Geographia Polonica
2016, Volume 89, Issue 3, pp. 389-404
http://dx.doi.org/10.7163/GPol.0065

INSTITUTE OF GEOGRAPHY AND SPATIAL ORGANIZATION
POLISH ACADEMY OF SCIENCES
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CONTRIBUTION OF THE DEPARTMENT OF GEOMORPHOLOGY AND HYDROLOGY OF MOUNTAINS AND UPLANDS IGSO PAS IN KRAKÓW TO THE DEVELOPMENT OF POLISH GEOMORPHOLOGY (1953-2012)

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Abstract

The Department of Geomorphology and Hydrology of Mountains and Uplands in Kraków was established in November 1953 by Professor Mieczysław Klimaszewski. Its first task was to act as lead partner in detailed geomorphological mapping. Parallel with the mapping efforts, studies developed in two directions: (1) the evolution of relief during the Quaternary, based mainly on studies of sediments carried out in cooperation with other disciplines, where the greatest attention was turned to the role of the Holocene period before and after the Neolithic evolution; (2) present-day geomorphic processes based mainly on the monitoring of the circulation of water and mineral matter by experimental field stations. Joint studies on the palaeoenvironment and present-day processes played an important role in understanding the evolution of relief, in the forecasting of future changes, and in its practical evaluation. The concept of rational land use was developed based on the evaluation of the Carpathian landscape. Furthermore, our interest in the geomorphology of mountain areas pushed us to cooperate with countries carrying out studies in European mountains, to organise the Carpatho-Balcan Geomorphological Commission, and later to send expeditions to Mongolia (1974-1980) and India (since 1983), as well as to organise international commissions and projects related to INQUA and PAGES.

Key words

geomorphological mapping • evolution of relief • monitoring • field stations • expeditions • mountain areas

VARIA: HISTORY

Early aim: geomorphological mapping

Up until 1953, Polish geomorphology had concentrated on regional studies of landscape evolution, especially during the Pleistocene (most of Polish territory was covered by Scandinavian ice-sheets) and on the characteristics of particular forms (terraces, landslides, karst, etc.).

The Department of Geomorphology and Hydrology of Mountains and Uplands was established as a small laboratory inside of the Institute of Geography of the Polish Academy of Sciences (IG PAS) in November 1953 by Mieczysław Klimaszewski, professor at the Jagiellonian University[1]. The unit's main task was to develop detailed geomorphological, as well as hydrographic, maps of southern Poland using Klimaszewski's concept for reconstructing the evolution of relief. Therefore, all landforms were mapped during the field survey to reflect various types of morphography and morphometry. Their origin and age were shown in different colours to reveal the history of the landscape (Klimaszewski 1956, 1963).

This mapping involved 20-50 persons from several universities every year (mainly assistants and postgraduate students). This survey formed the basis for reconstructions of the evolution of relief in various landscape zones of the country. As a result of a joint effort with a similar laboratory in northern Poland (Toruń), within two decades about 20% of the whole country was covered by maps at scales of 1:50,000 or 1:25,000. The multi-colour print was very costly and only 2 maps were published in the first decade. The concept of showing the evolution of relief on one map was truly innovative, and after the presentation of the first issues of the map at the International Geographical Union (IGU) Regional Congress in Rio de Janeiro in 1956 and then at the next IGU Congress in Stockholm in 1960, Prof. Klimaszewski was elected the chairman of a new Commission on Geomorphological Mapping. The international legend (Klimaszewski 1963) was prepared and published over a period of several years, which was then adopted in several countries. Klimaszewski was awarded the Patron's Medal of the Royal Geographic Society in London. The detailed maps that were devised formed the basis for the preparation of monographs on the relief of Poland (Klimaszewski & Galon 1972) or of several regional monographs on landscape evolution, as well as for a general geomorphological map of Poland – prepared at a scale 1:300,000 and published at 1:500,000 (Starkel et al. 1980). That later also served as the background for a new geomorphological regionalisation of the whole country (Gilewska 1986).

Studies on relief evolution and palaeogeography

The identification of both landforms originating in the past and of sediments in the Carpathians and its foreland turned our attention to the problems of the transformation of older landforms in the Quaternary, especially in the period since the last cold stage running up to the Holocene, i.e. to a development phase that was not fully comprehended.

The challenges related to the field trip held during the VI International Union for Quaternary Science (INQUA) Congress in Poland when various glacial and periglacial features were presented (Klimaszewski 1961), and later during the analysis of thick slope deposits exposed during the construction of dams in the San valley (Dziewański & Starkel 1967), were indeed inspiring. The study of Holocene alluvia, with subfossil oaks, helped to recognise several phases of increased fluvial activity connected with humid phases (Starkel 1960). This concept has been extended to other facies as well as to the whole of Europe (Starkel 1966). After the Symposium of the INQUA Holocene Commission in Poland in 1972, the centre of Holocene

[1] There is a detailed discussion with Professor L. Starkel in an extensive interview with J. Wolski published in "Geographia Polonica" two years ago (Starkel & Wolski 2014).

studies in Poland was located in our Department for about three decades. In 1977 Starkel published a monograph on the palaeogeography of the Holocene in Polish, probably the first summary of its kind in Europe. Next year, the decade-long International Geological Correlation Programme (IGCP) project No. 158 "Palaeohydrology of the temperate zone during the last 15,000 years" was started, led by L. Starkel and B. Berglund from Sweden. Among the detailed studies on selected river valleys, the largest valley investigated was that of the Vistula river examined over its whole length by a team of about 30 Polish geomorphologists and other specialists. The outcomes of the studies were published in a series of 7 volumes (Starkel 1982-1996), and a summary can be found in the final volume *Temperate Palaeohydrology* (Starkel et al. 1991). This work was supported by several hundred radiocarbon and dendrochronological datings carried out in the ^{14}C laboratory in Gliwice Polytechnic (M. Pazdur) and the dendrochronological laboratory at the University of Science and Technology in Kraków (M. Krąpiec) as well as by micromorphological soil studies (Budek 2010). The catchment of the upper Vistula was mainly investigated by a team from our Department (P. Gębica, E. Gil, T. Kalicki, K. Klimek, E. Niedziałkowska, L. Starkel). Parallel with the fluvial studies, alternative investigations documented synchronous climatic fluctuations in other facies of deposits: lakes and mires (Ralska-Jasiewiczowa & Starkel 1988; Starkel et al. 1996), landslides, and debris flows in the Tatra Mts. (including Kotarba & Baumgart-Kotarba 1997). The palaeogeographic problems were continually studied in the framework of the next European project led by B. Frenzel in which we participated (A. Kotarba and others). In these reconstructions we also discovered those phases with clustering of extreme events (Niedziałkowska et al. 1977; Starkel 1999) as well as describing the effects of human activity (Kalicki 1991; Starkel 2005). The studies on fluvial activity in the Late Glacial and Holocene were extended to the adjoining countries of Belarus (T. Kalicki) and western Ukraine where similar regularities of evolution were found (Starkel et al. 2009).

Studies on fluvial change also covered the Late Glacial and the whole of the last cold stage (Gębica 2004; Starkel et al. 2007). Cooperation with the ^{14}C laboratory in Gliwice helped to modify fluvial chronology (Starkel et al. 2006), and later an interdisciplinary team proposed a new Holocene climatostratigraphy for Polish territory (Starkel et al. 2013). Our activity, in addition to American and British studies, created the possibility which permitted the formation of the new INQUA Commission on Global Continental Palaeohydrology GLOCOPH in 1991 with L. Starkel as the first chairman. He presented the concept of palaeohydrological studies on a global scale (Starkel 1989).

Our Departmental team has also conducted other studies on the evolution of relief in Poland in the past. Gilewska (1964b) summarised studies on fossil karsts in Central Europe, organised an international conference in 1967, as well as summarising knowledge on the evolution of relief in the Tertiary in Poland (Gilewska 1987). Gerlach (1990) discovered a dominant role for periglacial processes in the formation of a great deflational depression in the flysch Carpathians and identified thick Carpathian loess on their foreland (Gerlach et al. 1993). Baumgart-Kotarba (1983), after studies of glacial and fluvioglacial forms in the foreland of the Tatra Mts. and together with A. Kotarba aided by geophysical methods, evaluated the scale of transformation of valleys in the Tatra Mts. through glacial erosion (Baumgart-Kotarba et al. 2008). Furthermore, she presented new facts on the origin and transformation of the Orawa–Nowy Targ intramontane basin by tectonic movements and fluvial activity during the Neogene and Quaternary in several studies (including Baumgart-Kotarba et al. 2004). The problem of climatically controlled terraces in uplifting mountains was discussed by Starkel (2003a).

Studies on present-day geomorphic processes

Professor Klimaszewski considered that parallel observation of present-day processes was needed in order to explain the evolution of existing forms. At that time studies on soil erosion in Poland were mainly undertaken by agronomists and pedologists. In 1955 Gerlach (1966, 1976) started to measure slope wash and soil creep in our laboratory examining various land use settings in the Carpathians. Using simple traps of his own construction, he confirmed that the rate of slope wash over potato fields is at least two orders higher than on other crops or on meadows. He also conducted the observations during snow-melt or periods of heavy rainfall.

In the Tatra Mts., mainly based upon work at our station located at the upper tree line at 1500 m a.s.l. which doubles as a meteorological station, seasonal observations on physical and chemical weathering, frost activity and gravitational processes, which reflect the role of vertical zonality and slope aspect, were conducted and developed by Kotarba (1976, 1984, 1992) and Kłapa (1980). Kotarba (1997) documented the trends in the transformation of slopes inherited following preceding glaciations, and compared them with other mountains. Kotarba et al. (1987) published a summary of present-day relief transformation in the Tatra Mts. This is a supplement to the great monograph entitled *Relief of the Tatra Mts*. (Klimaszewski 1988). In the last two decades more attention has been dedicated to cryogenic processes in the vertical belts in the high mountains of the Tatra and other European mountain ranges (Kędzia et al. 1998; Rączkowska 2007).

In 1967 a new research station started to function at Szymbark in the flysch Carpathians. There, on representative plots, individual slopes, or landslides and catchments, monitoring of all the parameters of water circulation on slopes was initiated for the first time in Poland (Słupik 1973, 1981). The range of the studies performed also comprised: slope wash (Gil 1976), landsliding (Gil & Kotarba 1977), sediment load (A. Welc, W. Bochenek) and, to a lesser extent, the measures of deflation and effects of fluvial erosion (L. Dauksza). Słupik and Gil introduced several new techniques to measure overland flow, infiltration, subsurface runoff, etc. In the studies carried out, thresholds of various processes were defined, in particular for landsliding (Gil 1997). Several new techniques to measure landslide movements were also introduced at Szymbark in cooperation with civil-engineers and geologists from the Geological Survey.

Our next station was organised three years later by Froehlich (1975, 1982) in the Homerka catchment which lies in the forest belt of the Carpathians. He concentrated on the monitoring of various types of fluvial transport in small creeks and on the supply of sediments from slopes to channels. For this purpose, Froehlich (1998, 2008) constructed several new instruments among them instruments to measure splash and bed load making use of acoustic and magnetic methods. He monitored sediment load during extreme events (Fig. 1). An important role of cart-roads in the load supply to river channels was also documented (Froehlich & Słupik 1980). Froehlich, in cooperation with D. Walling from the University of Exeter, introduced, for the first time in Poland, measurements of ^{137}Cs and ^{210}Pb to evaluate the rate of deposition and effects of soil erosion (Froehlich & Walling 1992). Finally, with the support of the International Agency for Atomic Energy in Vienna, he founded the laboratory for measuring radioisotopes. His studies on fluvial activity in the mountain catchment of Homerka (as well in India) received a very high evaluation from the International Union of Geophysical Sciences (IUGS) Commission on Continental Erosion, which elected him president for the years 2000-2004.

All three research stations have cooperated with IGU commissions since the 1960s and have had contacts with the teams and staff of stations from several countries (Germany, Italy, Sweden, Russia, Hungary, UK,

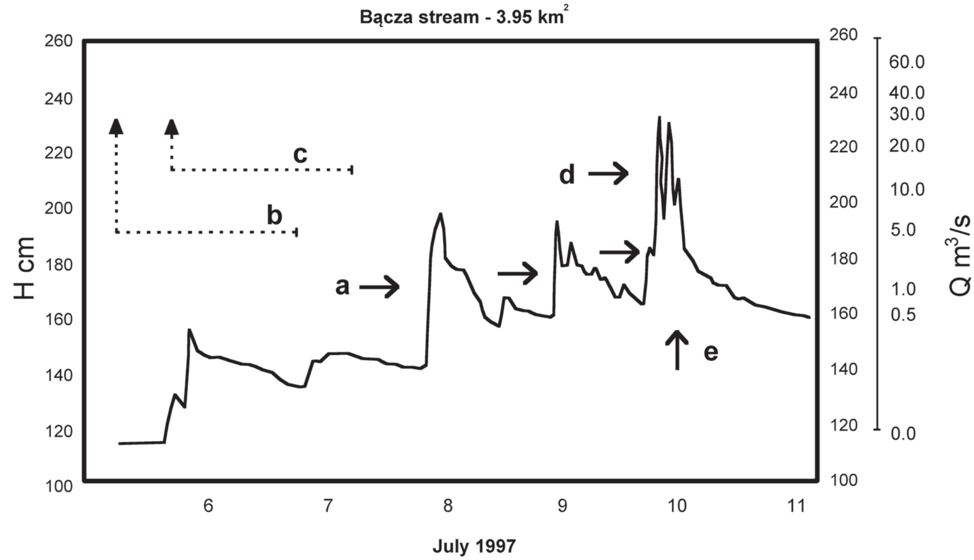

Figure 1. Several heavy downpour flood waves crossing thresholds of heavy bedload in small catchment of Bącza creek (3.95 km^2) in flysch Carpathians between 6th and 10th July 1997 (Froehlich 1998) Explanations: a – start of bedload, b – start of change of channel, c – erosion of bedrock, d – transport of 70 cm fraction, e – destruction of dam

etc.). They formed a model for a field station and helped in the foundation of similar stations in other parts of Poland. About 25 years ago this gave rise to the state network of interdisciplinary monitoring under the leadership of A. Kostrzewski from Poznań University. Szymbark belongs to this network.

Observations of the courses and effects of extreme events, that were frequently realised jointly with climatologists and hydrologists from the Institute of Meteorology and Water Management (IMGW) and from universities, formed an additional source of knowledge on present-day processes. In this field attention should be drawn to the following publications: our chapter in the monograph on the great flood of 1997 (Starkel & Kotarba 1999), monographs on two local downpours in loess in the Miechów Upland in 1995 (Starkel 1997) and in the eastern Carpathians in 2005 (Cebulak et al. 2008) as well as several papers on the effects of heavy rains in the Tatra Mts. (Kotarba 1998) and in the area surrounding the Szymbark station (Gil – several reports). In the case of the downpour in 2005, it was possible to make a full reconstruction of the processes involved due a dense network of automatic recorders of precipitation and river discharges as well as a parallel field survey of the erosional effects (Cebulak et al. 2008). It has been shown that the conclusions about the effects of events based only on daily records cannot be satisfactory (Starkel 2012). The effect of the studies of processes inspired the preparation of maps of present-day processes in mountain areas (Kaszowski et al. 1966). Unfortunately, these maps have not been continued with the exception of that for the Tatra Mts. (Kotarba and others).

Parallel studies on present-day processes and environmental change in the past help in the recognition of relations between the effects of processes and long-term trends as well as in highlighting relations between various temporal and spatial scales (Starkel 2007).

Investigations into the changes taking place in the last two centuries can be treated as intermediate studies. The latter draw upon and combine methods typically used for examining past and present-day processes, thus we can make conclusions on general trends in the evolution of slopes and river valleys. Having hydro-meteorological records, old photos and using lichenometric and dendrochronological dating, processes of higher intensity from the end of the Little Ice Age were documented in the Tatra Mts., as well as the human impact on the destruction of vegetation cover (Kotarba 2004, 2007). These changes are especially well reflected in cryogenic processes and forms studied in the Tatra and other mountain ranges in Europe (Rączkowska 2007). Studies on the last phase in the evolution of river channels in the foreland of the Carpathians (Klimek 1983) proceeded in a similar direction.

Assessment of the evolution of relief for economic and social purposes

The assessment of the evolution of relief for practical purposes was one of the leading aims of the foundation of our Department in Kraków. Therefore, from the very beginning we have tried to encourage the use of geomorphological maps in various branches of the economy and to evaluate present-day processes in relation to various land uses. A first relief quality map for agriculture was prepared when we commenced our activity (Starkel 1954). The Department developed similar maps for the Silesian industrial region (Karaś-Brzozowska & Klimaszewski 1960) and participated in the preparation of bonitation maps for administrative units covering the whole country. The studies on the anthropogenic transformation of the Upper Silesian mining region were carried out by Gilewska (1964a) and others. Klimek (1983) initiated studies on the human impact on fluvial systems (regulation of channels, exploitation of gravels). After 1980 he was appointed to the Institute of Nature Protection where he continued to develop work in this direction with his collaborators (A. Łajczak, B. Wyżga). The studies on the degradation of slopes in the Tatra Mts. by tourists were carried out under a similar framework (Kozłowska & Rączkowska 1999). Studies in cooperation with Slovak scientists have also demonstrated the recovery of natural ecosystems after the establishment of National Parks in both countries (Kotarba 2004). In 1972 detailed descriptions of the Carpathian relief were published with emphasis being laid on its value for different land uses (Starkel 1972a). Relief was taken as a primary factor for the whole environment due to the fact that its geometric parameters have a controlling influence on the circulation of energy and matter as well as limiting to an extent the impact of various destructive phenomena. The decisive factors and processes for different land uses were measured in particular physico-geographical units (landscapes). On the basis of this a model of rational land use in various types of Carpathian relief was constructed (Gil & Starkel 1977). The systems of land use existing at that time (50 years ago), were relatively distant from the proposed ones (Fig. 2). It gives satisfaction to the authors of the model to find out that the progressing socio-economic transformations during recent decades have resulted in a present-day pattern of forests, meadows and arable land which is very close to the one they proposed (Bucała & Starkel 2013). We also took part in constructing a national programme of regional planning for the coming decades which considered the regional differentiation of natural resources and global warming trends combined with an increasing frequency of extreme meteorological events (Starkel & Kundzewicz 2008).

The department as coordinator of other national projects and editor of review publications

Besides the earlier mentioned geomorphological mapping and the involvement of individuals in the organisation and leading of national or international commissions and working

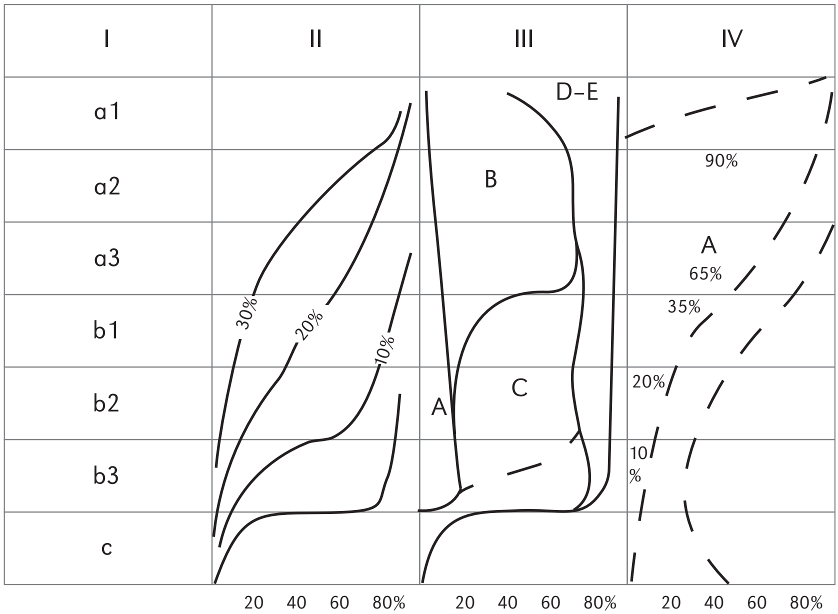

Figure 2. Rational postulated land use in various types of Carpathian relief (after Starkel in Gil & Starkel 1977) Explanations: I. Types of Carpathian relief (a1 – high mountains, a2 – middle and low mountains with steep slopes, a3 – middle and low mountains with gentle slopes, b1 – middle and high foothills with steep slopes, b2 – middle and high foothills with gentle slopes, b3 – low foothills, c – bottoms of river valleys and basins), II. Slopes with various inclinations in %, III. Participation of various geosystems (A – flat ridges, B – steep slopes with lithosol, C – gentle foothill slopes, D – landslides and talus cones, E – flat valley floors), IV. Postulated land use in % (A – forest, B – grassland, C – arable land)

groups, there were several projects which involved the whole Department or were affiliated to it.

- The editorial board of "Studia Geomorphologica Carpatho-Balcanica", a journal of the Carpatho-Balcan Geomorphological Commission; this periodical has been published since 1967 by the Polish Academy of Sciences and from 2011 by our Institute and the Polish Academy of Arts and Science in Kraków with chief editors: L. Starkel 1967-1991 (secretary M. Baumgart-Kotarba), A. Kotarba 1992-2010, Z. Rączkowska since 2011. The journal, printed in English, not only accepted papers dealing with the Carpathians and their forelands, but also papers dealing with other mountains in Europe and on other continents. Many volumes were dedicated to selected processes or landscapes.
- Coordination of the Central Scientific Programme No. MR I-25 (later CPBP 03.13) "Evolution of the geographic environment of the Polish territory" covering studies on transformation in the past, on present-day processes, and on applied studies (acting from 1981 to 1990). About 150 scientists, not only from the staff of the Institute of Geography and Spatial Organization PAS (IGSO PAS), but also from all geographic centres and other institutes, participated in the programme. This programme launched several new projects, among them the monitoring of present-day processes (coordinator A. Kotarba), the evolution of river valleys in the Holocene (related to IGCP project 158), etc. During the whole decade 1981-1990 our Department was represented by the project leader (L. Starkel) and scientific secretary (J. Słupik 1981-1982; after his death

by R. Soja). Every year scientific conferences were organised: both national and international. It led to close collaboration between the various research centres and to a rise in the level of Polish studies. Many of the scientific results developed in cartographic form became an input to a new edition of the *Atlas of the Republic of Poland* published by IGSO PAS.

- Preparation of a new monograph *Geography of the environment of Poland* (Starkel 1991; second edition 1999) presenting the current state of knowledge on all elements of the physical environment and its complexity. The monograph presented the environment in historical order from its pre-Quaternary roots to present-day processes. The book was written by about 20 of the best Polish specialists from various branches of the discipline. The editorial committee of 7 persons was headed by L. Starkel, assisted by S. Gilewska and the technical element was in the hands of K. Wit-Jóźwik and M. Klimek – all three from our team.
- Preparation of *Present-day transformation of the landscapes of Poland* in summary form (Starkel et al. 2008). This monograph was the product of the activity of three organisations: the Polish Society of Geomorphologists (represented by A. Kostrzewski), Institute of Geography of the Jagiellonian University (K. Krzemień) and our Department (A. Kotarba and L. Starkel). This book shows the state of knowledge on the present-day transformation of relief in various regions of Poland. Indeed, about 20 authors from all regional centres contributed to the book, but the part on the Carpathian region, as well as the introductory and summarising chapters, were written by persons from our own Department (Z. Rączkowska, L. Starkel). A modified version on the Polish Carpathians was included in the monograph on *Recent Landform Evolution. The Carpatho-Balkan-Dinaric Region* published by Springer (Rączkowska et al. 2012).

Our studies abroad – expeditions to mountains on the Asian continent

Our interest in the geomorphology of mountain areas pushed our Department to enter into close cooperation with scientists from various countries and into comparative studies abroad (Fig. 3). Besides the Carpathian countries, one should mention our close relations with Italy in studies on landslides, floods and periglacial phenomena (A. Kotarba, E. Gil, L. Starkel), Slovakia – on the Tatra Mts. (A. Kotarba, Z. Rączkowska and others), France – on high mountain relief (M. Baumgart-Kotarba, A. Kotarba, Z. Rączkowska), Great Britain – on fluvial geomorphology, palaeohydrology, dating methods, and periglacial phenomena (L. Starkel, W. Froehlich, A. Kotarba), Germany – on dating Holocene alluvia (L. Starkel, T. Kalicki), Sweden – on periglacial phenomena (A. Kotarba, S. Kędzia, Z. Rączkowska), the Soviet Union (and in recent decades, Belarus and Ukraine) – on slope processes, fluvial geomorphology, and Holocene palaeogeography (L. Starkel, T. Kalicki, A. Budek) and others. Many of these actions were followed by joint publications or even monographs (Wieliczko & Starkel 1994).

However, the most crucial expeditions for the advance of Polish geomorphology (after the Polar studies) were the research expeditions to Mongolia and India (Fig. 3). The expeditions to Mongolia were organised by our Department from 1974 to 1980 and were headed by K. Klimek, but they were open to various specialists from other departments and Polish universities. These expeditions had an interdisciplinary character. Our aim was to recognise climatic zonality and the vertical zonality of geoecosystems through the study of present-day processes and partly the history of past landscapes. In the first years most of the work of our team concentrated on the Khangai range rising to about 3500 m a.s.l. Across its southern margin runs the southern limit of forest and permafrost as well as the northern limit of deserts (Klimek & Starkel

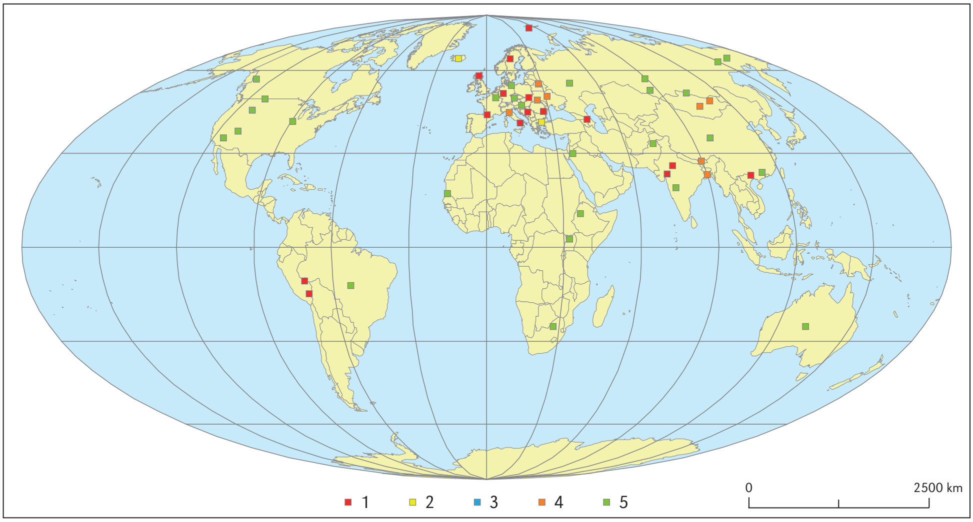

Figure 3. Research of our staff carried abroad, documented by published papers Explanations: 1 – individual studies and single papers, 2 – individual studies with several papers, 3 – team studies with papers, 4 – team studies or expeditions with many papers, 5 – other studies

1980). The forest belt is only 200-500 m wide (upper border controlled by temperature and lower one by humidity) and is restricted to slopes exposed to the N which are affected by patches of permafrost. At higher elevations with the remains of former glacial relief, there extends a staircase of cryoplanation terraces. Our team surveyed a small valley, the Sant, at a scale of 1:5000 and examined forms of relief, soil, water, vegetation, present-day geomorphic processes, monitoring of micro-climate, etc. (Starkel & Kowalkowski 1980). Besides this we recognised changes in the vertical zonality from the last cold stage and the impact of human activity (Kowalkowski & Starkel 1984). The visit during spring months helped us to discover the southernmost locations of icing and seasonally active pingos (Froehlich et al. 1977). Outside the Khangai range, K. Klimek studied the fluvial regime of some Mongolian rivers, while Dżułyński and Kotarba (1979) looked at cryogenic relief related to granitic rocks in the steppe zone. The great spatial differentiation of geoecosystems at the margin of permafrost very much helps us to recognise the context of various processes during the last cold stage in Central-Eastern Europe.

Interest in the geomorphology of the humid tropics started with the first journey of L. Starkel to India in November 1968. He studied the effects of heavy rain (about 1000 mm in two days) on slope and valley floor transformation in the Darjeeling Himalaya (Starkel 1972b). These effects have later been compared with phenomena in other climatic zones of the world (Starkel 1976).

Since 1983 we have carried out a continuous investigation of the effects of extreme processes in India. Among the conclusions we discovered a major role played by deforestation which leads, in smaller valleys, in the rising margin of the Himalaya to a change from erosion to aggradation (Froehlich & Starkel 1987). Cooperation with the Darjeeling Planters Association helped us to put our conclusions into practice and present them at several conferences and to local authorities. The survey and monitoring of the stabilisation of the greatest landslide at the Ambootia Tea Estate, which was created after catastrophic rain (Froehlich et al. 1992), should be mentioned. In 2000 the Indian National Science Academy published a book *Rains, landslides and floods in the Darjeeling Himalaya* presenting the results of parallel Polish and Indian investigations (Starkel & Basu 2000). Later we extended our studies to the piedmont zone where aggradation is progressing in the tectonically subsiding foredeep of the Himalaya and is related to the frequency of events (Starkel et al. 2008).

In the final years of the 20th century we started similar detailed studies on the processes transforming the southern edge of the Meghalaya Upland where 10,000-15,000 mm rainfall (3000-5000 mm per month) are recorded every year at Cherrapunji. In cooperation with colleagues from the North-Eastern Hill University (NEHU), we conducted detailed observations of rainfall intensity, runoff and soil erosion (Starkel & Singh 2004). The results of Cs measurements were very helpful (Froehlich 2004). We concluded that deforestation for agriculture, smelting and the exploitation of coal caused total degradation of the upper fertile soil and the formation of an armoured gravelly layer on the ground surface protecting local residual regolith against continuous destruction (Starkel & Singh 2004; Prokop 2007, 2010). The problems as well questions of re-cultivation were discussed with Indian colleagues from NEHU, who organised several workshops and are continuing the monitoring of several processes. Also Indian geographers from Delhi and Calcutta had earlier twice organised meetings of international commissions of the IGU (in 1995 and 2004) inviting us to lead the field trips and present papers. In 2006 we organised a 2-week long workshop of Polish geomorphologists in the Himalaya and Meghalaya followed by an Indian-Polish Seminar at NEHU mainly dedicated to natural hazards (Singh et al. 2008). In 2008 the non-governmental organisation "Save the Hills" organised a symposium on the protection of hills against landslides and invited L. Starkel to present a lecture on the catastrophe in 1968.

The team from our Department, led by P. Prokop, is still continuing the studies on present-day processes in relation to land use changes in both regions of India.

Summary – the roots of our successes and weakness

Professor Klimaszewski, the founder of our Department, instructed us that in starting any research on a selected problem we must first formulate a working hypothesis and select appropriate methods, but we should not start from a collection of incidental records. Therefore, he focused in his main activity on geomorphological mapping and to developing studies on contemporary processes. Then, the first geomorphological maps were published (with genetic and chronological parameters) and original new techniques appeared for the measurement of slope wash, the circulation of water on slopes, bed-load transport and other processes.

The second characteristic of our director and the whole team was a policy of being open to contacts both within the country and abroad, as well as to an interplay with other disciplines. After the initiation of contacts at the start of the 1960s we participated in the organisation of the VI INQUA Congress (1961), then we organised the first IGU meeting on geomorphological mapping (1962), and the next year – the first symposium of the Carpatho-Balcan Geomorphological Commission. We did not avoid the coordination of national programmes like that on the "Evolution of the geographic environment of the Polish territory" (CPBP 03.13) and international ones like "Palaeohydrology of the temperate zone during last 15,000 years" (IGCP No. 158), INQUA Commission on Global Continental Palaeohydrology or the Polish-Mongolian Expeditions in the 1980s. Also our field stations were open to interdisciplinary and international cooperation.

Our small team did not forget the editing of review books and monographs on the relief or the environment of Poland generally, the Carpathians and the highest mountain range, the Tatra Mts., as well as participating in editing special volumes on mountain geomorphology, the evolution of fluvial systems, extreme phenomena, etc. (Starkel et al.

1991; Singh et al. 2008; Lóczy et al. 2012). We underlined the role of parallel studies on past evolution and present-day processes in regional management and the prediction of environmental change (Starkel 2003b).

Several of our studies may be appreciated as contributions to some basic problems in geomorphology like the vertical zonality of processes (Kotarba 1984) and their transformation in time (Kowalkowski & Starkel 1984; Starkel 2011), the role of the Holocene in the evolution of relief (Starkel 1966), the fluctuation of the hydrological regime in the Holocene and its overlapping with human activity (Starkel 2005; Kalicki 2006; Starkel et al. 2006), the threshold values of various processes in relation to types of extreme rainfall and their clusters (Starkel 1976, 2012; Kotarba 1992; Gil 1997; Froehlich 1998; Starkel & Basu 2000) or the recognition of a new slope equilibrium as the effect of deforestation in the Cherrapunji region (Starkel & Singh 2004; Prokop 2007).

Compared with other Polish centres of geomorphological research, our small team is characterised by a greater diversity of subjects undertaken.

Besides all these activities, our team, as well the whole of Polish geomorphology, has not entered more deeply into the discussion on some fundamental questions of geomorphology like the theory of planation, or of slope evolution, etc. These are mainly a domain of British, American and other schools of geomorphology. Looking from a distance at a growing flood of records and great diversity of processes and forms on the globe, we should remember that all these processes and their product-forms of relief cannot be classified precisely. Their nature is much more complicated. Transitional and polygenetic forms are more universal on the Earth's surface and may change their shape and function with time.

Finally, it should be mentioned that in 2012 our Department changed its name from the Department of Geomorphology and Hydrology of Mountains and Uplands to the Department of the Geoenvironment (in the same IGSO PAS).

Acknowledgements

I would like to dedicate this review paper to all those who are no longer among us: to our founder – Prof. M. Klimaszewski and to my colleagues – J. Słupik, K. Wit-Jóźwik, M. Kłapa, M. Baumgart-Kotarba, W. Froehlich and T. Gerlach.

Editors' note:
Unless otherwise stated, the sources of tables and figures are the authors', on the basis of their own research.

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Article first received • April 2015
Article accepted • July 2016