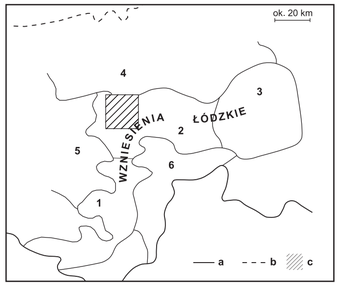

Fig. 1 The position of Łódź within the geomorphology of Central Poland according to Gilewska (1986).

a. northern border of Polish Upland
b. maximum range of the last Scandinavian ice sheet
c. research area
1. Bełchatów High Plain
2. Łódź High Plain
3. Rawa High Plain
4. Łowicz-Błonia Plain
5. Łask Plain
6. Piotrków Plain

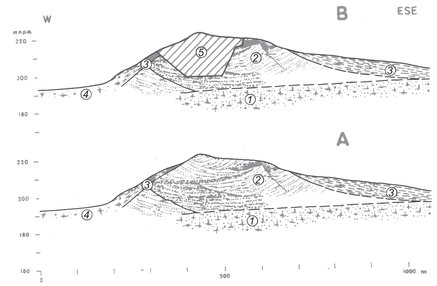

Fig. 3 Józefów.

A. Cross-section of a kame according to Klatkowa (1972)
B. Changes resulting from sand and gravel quarry and from infilling with waste
1. lower moraine silt
2. kame sand and gravel
3. ablation silt
4. upper moraine silt
5. waste infill

J. Goździk 1977

Photo 2. RadogoszczZachód: meandering channel of the Sokołówka River

J. Goździk 1977

Photo 1. Mileszki: gully

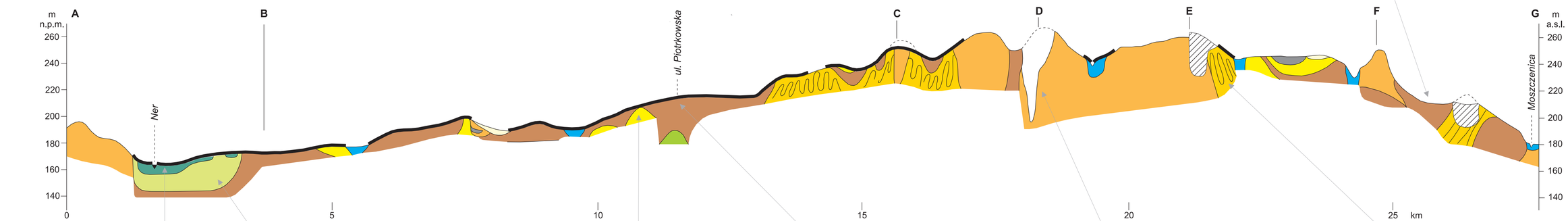

Fig. 2 Geomorphological and geological cross-section through significant landforms Cretaceous

Kreda
1. marl

Central Polish (Saalian) Glacial - Warta Stadial
2. ground moraine - till
3. glaciofluvial sands and gravels
4. glaciofluvial sands
5. disturbed sands and gravels with clay and silt

Eemian Interglacial
6. Peat

Vistulian Glacial
7. sands and silts found in small valleys
8. aeolian sands
9. fluvial sands of fill terraces

Holocene
10. alluvial sands and silts of valley floor
11. anthropogenic sediments
12. anthropogenically transformed surfaces

A G points where the cross-section direction changes

K. Turkowska 1990

Photo 8. Lublinek - Ner Valley: valley floor sediments

K. Turkowska 1990

Photo 7. Lublinek - Ner Valley: Vistulian fill terrace sediments

J. Goździk 1977

Photo 6. Łódź, Mickiewicza St near Żeromskiego St. Two boulder clay (ground moraine) beds separated by sand

J. Goździk 1993

Photo 5. The corner of Piotrkowska St. and Struga St. Exposed boulder clay (ground moraine) covered with aeolian sand and a thin layer of anthropogenic sediment

J. Goździk 2001

Photo 4. Stoki: glaciofluvial sand and gravel of a kame. The deepest gravel pit in Łódzkie Region (70m)

J. Goździk 1977

Photo 3. Nowosolna: accumulated sandy deposits from the terminal part of a kame

THE ŁÓDŹ ATLAS

Sheet VIII: Landforms

Jan Goździk & Jadwiga Wieczorkowska

The environs of Łódź are located in a vast geomorphological province – the Central European Lowland, in proximity to its southern border with the Polish Uplands. About 65 km to the north of Łódź runs an important geomorphological border, indicating the southern extent of the last ice sheet in Poland (fig. 1). At the same time, it constitutes the border of two subprovinces: Southern Baltic Lake districts and the Central Polish Lowlands (according to the classification by Gilewska). Łódź and its region are situated within the limits of these lowlands, in the macroregion of the Łódź Heights and in the mesoregion of the Łódź High Plain. Some geographers used to describe the region of Łódź itself as belonging to the uplands area. However, it cannot be considered an upland, because of its low altitudes (below 300 m a.s.l.) and the absence of the older substrata in the topography. On the basis of the similarity of morphologic features and, to a considerable extent, the internal structure and the origin of the landforms, the following geomorphological units have been identified on the territory of Łódź (map 1):

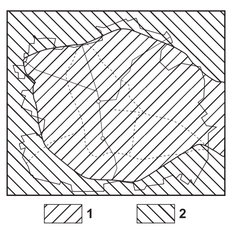

Fig. 4. Authors
1. J. Goździk
2. J. Wieczorkowska

Łagiewniki Hills
- Stoki Plateau
- Rogowskie Flatness

Edge zone of the Łódź Heights
Łódź Plain
- Higher level the inner city
- Lower level Retkinia

Smulsko basin
Moszczenica valley
Bzura valley
Sokołówka valley
Łódka valley
Jasień valley
Olechówka valley
Ner valley

The landforms on which Łódź is located were produced by the action of the ice sheet, glacial waters, and processes that took place in the periglacial environment, and temperate climate. The features of the land relief and its origin have been the subject of many studies, the most important of which are listed in the bibliography.

In the Pleistocene, Scandinavian ice sheet advanced over this area several times, leaving deposits up to 150 m thick. The last of these was the Warta ice stadial that produced an assemblage of landforms which constitute the most important elements of the topography to this day. The dominant form is the **kame plateau** located in the north-eastern part of the region (altitude 240–280 m a.s.l.), composed of sands and gravels left by glacial water in the ice-free spaces of the melting ice sheet (map 1, map 2, fig. 2, photo 3, photo 4).

The surface descends steeply from the plateau towards the **erosion level** composed of predominantly sandy formations, deformed to a varying degree, truncated and in some places covered with a sand and gravel or clay cap. Only the eastern edge of the plateau is in direct contact with the undulating, primarily clay **moraine upland**. A similar plateau, left by the receding ice sheet, extends below the erosion level and descends to the west and south (photo 5, photo 6), in the lowest places taking the form of **kettle holes** left by ice blocks. Small hills rise above the surface of the moraine high plain. These are **kames**, landforms composed of sand and gravel that were deposited in ice sheet crevices. Kames are usually scattered, but sometimes they are clearly grouped in clusters, e.g. in the region of Ruda Pabianicka and Chojny (fig. 3).

Directly to the north of Łódź, there are hills of the **terminal moraine,** built from glaciotectonically deformed sand and gravel deposits and clays (the ridge to the south west of Łódź has a similar structure). Further to the north, the terrain descends towards the Warsaw-Berlin proglacial valley. The last traces of the action of glacial water are the **outwash fans** visible in the north-western and south-eastern outskirts of the city. Melting ice blocks carved out **closed hollows** in the surface of the moraine plateau and outwash fans, some of which are filled with lakes.

In the Eemian interglacial climate, similar to the contemporary one, lakes gradually became shallower and overgrown with vegetation producing peat (map 2, fig. 2). A network of river valleys also began to form, following the lowest lying land.

During the next cold period (Vistulian glacial), the region of Łódź was exposed to the effects of a periglacial climate. Vegetation, which had been luxuriant in the Eemian period, diminished considerably, at times even disappeared, enabling erosional and other processes of transporting loose material down the slope. Long-lasting permafrost developed, leading to widespread impermeability of soils. Surface runoff was extensive and powerful, forming a network of now-dry **denudation valleys**, carved into previously developed landforms. The denudation valleys opened into river valleys carrying large amounts of sediment (fig. 2). The coolest and driest period was marked by intensive aeolian sand transportation processes. Some of this sand found its way into valleys where overburdened rivers flowed in multi-channel riverbeds carving out large river floors. In the final stage of this period, emerging vegetation halted the movement of aeolian sands, leading to the formation of aeolian covers (photo 5) and **dunes**. The process of filling in lake basins and depressions in the surface of the moraine high plain further continued throughout the entire Vistulian period.

The warming at the end of the Vistulian period and the return of temperate climate in the Holocene caused three more changes. Carrying larger volumes of water and eroding deeply into their valleys, the rivers cut through the former sediments, reducing them to **fill terraces** (photo 7). Today, rivers flow in single channels (photo 2) meandering through much narrower **valley floors** (photo 8). Vegetation, richer than in the Vistulian period, consolidated the transformed and diminished glacial and periglacial landforms. Nonetheless, landforms produced by periodic water flow – **ravines** (photo 1) and **gullies** did develop in some denudation valleys.

The action of all these geomorphological processes shaped the relief as shown on map 2. In the north-eastern part, where the terrain rises to its highest points (map 1), and where the topography is strongly varied, the land drops most steeply, in some places by more than 10°(map 3). This is in contrast to the outstanding part of Łódź that features weak terrain inclination, save some narrow valleys.

In Łódź, just like in other highly urbanized areas, there are found discernible relief transformations caused by economic human activity. A large number of new relief forms have developed and numerous natural landforms have undergone transformation. At the same time, anthropopression has entailed the effects of the natural relief-shaping factors being either intensified or weakened.

The map of the anthropogenic relief transformations (map 4) shows the landforms that have developed as a result of human economic activity, and presents the resulting transformation of natural landforms. These transformations are shown in three stages:

1. up to 1914, 2. from 1914 to 1960, 3. from 1960 to 2001

In Łódź, among the landforms ensuing from destructive human activity prevalent are **quarry pits** mined for mineral raw materials for construction purposes. The type of the raw materials and the scale of their extraction have been changing as the building technologies have advanced. Until the 1970s, the most widely-used building material was brick, and clay deposits necessary for brick production can be commonly found close to the surface, except in the eastern part of the city. Brick yards, accompanied by vast but shallow clay-pits, were built on the outskirts of the city during the successive stages of its development (map 4). In this period however, relatively small amounts of sand were used in the building industry, therefore only some of the quarry pits with diameters greater than 100 m could be shown on Map 4 in view of its scale.

A fundamental change in the type of extracted raw materials took place at the turn of the 1960s and 1970s, when precast concrete slabs began to be used in the building industry. At the time, brick yards were being closed down, while concrete slabs manufacture required bulky quantities of sand and gravel. It was then that large and deep sand and gravel quarries were set up (especially in kames fig. 3), some of which are still in service today (map 4), including the deepest sand and gravel pit in the województwo Łódzkie (photo 4).

As a result of intensive aggregate extraction, some kame hills disappeared and the land was levelled. A number of pits, the mining of which had been discontinued, were filled with waste and some were restored to the approximate shape of their original forms. The depth of other pits diminished and their slopes became less steep due to the effects of natural processes.

Cuttings and **embankments** were formed mainly along railway lines and roads to produce even levelled surfaces in the areas with more diversified topography. In the case of roads, embankments or cuttings were built for the purposes of constructing grade separated junctions.

Few **waste heaps**, with the sides in excess of 100 m, therefore large enough to be shown on a 1:100 000 map, are basically built from the soils excavated for the purpose of laying building foundations on new and large housing and industrial estates.

Valley floors are some of those relief elements that have been most strongly affected by human activity. Valley floors that in natural conditions are visibly distinct in the river valleys, have in places undergone so strong transformations that they are hardly visible in the city landscape. The effects of these transformations at the various stages of the city's development overlapped and are now difficult to take apart. Therefore, map 4 presents the cumulative extent of such transformations.

Built-up areas can be described as specific landforms themselves, the upper surface of which marks the upper boundary of the lithosphere. They affect, e.g. the air flow dynamics near the terrain surface and surface water drainage.

Given the strong anthropopressure, the relief transformation process in the city never stops.

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