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Human impact and geomorphic change through time in the Sudetes, Central Europe

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ABSTRACT

The paper provides an overview of various types of human impact on the geomorphic system in the Sudetes. The article sets the landform change in the temporal and spatial context and addresses the issue of persistence of landforms and other changes brought about by humans. This is discussed on the example of four representative case studies, reflecting both heterogeneity of the Sudetes and different levels of recognition of human – environment interactions during historical times. We discuss the direct and indirect geomorphic effects of human activities such as agriculture, ore and coal mining, quarrying, forestry and tourism, and the themes explored are soil and gully erosion, slope terracing, impact of quarrying, mining and road building, alteration of fluvial systems, and sedimentary record. In the Sudetes human impact started to play an increasing role in modifying geomorphic system since the 13–14th century but the trend was not linear, with periods of decreasing human impact, especially from the mid-20th century when many areas were abandoned. The persistence of human imprint in the Sudetes varies and is related to the type of activity and the size of anthropic landforms rather than to time elapsed since the activity ceased or the landform was created. The most altered geomorphic environments include areas subject to intense mining, bare, unprotected agricultural slopes, terraced slopes, and valley floors, which are “hot spots” of human impact. While mining left the most obvious legacy, the impact of agriculture was most widespread.

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1. Introduction

Assessing human impact on the environment is one of the crucial themes of research focused on the Quaternary. Studies vary both in spatial scale, from site-specific investigations (i.e. Madeja et al., 2010; Pawłowski et al., 2015) to worldwide overview of human impact (Goudie, 2000; Szabó et al., 2010), and temporal context, referring either to prehistoric, historic or very recent changes of the ecosystems and morphological processes triggered by various human activities (e.g. Gębica et al., 2013; González-Amuchastegui and Serrano, 2015; Woodbridge et al., 2016). Additionally, these studies use multiple methodologies, including direct field evidence, various proxy data and modelling (i.e. Kalicki et al., 2008; López-Sáez et al., 2014; Chapman, 2017). The presented paper focuses on the long-term human impact on the geomorphic system in the Sudetes and its changes through time. It is based on

literature review and published data, now set into long-term and range-wide context, as well as on new evidence emerging from field work and high-resolution LiDAR data, made available recently.

The Sudetes are a medium-altitude mountain range in Central Europe, straddling the Czech/Polish border and extending into the easternmost part of Germany (Fig. 1). Being the highest tract of terrain within the Central European belt of uplands, low and medium-height mountains, they assume the key marker role in studies of geomorphology and Quaternary of Central Europe (e.g. Engel et al., 2010, 2014; Stěpančíková et al., 2010; Tremel et al., 2010). They are also known for the long history of human impact on the environment which left both subtle and spectacular imprint on landform inventories and geomorphic systems. However, this rich and multi-faceted history has so far been presented in fragmentary ways, and most of it in local publications, whereas a comprehensive picture is missing. Hence, there remains a gap in broader understanding of the nature of human interference with geomorphology of this important Central European mountain range in the most recent time slice of the Quaternary.

In this paper we intend to partially fill this gap and aim to: (a)

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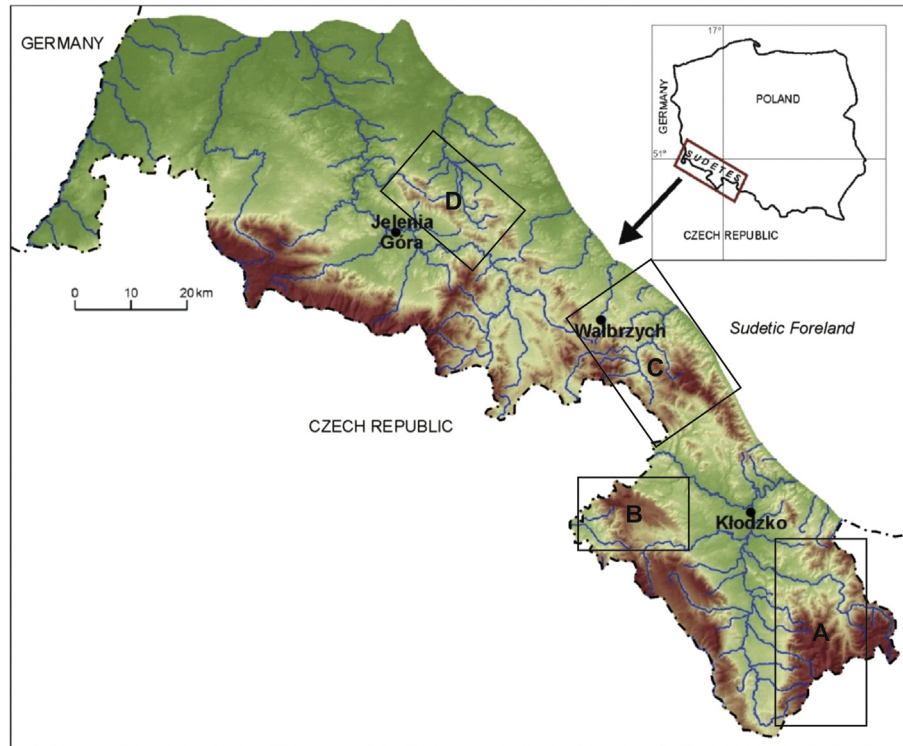


Fig. 1. Study areas: A – Śnieżnik Massif - Złote Mts., B – Stożowe Mts., C – Sowie Mts. - Wałbrzych Upland; D – Kaczawskie Mts. and Foothills. See more in Table 1.

provide an overview of various types of human impact on the geomorphic domain; (b) to set landform change in the temporal context, broadly known from historical sources; (c) address the issue of persistence of landforms and other changes brought about by humans. The structure of the paper reflects heterogeneity of the Sudetes and different levels of recognition of human – environment interactions during historical times. Geological and topographic terrain complexity on the one hand, and complicated socio-political history on the other one preclude generalizations, especially as far as quantitative data are concerned. Therefore, we will focus on four specific, but representative areas within the Polish part of the Sudetes, where various human activities left its imprint. The final picture is largely qualitative, although supplemented by quantitative data wherever possible. This is mainly because such quantitative data sets have been collected in small areas (individual slopes, small catchments) and their upscaling to the entire mountain range does not seem feasible and indeed, meaningful. Nevertheless, they seem sufficient to identify main impacts and trajectories of change which typify the latest Quaternary.

2. The Sudetes

2.1. Physical environment – landforms and geology

The Sudetes extend for about 300 km in the NW–SE direction, separating the lowlands of the central-north part of the Bohemia in the south from the Silesian and Lusatian Lowland in the north (Fig. 1). They represent a medium-relief type of mountains, with altitudes generally below 1200 m a.s.l., a moderate mean slope of 7.7° and only c. 8 per cent of the area being inclined more than 15° (Placek, 2011). However, the second-order topography of the Sudetes is one of interspersed mountain massifs and ranges, hilly lands and marginal uplands, wide intramontane basins and deep river gorges connecting the basins (Fig. 1) (Jahn, 1980; Migoń,

2008). Water divides are often flattened, locally giving way to wide, high-elevation surfaces of low relief. Slopes below are of different inclinations, but hardly exceeding 30°, thus of low and moderate angle, allowing for various kinds of human use. Altogether, this complicated spatial pattern is thought to reflect superimposed effects of differential uplift and subsidence, dissimilar rock strength and unequal resistance of various rock complexes against weathering and erosion, with additional consequences resulting from the advances of the Scandinavian ice sheets into the northern, marginal parts of the Sudetes (Migoń, 2011).

The Sudetes are characterized by huge lithological diversity. The crystalline basement consists predominantly of gneiss, mica schist, occasionally greenschist, slate, amphibolite and quartzite, intruded by mainly Carboniferous granites. Since the Carboniferous the sedimentary cover has started to build up and is present especially in the central and north-western part of the Sudetes. The sedimentary series are dominated by clastic rocks, with an important role of Upper Cretaceous sandstones. This diverse geology, via differential weathering and erosion, underpins the present-day relief and hence, dictates land use patterns. Many pre-Variscan rock series were recognized to contain valuable ores and these were mined, locally on a large scale. Likewise, coal seams in Carboniferous sedimentary formations supported the coal mining industry. Solid rocks were also extensively quarried for building stone production and the use of local stone has contributed to the identity of cultural landscapes, locally in a decisive way as in certain Cretaceous sandstone areas (Adamović et al., 2010; Migoń and Latocha, 2013).

2.2. Climatic background

The contemporary climatic conditions of the Sudetes reflect regional circulation patterns within Central Europe which in turn dictate the occurrence of extreme meteorological events (Sobik,

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