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Dirt road: A geomorphological and geochemical record of Late-Holocene human activity in the catchment of Lake Radacz (Central Pomerania, Poland)

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ABSTRACT

The paper offers a discussion of the record of human activity in the relief and sediments of a selected lake catchment in Central Pomerania in Poland. One of the basic markers of human activity here is a change in the lake-water level. The dropping level (on average, 1 m/100 years) made it possible for people to develop successively exposed stretches of land along the shore. An analysis of the Polish National Archeological Records and archival maps showed that human development and impact appeared in the lakeshore zone as early as the Neolithic. In Central Pomerania, the changes were especially intensive in the Late Holocene; in the catchment of the lake under study they included a 100% increase in the length of nearby roads. In the archives of its paleoenvironmental data, most traces have been left on farming terraces, while a poorly studied form of record of human activity is a dirt road running parallel to the shoreline. Geodetic and geochemical examination has revealed that the road is a stimulant of change. Its wheeled traffic mixes the accumulated and eroded material, and this causes changes in the shoreline section: the road cutting, which is 2 m wide, deepened, while material accumulates in the form of 0.5-m-wide lateral bars. The compaction of the material brings about changes in the structure of the ground or soil (its density, porosity, compactness, moisture), which affects its level of oxygenation and water-logging, and, consequently, its iron content. To establish this, a speciation analysis was carried out using the Fe(III)/Fe(II) ratio. It was determined that the lower the ratio, the higher the susceptibility of land to deformation owing to an increase in soil density, a drop in its water capacity, reduction conditions, and the predominance of Fe(II). The research discussed here is only a pilot study, but the authors see extensive opportunities for using speciation analysis in geoarcheology.

1. Introduction

Humans perform an important morphogenetic function in the environment (Starkel, 1989), because their activity can disturb its stability and start denudational processes. Over recent decades, special importance has been given to anthropogenic denudation, the term introduced into Polish geomorphological literature by Dylik (1954). Jones (2001) divided slope processes moulding the relief of the last 1000 years into natural, human-modified, human-induced, and human-made. Thus, anthropogenic denudation can be taken to include all natural processes of dissecting and lowering the land surface initiated by people.

The first changes in relief, caused by advancing deforestation and the spread of farming, can be dated back to about 5 thousand years ago (Czebreszuk, 2009). Depending on their knowledge, technical skills and living needs, people transformed the environment. The most abundant traces of human activity have been found for the Late Holocene, which started between ca 5400 and 4900 cal BP, depending on the region of the world (Porter, 2000). On the basis of the development of mountain glaciers, Grove (2004) distinguishes the Subboreal (3800 and 3100 cal BP) and Subatlantic (3000 and 2300 cal BP). For Turner et al. (2014), the beginning of the Common Era is primarily the mark of climate changes and human activity that have transformed lakes and peatlands. At the start of the second millennium, evidence of a generally warm

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climate (reconstructed from wood macrofossils, upper tree limits, pollen, diatoms, ice-cores, and other proxy data) and reduced glacier activity (proglacial lake sediments) between 900 and 1240 AD can be found in various parts of the world (Bradley et al., 2003; Grove, 2004; Wanner et al., 2008). Lowell et al. (2013) suggest that the Late Holocene ended between 1050 and 1150 AD. The last Holocene event has been termed the Little Ice Age. In glaciological terms, it lasted from 1300 to 1850 (Matthews and Briffa, 2005), and in climatic terms, from 1570 to 1900 (Pfister, 1980). Today the Late Holocene, persisting for the last 4–5 thousand years, is called the Neo-Glacial (Luckman, 2004), and the Little Ice Age marks the last glacial transgression. Recently, however, there has been talk about distinguishing a new geological epoch: the Anthropocene. The term, proposed by Crutzen (2002), reflects human interference with the environment. Its manifestations include the rapid urbanisation of the world, fast depletion rate of fossil fuels that have been accumulating for hundreds of millions of years, as well as environmental pollution and emission of greenhouse gases. According to Crutzen (2002), the new geological epoch began 200 years ago.

At the turn of geological and historical epochs, in certain environmental conditions, human civilisation developed causing, among other things, changes in relief. Among forms of human impact on relief, Haigh (1978) sees anthropogenic processes connected with construction, extraction and hydrological activities. Szpikowski (2010) distinguishes five periods in the human-made transformation of relief in the Perznica catchment (Central Pomerania): adaptation, defence, defence mixed with aggression, expansion, and aggression. In the opinion of Nogaj–Chachaj (2009), in some cases prehistorical changes in relief caused by people in their effort to satisfy such basic needs as safety and access to water and fields brought about far-reaching environmental changes. This meant that over the last few thousands of years, the river valleys along which people built their strongholds and settlements were especially susceptible to changes in morphology. Water routes were of prime importance for transport at a time when woodland covered nearly the entire country (Robak, 2008). Thus, the greatest changes in relief took place in the shore zones of lakes and rivers used not only as living places but also as fords. That is why the most abundant traces of economic and climate-related human activity have been found in river valleys (Kalicki, 1997; Kalicki et al., 2008; Hildebrandt-Radke, 2013).

The research on environmental and cultural processes in the shore zones of lakes, both in the past and today, covers many aspects and involves the use of various study methods. Peoples' relations with a lacustrine environment can be reconstructed with the help of geoarcheological methods described at length by Hildebrandt-Radke (2007), but scholars have often emphasised the role of the research on contemporary geomorphological processes (e.g. Lamentowicz et al., 2007; Kostrzewski et al., 2008). Studying those processes, including denudation, in the shore zone of lakes is no easy task, if only because, in addition to their numerous ecological functions, those water bodies also perform a recreational one. Given the dynamics of tourist traffic, it is practically impossible to set up a measurement system in such locations. Thus, one must look for indications of degradation by way of indirect studies. A possible approach is to analyse the chemical composition of sediments to determine patterns of the distribution of heavy metals within lakeshore zones.

According to Hildebrandt-Radke (2007), geochemical analysis is a useful tool in archeological studies on condition that it is skilfully employed. Aston et al. (1998) stress that one should pay attention to factors that might disturb the original concentrations of the analysed elements in deposits, like migration of elements, mineral fertilisation, discharge of waste, effect of transport routes, and land cultivation. The least-studied factor affecting the environment of lakeshore zones is roads. Although it has been found that dirt roads are stimulants of changes in relief, especially in loess areas (Gardziel and Rodzik, 2001) and on flysch mountain slopes (Froehlich and Słupik, 1986), there have been no results concerning lakelands and lake catchments.

Changes in transport routes have only rarely been studied by archeologists and geomorphologists. A major contribution to this field has been the works by Wąsowicz (1971) and Wyrozumska (1971). One might say that little has changed over the last 2000 years in the matter of the choice of a place to live. In turn, the choice of a place to relax is determined by the proximity of water and woods as well as a local road. That is why building lots situated on a lake and close to road infrastructure are sold first and fetch the highest sums of money. On the one hand, Articles 15 and 27 of the Water Act of 18 July 2001 (Official Gazette no. 115/2001, position 1229) ensure each citizen access to the shore of a lake, but on the other hand, the attitudes observed on lakeshores are often far from pro-ecological. It happens that tourists illegally drive into a forest, set camps, wash their cars, or leave litter. Thus, human impact on the shore zone of a lake has always been determined by its accessibility.

The aim of this paper is to examine the way in an unsurfaced road that appeared along the water line of a lake not more than 100 years ago is manifested in the relief of its shore zone and in the geochemistry of the surface deposits in its shore zone. An important reference point for modern denudational processes and deposits will be an analysis of the length of roads and changes in the lake-water level over the last 2000 years. The time scale adopted is directly connected with the period of factual human impact on the relief of north-western Poland (Kulczycka-Laciejewiczowa, 2004). However, if we assume, after Crutzen and Stoermer (2000) as well as Zalasiewicz (2013), that over the last 160–200 years we can observe increased rates of erosion and sedimentation of deposits as well as elevated levels of nitrogen, phosphorus and metals, then the research conducted also embraces the Anthropocene. To achieve the above aim, use will be made of classical geoarcheological methods and tools, including geochemical analysis (Aston et al., 1998).

One of the metals whose biological importance in sediments and soils has so far been low is iron. Because of its naturally high level and low mobility, the interest in determining its content has so far been limited. However, with the development of studies on the speciation of elements and efforts to use the information on their levels (the geochemical 'fingerprint') to monitor processes taking place in the environment (Kozak and Niedzielski, 2009, Kozak et al., 2012), the interest in iron speciation has increased. Determinations of the levels of various forms of iron rely on colorimetric methods that utilise their selective ability to form colour complexes with sulphocyanateions (in the case of Fe(III), Tarafder and Thakur, 2005) and with 2,2'-dipyridyl (in the case of Fe(II), Whitehead and Malik, 1975), thus competing with the latest combined techniques (Gonzalvez et al., 2009). In determinations of total iron content, colorimetric methods have practically been replaced by spectrometric ones (Hosseinimehr et al., 2007).

This article presents an innovative use of iron speciation, or more exactly, an analysis of the ratios of iron forms (Awadallah et al., 1996; Curtin et al., 1998). The indicator of changes connected with the degradation of lakeshore zones is the Fe(III)/Fe(II) rate. The basic assumption made in the research, after Jóźwiak (2011), was that the relative stability of iron (II) and (III) is low, and that even small changes in the conditions of the natural environment (e.g. due to human impact) can cause oxidation of Fe(II) to Fe(III) or a reduction of Fe(III) to Fe(II).