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Measurement of rates of surface lowering of limestone in the southern Pennines: an example in the Wye catchment, Derbyshire, UK

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ABSTRACT

Measurement of the differential denudation between chert and limestone in a Carboniferous limestone sequence that was cut during excavations for a railway tunnel (in 1865) has provided a means of assessing limestone dissolution rates in a valley side setting in the southern Pennines over the last ~150 years. Dissolution rates of 0.031 mm/annum have been determined. This rate falls within the range of previously determined limestone dissolution rates in the UK, which have been described in the context of different methods of measurement and the difference in denudations rates over time.

1. Introduction

Monitoring rates of weathering and erosion provides data that contribute both to the interpretation of landscape evolution (including speleogenesis) and understanding of the durability of building stones (Pope et al., 2002; Trudgill and Viles, 1998). In the case of limestone such studies have a long standing, but ongoing place in karst literature (Goodchild, 1875; Sweeting, 1972; Trudgill, 1983; Ford and Williams, 2007). Developments in the potential to calculate exposure ages and erosion rates, e.g. Balco and Shuster (2009) have rejuvenated interest in rates of surface lowering, e.g. Wilson et al. (2012). The aim of this paper is to review the different techniques that are available for the measurement of rates of dissolutional lowering of limestone and then describe a technique and results from a trial locality in the Peak District, Derbyshire in the context of other published rates of dissolution. Whilst the research area is inevitably site-specific, it is considered that the method of measurement deployed in this study can be applied to other karst environments in a range of geographical settings. The research area was centred on National Grid Reference SK 17150 72428 (Fig. 1A) on the southern valley side of the River Wye, Derbyshire, UK, at an elevation of approximately 240 m OD where the bedrock comprises Carboniferous limestones of the Monsal Dale Limestone Formation. These Dinantian rocks comprise shallow water, carbonate shelf limestones, which were laid down during the Carboniferous when Britain was closer to the equator than it is today.

The Brigantian stage Monsal Dale Limestone Formation comprises an upper pale limestone facies and a lower dark limestone facies. It is the latter that underlies the research area with a dip of approximately 5 degrees to the south in the vicinity of the research area (BGS, 1978). The dark facies have been shown (Walkden, 1987) to be cyclic (regressive sequences), albeit with less evidence for emergence than observed in the pale facies (Aitkenhead et al., 1985). These limestones largely comprise biosparites and bioclastic calcisiltites with rarer biomicrites and range in colour from mottled shades of grey to true dark grey (Cox and Bridge, 1977; Gawthorpe et al., 1989). Aitkenhead et al. (1985, p. 26) note that chert is common, but not universally present and Ford (2002) suggests that the chert, which occurs as nodules, is the product of the alkali solution of silica derived from siliceous skeletons and re-precipitation in zones of acid conditions. The depositional environment has been interpreted by Aitkenhead et al. (1985) as one of a shallow carbonate shelf subject to interplay between eustatic and tectonic controls on sedimentation. The evidence favours eustatic changes, of a type that could have been brought about by the fluctuations in the ice mass covering Gondwanaland, superimposed upon the tectonic control. The limestone sequence was subject to late Carboniferous mineralisation of the Mississippi Valley type such that many of principal faults and joints in the vicinity of the research area contain lead–zinc mineralisation. Aerial photographs indicate that the

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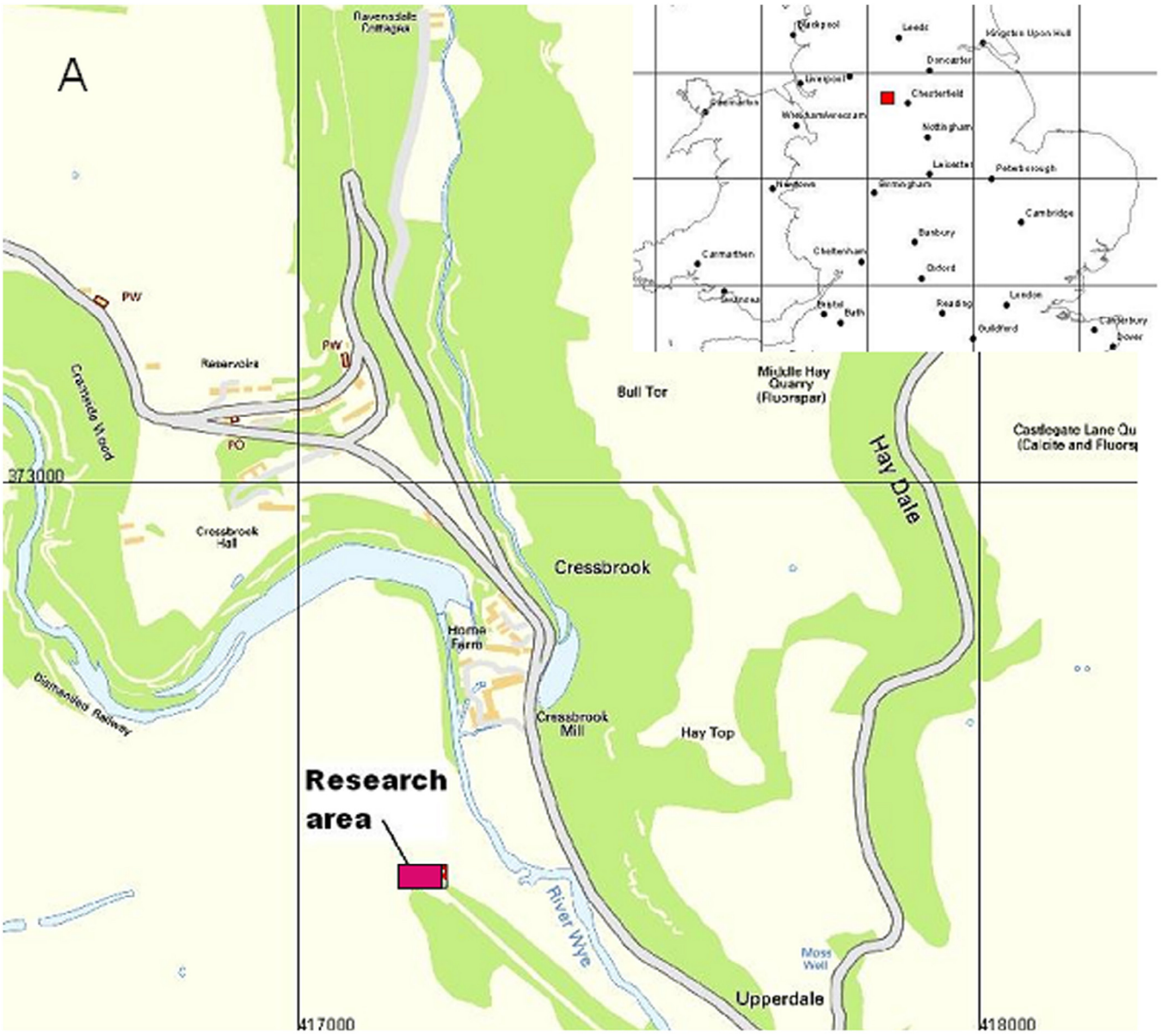

Fig. 1. (A) Location of the research area; (B) interbedded limestone and chert, metre rule for scale, and (C) north-west facing view of the survey site [note 28° slope angle and higher density of medium mature trees on the north-east side of the cutting (right)].