

Human interactions with the sandstone landscape of central Sudetes



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A B S T R A C T

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The paper examines the history of human interactions with the specific plateau and cuesta morphology developed upon Cretaceous sedimentary sequences in the Middle Sudetes, Central Europe (Poland, Czech Republic). Lithological contrasts influence relief at regional and local scale, providing diverse opportunities and limits to human activities since medieval times until the present. As a result a complex cultural landscape underpinned by geomorphology evolved through time, illustrating the concept of 'sandstone phenomenon'. The following interactions with the physical landscape are identified: avoidance, adaptation, modification, and withdrawal. Although early modifications occurred in the late medieval period, adaptation rather than direct human impact typified the area until the mid-18th century. The expansion of settlement network in later times, along with forest clearance, development of quarrying and growth of tourism have led to substantial modifications of the geomorphological landscape and the origin of a suite of anthropic landforms. Depopulation of the region, particularly on the now Polish side, amplified after World War II, resulted in land use changes and renaturalization of many areas. Many previously occupied areas have been abandoned and various forms of nature and landscape protection now provide limitations to further development. Modification is tightly controlled, while re-adaptation is preferred and promoted, driven not by physical constraints anymore but by changing attitudes and increasing environmental awareness.

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Introduction

The geomorphology of sandstone terrains, due to its distinctiveness and diversity, has long been the subject of attention. After decades of a predominantly descriptive approach and a focus on landform identification and classification, new research fields have been opened, directed towards more thorough understanding of processes, rock properties that control them, structural geological and sedimentological background (see Young, Wray, & Young, 2009, 304 pp.). These studies, often highly illuminating in terms of basic geomorphological research, are however largely dissociated from the human factor. This is paradoxical since many excellent examples can be provided of very close interactions between people and sandstone landscapes, in which characteristics of the latter were used for the benefits of the former. The examples are essentially from each continent and include, but are not limited to, the 'red rock city' of Petra, large parts of it having been carved in sandstone (Paradise, 2005), Anasazi settlements and shelters within the sandstone cliffs of the Colorado Plateau (Kantner, 2004,

324 pp.), sandstone terrains of central and northern Australia with various Aboriginal associations, particularly with rock art (Chippindale & Taçon, 1998), or the spectacular Danxia landscapes of south China, among which various philosophical and art schools flourished over centuries (Fang, Qingheng, Xiaojun, Wenge & Zhonghua, 2007). In certain places linkages between people, their spiritual values and beliefs, location and shape of the physical terrain were or are so strong that specific sandstone geomorphic features attained the status of 'sacred places', of which the arkosic sandstone inselberg of Uluru in Australia is the prime example.

Another area where interactions between people, human activity and sandstone terrain are both protracted in time and manifold, is Central Europe. In the northern part of the Bohemian Massif (Czech Republic, parts of Germany and Poland – see Fig. 1) an extensive sandstone tableland occurs, subject to human impact since prehistory. However, except for specific places and the recent decades, human alterations of the natural environment were relatively modest and adjustment rather than far-reaching reshaping has been the norm. In this paper, we intend to investigate the nature of these relationships, on the example of the north-eastern extremity of the Cretaceous sandstone tableland of the Bohemian Massif, at the Czech/Polish boundary, in the central part of the Sudetes Mountains. The very specific morphology of sandstone plateaus and escarpments exerted a profound influence on the

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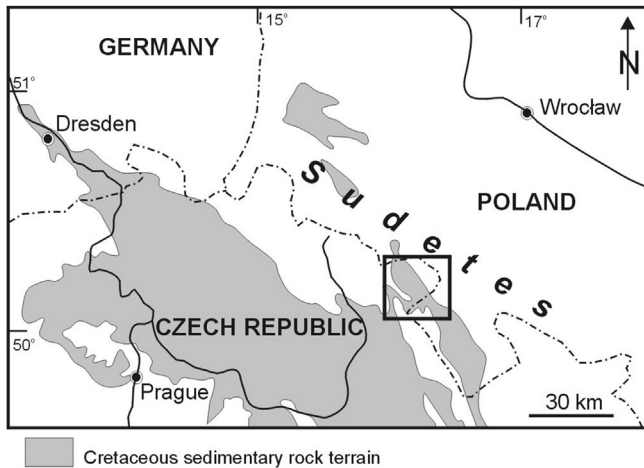


Fig. 1. Location of the study area (black rectangle) in Central Europe.

range of activities undertaken by humans since medieval times, and adaptation rather than severe human impact has typified the area until the present-day. Hence, geomorphology has provided an essential background to the development of a cultural landscape.

Background – Sandstone phenomenon

The close relationships between rocks, landscapes and humans in sandstone terrains are included within the general term of 'Sandstone phenomenon'. This notion was first coined by Čílek and Kopecký (1998) in a conference proceedings collection from a meeting in the Czech Republic and simply defined as '(...) the sum of all abiotic and biotic constituents associated with specific type of sandstone relief' (p. 9). It was also commented that the term particularly applies to '(...) cases of interactive feedbacks among the substrate, microclimate, vegetation and fauna' (*op. cit.*). Subsequently, however, the concept was broadened and refined, providing background for the comprehensive evaluation of sandstone terrains. It was realized that close relationships exist not only between sandstone and vegetation, but that humans play an important role too. Thus, Čílek, Williams, Osborne, Migoń, and Mikuláš (2007) observed that '[sandstone areas] often attract settlement or act as refuges, and may include 'art galleries' of previous civilisations (...). Possibly nowhere among Earth's landscapes can we observe such a close relationship between "stone and life" as in sandstone areas' (p. 34). Consequently, the sandstone phenomenon was redefined as a case where '(...) the substrate, climate, life and human activity all participate in creating a single system intertwined by a complex network of feedbacks and interrelationships at multiple levels' (Härtel, Čílek, Herben, Jackson & Williams, 2007, p. 9). Adamovič, Mikuláš, and Čílek (2010, 460 pp.) provided numerous examples of direct human associations with sandstone morphology, ranging from small-scale rock carvings and rock art to extensive rock-hewn castles and quarries, while Jenč and Peša (2007) and Belisová (2007) explored the theme how people used natural resources in the sandstone area of the northern Czech Republic through time.

Among various natural attributes and features of the sandstone terrain subject to this study the following assume particular significance in the context of human interactions with landforms and landscapes. First, bare rock outcrops are numerous and occur in a variety of forms and shapes, from hoodoo rocks a few metres high through tors of curious shapes, solitary columns and towers, buttes and mesas, extensive cliff lines around plateaus or inside canyons,

to deeply dissected 'rock cities'. Relative relief within the latter comes to 100 m. Second, these vertical outcrops occur adjacent to very gentle or even flat terrain that follows structure. Hence, stepped topography and extreme contrasts in slope gradients characterize sandstone tablelands of the Bohemian Massif. Third, although the rock mass strength of sandstone is high, it is so due to the very wide spacing of discontinuities (Remisz, 2008). The intact strength of sandstone is moderate and the rock is easily cut and dressed. This provided an opportunity to modify natural rock outcrops to suit people's purposes. Fourth, the weathering pattern of Cretaceous sandstone is such that the rock breaks down into sand which can be easily eroded away. In consequence, the weathering mantle is very thin and erodible, and soils developed upon it are shallow and poorly suited to agriculture. Fifth, at the rock mass scale, sandstone outcrops tend to release huge blocks defined by widely spaced joints. Hence, block talus deposits occur below cliff lines and may extend far onto the footslope.

It needs to be noted that the above-mentioned features in the Sudetes are almost endemic to the Cretaceous sandstone terrain. The remaining parts of the mountain area, although hugely diversified in terms of rock type and age, do not show any geomorphological parallels to the sandstone tablelands and escarpments (Migoń, 2011). Moderately steep all-slopes topography (*sensu* Twidale, 1982, 372 pp.), with occasional rock outcrops and widespread fine-grained regolith, is the dominant physical landscape.

Study area

The study area is located in the central part of the Sudetes range – a mountainous terrain of complex morphology, striking NW–SE along the boundary of the Czech Republic and Poland. Although the Sudetes as a whole constitute a block-faulted massif, with numerous second-order horst and graben structures delimited by normal faults active in the late Cenozoic (Zuchiewicz, Badura, & Jarosiński, 2007), in the central part of the Sudetes the impact of differential tectonics was relatively minor. The gross features of relief are the outcome of long-term differential erosion acting upon sedimentary formations spanning the period from Carboniferous to Cretaceous (Tásler, 1979). They form a large structural unit known as the Intra-Sudetic Trough. Our focus in this paper is on the youngest formations within the trough, laid down during several transgressive–regressive cycles in the Late Cretaceous, between Cenomanian and Coniacian (Wojewoda, 1997). In fact, at that time the former intramontane trough was connected with the sedimentary realm in the present-day Bohemian Cretaceous Basin. Subsequent separation of these two areas of Cretaceous rock occurrence is due to uplift and erosion along the regionally important Hronov – Poříčí fault zone (Valenta, Stejskal, & Štěpančíková, 2008).

The Cretaceous sequence includes various sedimentary rocks, from quartz sandstone and locally conglomerate through arkosic and glauconitic sandstone, siltstone, mudstone, calcareous and siliceous marl, to claystone (Tásler, 1979; Wojewoda, 1997). Among them, sandstones are the strongest and support rock escarpments and structural plateaus, with a range of subordinate medium and minor landforms. Local differences in lithology, structure and magnitude of uplift account for geographical divisions of the area. Consequently, a few distinct sub-regions are distinguished (Fig. 2).

The Stolowe (Table) Mountains constitute the highest part of the central Sudetic sandstone tableland, peaking at 919 m a.s.l. (Mt. Szczeliniec Wielki). The main terrain unit is an elevated plateau underlain mainly by fine-grained sedimentary rocks, while massive arkosic sandstones make the northern rim, with vertical rock faces up to 40 m high in the upper slope. Above the main plateau level remnants of an upper level rise, including two more extensive

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