Teaching of geological mapping at Geological Mapping Department, AGH University of Science and Technology, Kraków

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Abstract. This paper presents the methods and scope of teaching geological mapping at the Geological Mapping Department, Faculty of Geology, Geophysics and Environments Protection, Stanisław Staszic AGH University of Science and Technology. The main curriculum of Structural Geology and Geological Mapping consists of lectures, laboratory exercises and a summer field practice in Poland, Croatia, Slovakia or Ukraine. Teaching of geological mapping is linked to research done by the staff and to the content of the course Geomorphology and Quaternary Geology (geomorphological mapping). Students have been also taught practical use of the GPS (Global Positioning System).

Key words: *teaching, geological mapping*

At the Stanisław Staszic AGH University of Science and Technology, Kraków, the essentials of geological mapping for the students of the Faculty of Geology, Geophysics and Environments Protection are taught at the Geological Mapping Department (GMD). The basic course is *Structural Geology and Geological Mapping,* including lecture, laboratory exercise and summer field practice in geological mapping. One of the basic principles of teaching at GMD, aimed at providing top-level instruction, is sharing with students the knowledge and expertise acquired by staff members in their own work. The results of this work are largely published as textbooks, monographs, journal articles, conference notes, etc., from various fields. The study interests of the GMD staff include also geomorphological mapping, remote sensing and mineral resource mapping, reflecting the fact that a part of the staff came from Department of Building Stone Resources.

Recent work by the GMD staff focused on geological structure of the Kraków–Wieluń Upland, especially Kraków and its vicinity, and the Krzeszowice Graben with adjacent areas. Mapping was also done in the Pieniny, the Nida Depression, near Miechów, Bełchatów, Tarnów and in the Suwałki Lake District. Research has been also carried abroad for several years. Noteworthy is mapping in Germany, in Swabian Alb area (Matyszkiewicz, 1997) and the recently initiated work in Crimea, including mapping of local Mesozoic sedimentary formations (Krajewski & Olszewska, 2005).

The most important achievements of the GMD staff in the field of geological mapping include making the sheet *Kraków* of the *Detailed Geological Map of Poland 1 : 50,000* (*DGMP*) by the team lead by J. Rutkowski and including I. Felisiak, T. Leśniak, J. Małecki, J. Matyszkiewicz, J. Rutkowski, T. Sokołowski and Z. Wiśniowski. The field work was carried out with utmost care on topographic maps in 1 : 10,000 scale. The precision of this work is apparent on the fragment of surficial geological map of St. Bronisława Hill, made by I. Felisiak (Fig. 1 — see insert).

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Currently, most important work is mapping, based mainly on borehole data, of the open pit brown coal mine Bełchatów (Czarnecki & Felisiak, 2004; Felisiak, 2001; Szewczyk, 1997) and the work on the map of bottom sediments of the Wigry Lake using seismoacoustics and sediment cores, coupled with microfacies and geochemical studies (Rutkowski et al., 2005). Important for the study of the geological structure of the Kraków area are complex studies of Upper Jurassic sediments including facies mapping (Matyszkiewicz & Krajewski, 1996; Krajewski & Matyszkiewicz, 2004). Ground-penetrating radar (GPR) and magnetic survey are used for the study of shallow structures within the Kraków-Wieluń Upland (Jędrys et al., 2004). This work is being done in cooperation with the AGH Department of Geophysics.

The courses of geological mapping are addressed to students graduating in various specialities (Geology and Mining, Management of the Environment, and Environment Protection), hence they are adequately tailored to the students' needs. In general, the lectures in *Structural Geology and Geological Mapping*, besides the topics of rock deformation, tectonic structures and styles, cover also material and methods used in geological and sozological mapping, including aerial photographs and other remote sensing data. Also discussed is classification of maps, with special attention given to various geological maps, but including also sozological, geomorphological and other thematic maps from the area of Poland. Soil and forest maps are also discussed. The students are taught writing projects related to geological mapping. An important aspect concerns legal issues involved in the process of geological mapping.

During the laboratory exercises in geological mapping students learn basics of geological intersection and train drawing geological cross-sections. The latter are done using maps and borehole data. Students learn interpretation of simple intersection maps of areas with various relief and structural maps. They are also thaught about basic types of topographic and geological maps of Poland.

A special place in the system of teaching geological mapping is taken by the summer field courses during which students make a geological map of an area of a few square kilometres. They base their work on the instructions for *Detailed Geological Map of Poland 1 : 50,000*. The aim of

Fig. 2. Geomorphic sketch of Wojnicz area after Gabała & Sokołowski (2000), slightly changed

this course is to familiarise students with the method of producing these maps and with the analysis of aerial photographs. Students have been also taught practical use of GPS (Global Positioning System) receivers to locate their data points and transects on topographic maps 1 : 10,000 with "1992" coordinates. Traditional areas of these courses have been the Kraków–Wieluń Upland and the Flysch Carpathians. Foreign locations have been recently added, increasing the attractiveness of the courses and the diversity of tectonic styles among the mapped areas. The foreign courses started in the Caucasus, and later included locations in Croatia (Pag Island), Slovakia (Slovenske Rudohorie) and Crimea (Crimean Mountains).

Teaching of geological mapping is intrinsically linked with the content of the course *Geomorphology and Quaternary Geology*, also taught by the GMD staff. Geomorphological maps, especially of the areas with extensive Quaternary covers, are often more important for environmental studies than geological maps. Geomorphological mapping has been thus one of the methods widely used in the Department and the maps have been published in papers on various topics. The maps made in the department included maps of modern relief for sheet *Kraków* SMGP (Rutkowski, 1993 a) and more detailed maps of fragments of the Vistula valley in the area of the Brama Krakowska and of the Racławka valley (Rutkowski, 1987, 1991). Maps of modern and fossil (sub-Quaternary) relief were also made for Tenczynek Basin (Rutkowski, 1998), lower course of the Dunajec river valley and neighbouring area (Fig. 2) as well as for the Vistula valley between the confluences with Uszwica and Breń rivers (Sokołowski, 1987, 1995; Gabała & Sokołowski, 2000). An important line of geomorphological studies in the recent years has been the study of the bottom relief of the Wigry Lake. Anthropogenic forms of relief have been studied for several years (Rutkowski, 2001, 2003; Mycielska-Dowgiałło et al., 2001; Gębica & Sokołowski, 2001). GPR sounding has been recently introduced to the studies of karst forms (Jędrys et al., 2002).

Geomorphological mapping has its place also in teaching. It is included in the course of *Geomorphology and Quaternary Geology* for some specializations. Mapping is mostly dealt with during project works. Students usually make detailed geomorphological maps by interpretation of contour patterns on topographic maps. Students also make descriptions of individual forms taking into account their morphological and morphometric characteristics, as well as origin and, in some cases, age.

Students also learn how other types of geomorphological maps are used in research and make a map of slope gradients as an example. Then they estimate how suitable are the slopes for various practical uses.

During laboratory exercises students are also taught in the field on the types and uses of hand drilling equipment (peat probe, "INSTORF" corer, spiral corers and others) for studying lithology and extent of shallow subsurface layers.

Geomorphological maps have been also included into the *Geological Mapping* field courses. One of the components of the final report from the course is a geomorphological sketch map of the mapped area.

An important innovation 30 years ago was introducing various remote sensing materials in the mapping. These were used for mapping of mineral resources (Rutkowski & Sokołowski, 1977; Rutkowski et al., 1978) and basic geological mapping (Rutkowski, 1993 b), or the geomorphological mapping. Air and satellite photographs have been widely used as basic or supplementary material in making various thematic maps (geological, geomorphological, economic. etc.) published in papers on highly diversified topics (Rutkowski, 1981, 1983, 1996; Rutkowski & Sokołowski, 1985; Sokołowski, 1987, 1995; Gębica & Sokołowski, 1999; Gabała & Sokołowski, 2000 among others).

The importance of the use of remote sensing material is reflected in teaching. This topic has been included in teaching for more than 30 years, since basics of photointerpretation became included in syllabus of *Geomorphology and Quaternary Geology*. Lectures included information on the then novel remote sensing methods. Laboratory exercises involved learning stereoscopic analysis of eolian, fluvial, karst, glacial and other forms as well as lithology of surface deposits from various areas of Poland. Students presented their results on photointerpretation sketches, complete with text comments. Instruction was also given on transfer of information from photointerpretation sketches drawn on transparent substrate on topographic maps using LUZ transponder. An important role in the teaching was played those days by field exercises in vicinities of Kraków, where students made a geological and geomorphological map of a small area using photointerpretation sketches made by them earlier at class.

More comprehensive coverage of this subject was included in the course of *Photogeology* realised during individual tutoring and as courses for postgraduates. A group of staff from the then organized Cartography Department of Przedsiębiorstwo Geologiczne (Geological Enterprise) took part in the postgraduate studies in the late 1970s. Later on, analysis of solid rocks (sedimentary, magmatic and metamorphic) and tectonic structures was added, as well as basics of analysis of Landsat satellite imagery from the area of Poland. Similar content was included in the course of the same name, taught for several years for the then new specialization *Prospection Geology*. This course is discontinued now. Some elements of application of remote sensing in research are now present in syllabi of lectures and field exercises within the basic course dealing with this subject — *Structural Geology and Geological Mapping*.

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Polish Geological Institute recommends:

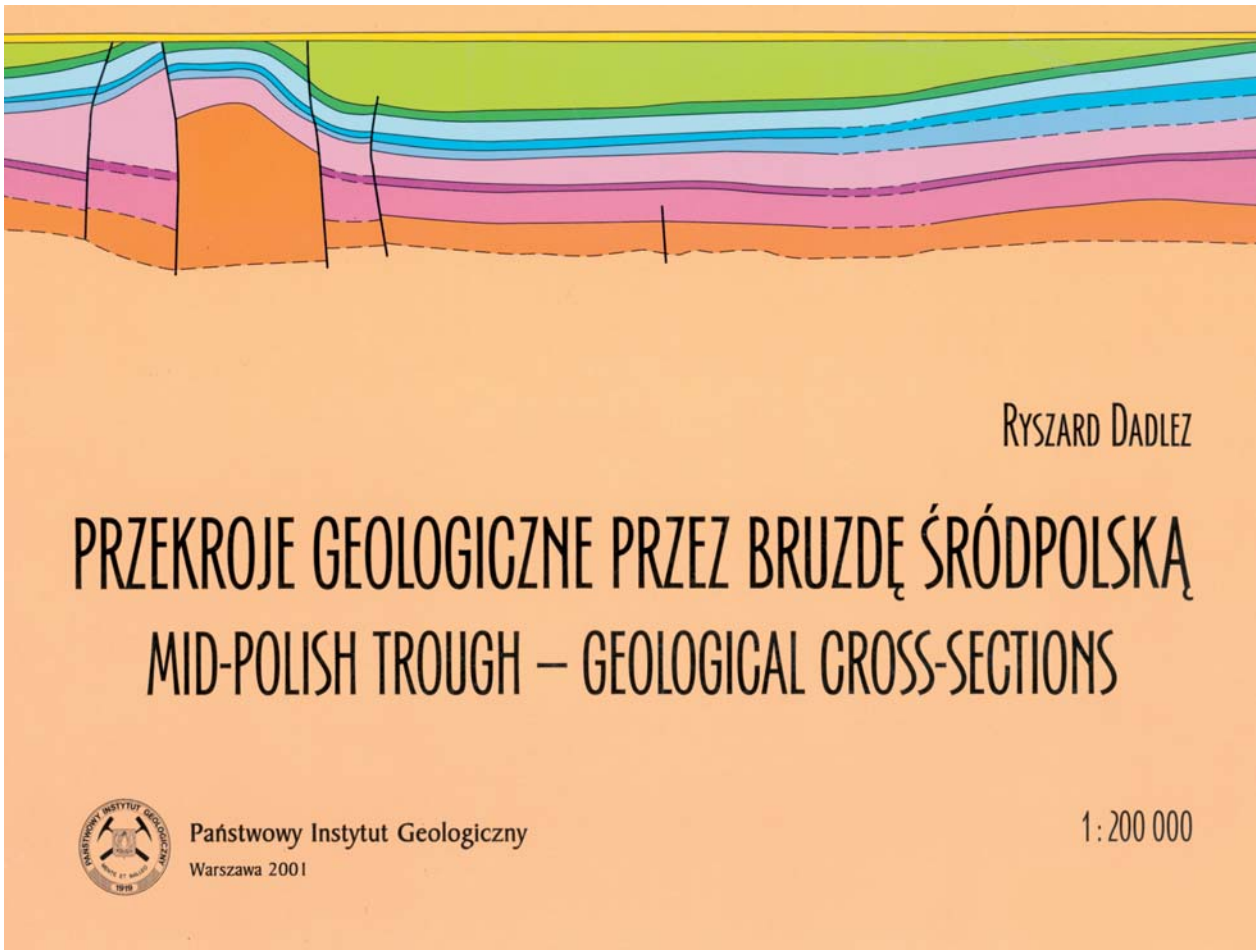

Fig. 1.
See — *Teaching of geological mapping at Geological Mapping Department, AGH University of Science and Technology, Kraków* (p. 899)

DETAILED GEOLOGICAL MAP OF

LAS WOLSKI AND ŚW. BRONISŁAWA HILL

IRENEUSZ FELISIAK

500 0 500 m

N W E S

Warszawa Kraków Kielce

OLSZANICA CHEŁM BORY CHOLERZYŃSKIE ZAKAMYCZE SOWINIEC WOLA JUSTOWSKA FORT SKAŁA Piłsudski Mound Panieńskie Skały Strzelnice SIKORNIK Kościuszko Mound Lisie Jamy SALWATOR Sojunka Hill Monastery of the Camaldolite Brothers KRYSPINÓW PRZEGORZAŁY BIELANY Na Górkach Na Skale Zoo Rudawa WISŁA Rzepiszów Creek

EXPLANATIONS:

QUATERNARY

- Holocene
  - $^{al}_{py}Q_h$ — alluvium: silts, mud (py)
  - $_{py,t}Q_h$ — peat (t), silts (py)
- Pleistocene
  - $_lQ_p$ — loess and loess like silts
  - $_pQ_p$ — sand
  - $_{z,km}Q_p$ — quartz-flint gravels(ż) with pebbles of carpathian rocks (k); till (m)
  - $_{r,p,z}Q_p$ — weathering deposits: clay (i), clayey sands (i,p), debris of jurassic limestones and flints with weathering clay (r)

MIOCENE

- Badenian
  - M_b^{IIA} — clays (IIA, IIB, IID - microfauna assemblages)
- Karpathian
  - $_{l,me,w}^{c}M_k$ — terrestrial and freshwather deposits: clays (i), marls (me), limestones of calitche type (w)
  - $_{l,me,w}^{o}M_k$ — marine deposits: clays (i), marls (me), limestones (w)

OLIGOCENE/ EARLY MIOCENE

- OlM — weathering deposits

UPPER CRETACEOUS

- Campanian
  - Cr_{cp} — marls with cherts

JURRASIC

- Oxfordian
  - $^{b}J_o$ / J_o — bedded and massive limestones (J.), basinal facies (J.)

- outcrops of unweathered (solid) rocks
- rubble
- a — dug well (a), water drilling (b), sounding (c) and age of the bedrock (Q_p - drilling finsihed in the Pleistocene)
- b — cave
- c — seepage
- cliffs, crags
- creeping slopes
- scarps, gullies
- wet areas
- dumps, embankments
- landslide
- gorge
- abandoned quarry
- alluvial fan
- river embankment
- suffosion kettle
- suffosion outlier