and the investment in employment and plant on the one hand and safeguarding of local settlements and high quality landscape from the impact of quarrying and related activities, including transport, on the other". However, there are major difficulties as the case for quarrying can generally be put in terms of national demand for limestone and/or local employment needs whereas the environmental case is less easily quantifiable. The present paper has sought to outline some of the ways in which karstologists can contribute to the ongoing debate particularly in association with resource specialists.

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