The Kamienna Valley Geopark — more than dinosaurs

Grzegorz Pieńkowski[1]

Protecting the environment is essential for the quality of life of current and future generations as well as for economic growth. Geodiversity is defined as the natural range (diversity) of geological (rock formations, fossils, minerals and processes), geomorphological (landform and processes), and soil features. It includes their assemblages, relationships, properties, interpretations and systems (Gray, 2004). It underpins our economy through exploitation of resources and on the other hand it inspires our awareness and knowledge on environment through activities such as tourism and recreation. Geodiversity is an important part of environmental and national asset, it plays a fundamental role in contributing to sustainable development, but still it is one of the least recognised and valued (Kozłowski, 1998, 2004; Kozłowski et al., 2004; Alexandowicz, 2006; Prosser et al., 2006). The only European organization integrating activities in terms of geoprotection is European Association of Geological Heritage Protection (ProGEO). European geoparks are intended to be model objects for creating a global geopark network, as accepted in 2000 (Lesvos Island agreement, Greece) by the creators of European Geoparks Network i.e. France, Greece, Spain and Germany. Since this network was set up, the requirements for entry have become more demanding. Not only must an area have an outstanding geological heritage, but also it must have a strategy for sustainable development through geoturism. A geopark needs to have a clear management structure and cannot be just aspirational. It needs to prove that it is already operating as a geopark by having interpretation in place and by organizing a program of events each year.

A model system of geological conservation is being developed in Great Britain and the guidelines by Prosser et al., 2006 (Geological conservation — a guide to good practice) along with other publications (Stace & Larwood, 2006; twice-yearly magazine *Earth Heritage*) can serve as a template for development of geological conservation in other countries. The British system is the most comprehensive one and it is likely the best model to be adapted in Poland. The Earth Science Conservation Classification (ESCC) is at the heart of geological conservation in United Kingdom. Since 1990, the ESCC was developed in order to rationalize the practical approach to conservation of the various types of geological sites. The ESCC uses site type as the basic unit of classification. The classification allows generic threats and conservation strategies to be defined for the different site types.

Moreover under the umbrella of UNESCO, important national geological sites gain worldwide recognition and benefit from the exchange of knowledge, expertise, experience and staff with other members of the global network. As yet, 54 national geoparks in 17 countries have been established. Some geoparks are also part of a UNESCO biosphere reserves. Also, International Union of Geological Sciences (IUGS) cooperates with UNESCO's Geoparks program to protect geological heritage via its own Global Geosites Project launched in 1996.

Geological features over the world provide a fascinating scientific and educational resource. They help us to understand the dynamic nature of the environment, as evidence from the geological record demonstrates how our climate has changed, how sea-levels have risen and fallen, and how numerous species (such as dinosaurs) have appeared, evolved and become extinct. However, rocks, fossils, landforms and natural processes are subject to a wide range of threats, which unless deflected or managed, will result in serious loss or damage to some of the most important geological sites. In Poland, the biggest threats are:

1. Loss of geological exposure as a consequence of vegetation encroachment;
2. Loss of geological exposure through landfill, waste disposal and burial under building schemes;
3. Removal of fossil or mineral specimens through neglect quarrying and irresponsible collecting;
4. Waste disposal in disused quarries.

Implementation of a National Geological Conservation project is necessary. Geological and Mining Law (the Parliamentary Bid) established a legal framework for protection of geodiversity. The Department's agent in this effort is Polish Geological Institute (PGI), performing duties of the Polish Geological Survey. The PGI possesses both sufficient staff and experience to coordinate this project in cooperation with Polish Government, local governments, other scientific organisations and business. Therefore, geological conservation is one of the statutory obligations of the Polish Geological Institute. Up to date, several geoprotection initiatives (originating mostly at the local government level) have been undertaken and implemented (for example, the Kielce Geopark). The Polish Geological Institute already participates in creating the Muskau Arch (see page 692) geopark situated at the Poland/Germany/Czech Republic border and coined in the idea of Kamienna Valley Geopark.

Geopark Kamienna — the priceless valley

The Kamienna River valley between Sołtyków and Bałtów and its tributaries is an extremely valuable area on European and even World scale. The exposures of Paleozoic, Mesozoic and Quaternary rocks (Fig. 1), located along the river valley, contain precious paleontological, mineralogical and tectonic objects (Wróblewski, 2000; Pieńkowski, 2004a, b). They require urgent protection giving the chance to take advantage of the unique educational nature values. Traditionally, the conservation of geodiversity in this area has focused on individual sites (such as Krzemionki Opatowskie Neolithic Flint Mine or the Sołtyków Jet Natural Reserve) but, in the future, effective conservation will need to integrate the efforts of all interested parties and seek to conserve geodiversity in the wider landscape — both natural and historical one. Geological heritage sites and nature reserves can function as individual objects, but

[1]Polish Geological Institute, ul. Rakowiecka 4, 00-975 Warszawa, Poland; grzegorz.pienkowski@pgi.gov.pl

if they are combined to form a regional thematic network, their educational and protective ability significantly increases. The idea of establishment of the Kamienna Valley Geopark (Dolina Kamiennej Geopark) was conceived by Pieńkowski (2004b). This idea is further developed herein (Fig. 1). This region has a rich cultural history related to its natural resources. For this reason, the projected geopark will include a network of 20 documentation sites and nature reserves (geosites) forming a protection, information and educational system (Fig. 1). The geopark area is projected in such a specific way to enable development of geotourism. The problem with the projected area of future Kamienna Valley Geopark is that this area as a whole does not have an existing comprehensive protection framework (such as a landscape park or the Natura 2000 area). If necessary, buyout procedures will be initiated for acquisition of private land (for example in the Gromadzice area near Ostrowiec Świętokrzyski and Gliniany Las near Mniów). Access roads and pedestrian paths must also be constructed. It is necessary to conduct groundworks, to design didactic ecological paths and install unified information boards. Information leaflets, guidebooks and school textbooks should also be printed and prepared in a digital form. The Kamienna Valley Geopark will have to be coordinated with neighboring geoparks — existing Kielce Geopark (see page 618) and planned Gielniów Highs Geopark, located on the territory of Mazovian Voivodeship.

The *sine qua non* of the project's success is to gain, interpret and popularize the knowledge about geology of this region. Comprehensive geological knowledge will be the key element of the project. However, it seems that the essential factor of its success is the ability to bring together various interests of authorities, local societies and private businesses. There is a possibility to obtain EU and other subsidies, and the projected geopark and other geoparks or single geosites in its vicinity are intended to be included in the European and World Geopark Network.

Proposed 20 geological outcrops (geosites) of the Kamienna Valley Geopark reveal Devonian, Triassic, Jurassic and Quaternary sedimentary rocks. They represent mostly disused quarries or clay pits (Sołtyków, Krynki, Podole, Gromadzice, Starachowice, Wióry-Doły Opacie, partly Bałtów) few of them (Niekłań, Adamów, partly Bałtów) represent natural outcrops, two of them are partly used quarries or clay pits (Baranów, Kopulak), one is a road cutting (Brody). One of proposed geosites (Krasna Bog natural reserve) represents an extant bog ecosystem which can be compared to the 200-million-years old lacustrine system outcropping in the nearby Sołtyków Jet Reserve (Fig. 2). Some of the geosites are composed of several nearby outcrops (Adamów, Gromadzice, Bałtów, Wióry-Doły Opacie, Podole). The Paleozoic outcrop in Doły Opacie reveals steeply inclined Middle Devonian dolostones and Triassic redbeds, overlying the Devonian rocks with spectacular post-Variscan angular unconformity. Similar unconformities can be seen in one of the Podole geosites, where two angular unconformities can be seen — Variscan one (Devonian/Triassic) and Laramian (Triassic/Quaternary) one. Another tectonical phenomena (although in much smaller scale) can be seen in the Krynki disused quarry (tectonic mesostructures such as tectonic streamer small faults and cleavage). In all the geosites, a variety of rocks representing a wide range of paleoenvironments can be observed. Continental alluvial redbeds are well exposed in Wióry, Baranów (Fig. 3), Kopulak, Doły Opacie, while alluvial/lacustrine coal-bearing association outcrops in Sołtyków. Different Lower Jurassic marginal-marine deposits occur in many outcrops: deltaic facies in Podole and Gromadzice, nearshore deposits in

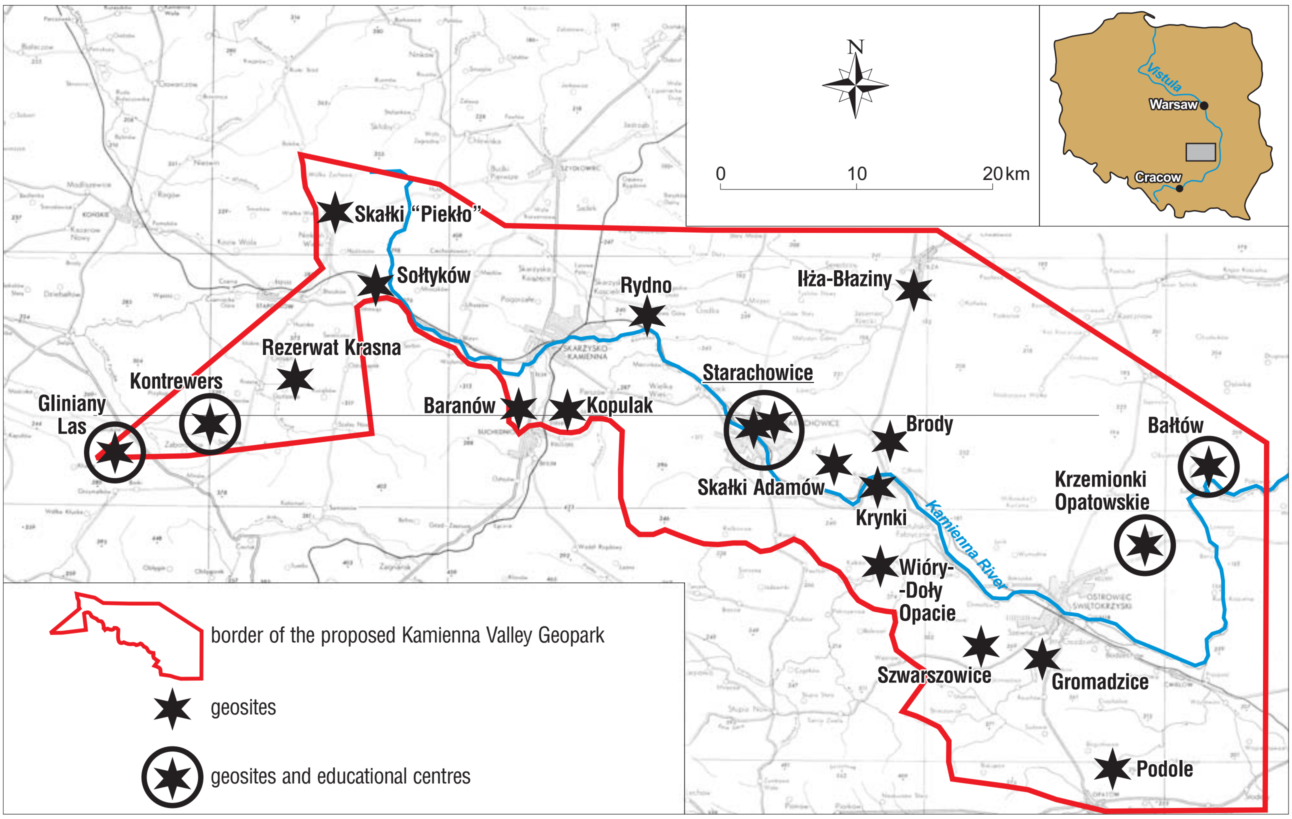

Fig. 1. Map of the proposed Kamienna Valley Geopark indicating the most important geosites and educational centres

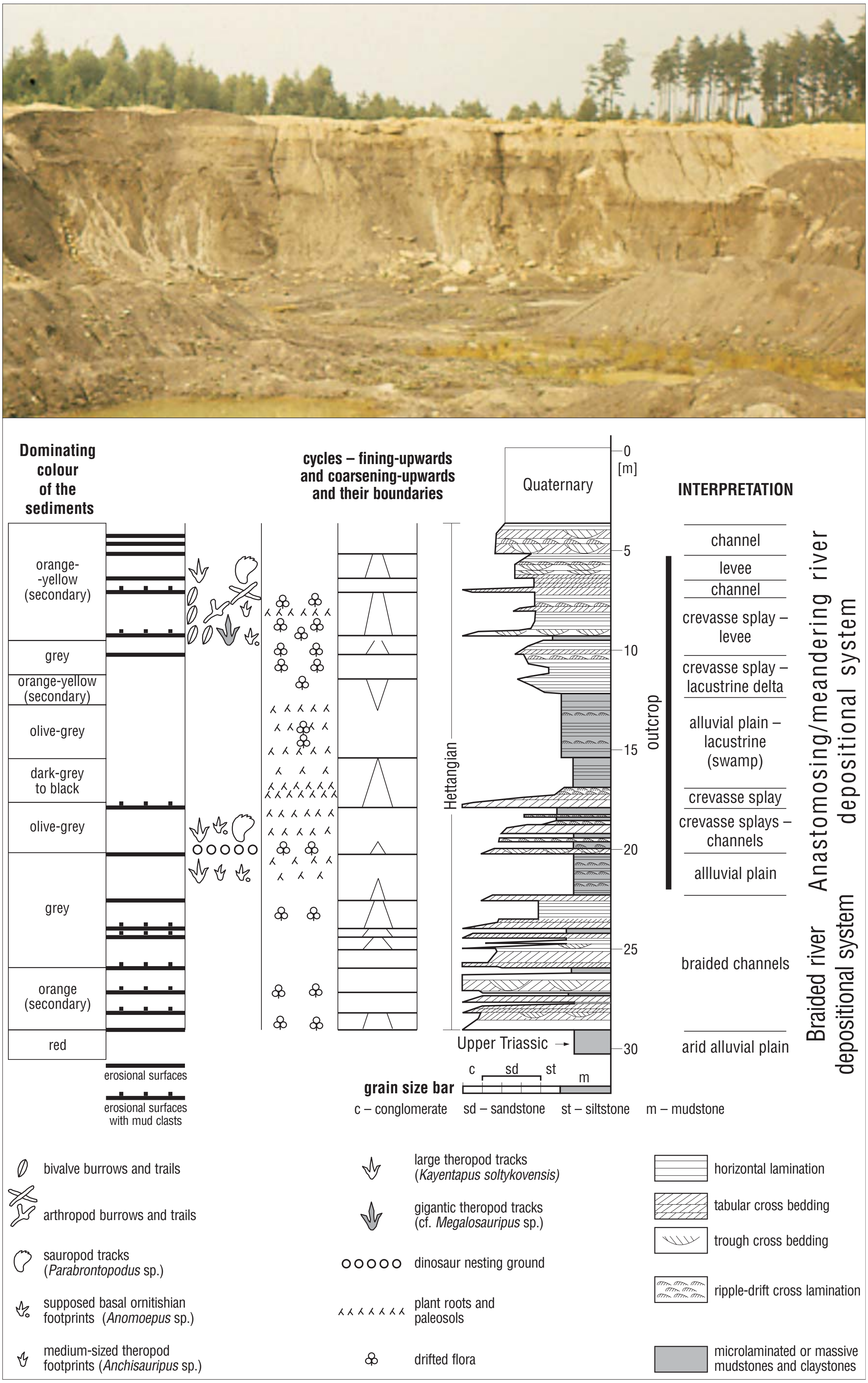

Fig. 2. Sołtyków Jet Reserve — one of proposed geosites of the future Kamienna Valley Geopark. The photograph was taken in 1979, since that time many important discoveries in this outcrop have been made, but the state of this site much deteriorated due to landslides, vegetation overgrowth and irresponsible collection of jet

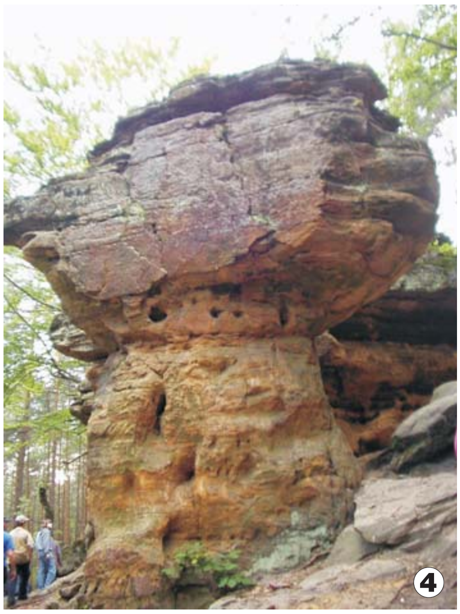

Fig. 3. Baranów — an example of fossil semi-arid alluvial plain with fluvial channels (Upper Buntsandstein). Photo by G. Pieńkowski
Fig. 4. The Piekło Nature Reserve near Niekłań — shoreface/foreshore Sinemurian sandstones — the rocks owe their shapes both to the genesis of sandstones (different properties of shoreface and nearshore sandstones in terms of weathering) and to the Pleistocene peri-glacial weathering

Niekłań-Piekło, Adamów, Gromadzice, Starachowice, Szwarszowice and Krynki or marine carbonates (Krzemionki Opatowskie, Bałtów). The Lower Jurassic (Sinemurian) sandstones in the Piekło Nature Reserve near Niekłań (which has been protected since 1966) owe their shapes both to Pleistocene erosion and to greater weathering resistance of beach sandstones (upper; Fig. 4) than sandstones deposited in a shallow nearshore zone of the Early Jurassic sea (lower; Fig. 4). Large logs of Jurassic trees can be seen in the cuspate forms within sandstone of beach (foreshore) origin. The early Jurassic sea was similar to the recent Baltic Sea in its lowered salinity and Jurassic conifer trees were ancestors of the big pines growing now in the Piekło Nature Reserve.

Protecting this unique geodiversity will help us to understand geological history of Poland, including tectonic movements, evolution, climate changes and sea level changes, to name the few. Paleogeographical maps combined with photographs of similar recent environments should be of particular interest (Figs. 5, 6).

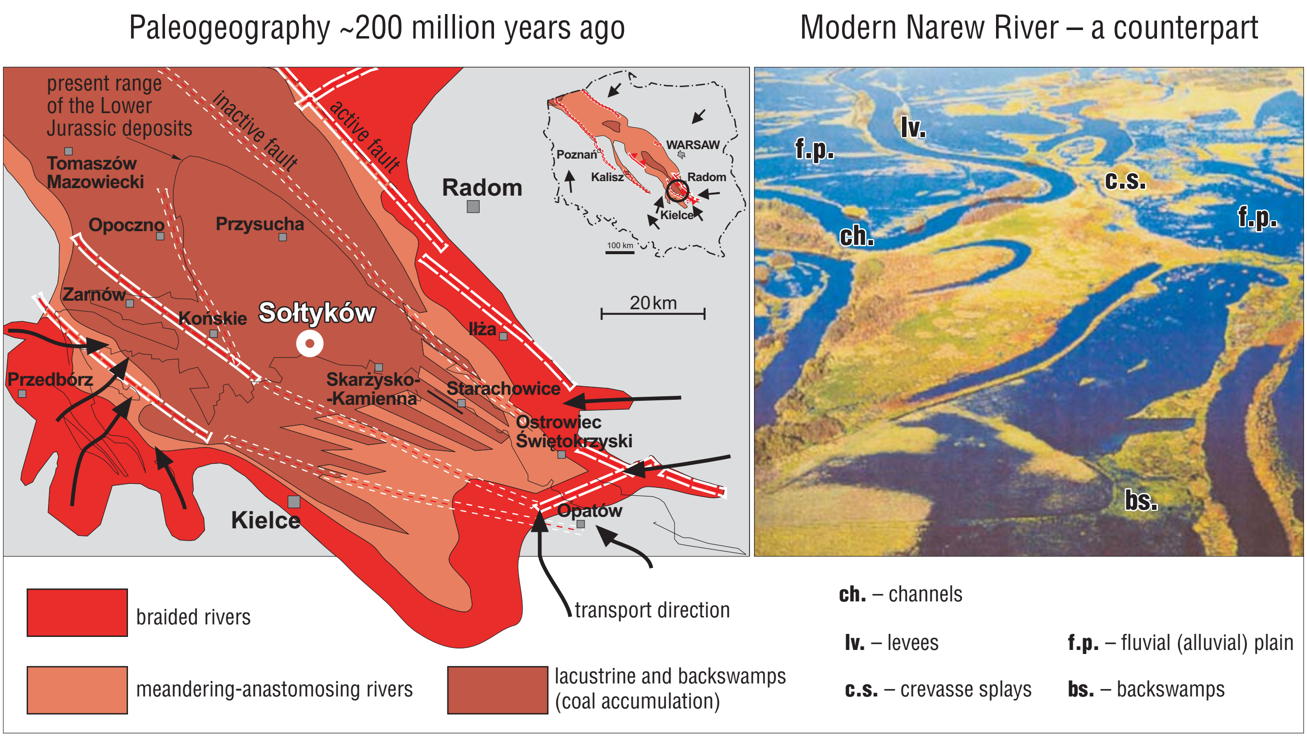

Fig. 5. Earliest Hettangian (Early Jurassic) paleogeopraphy of Poland and Świętokrzyskie Mountains area with location of Sołtyków site marked — a proposal of educational plate at the site (after Pieńkowski, 2004)

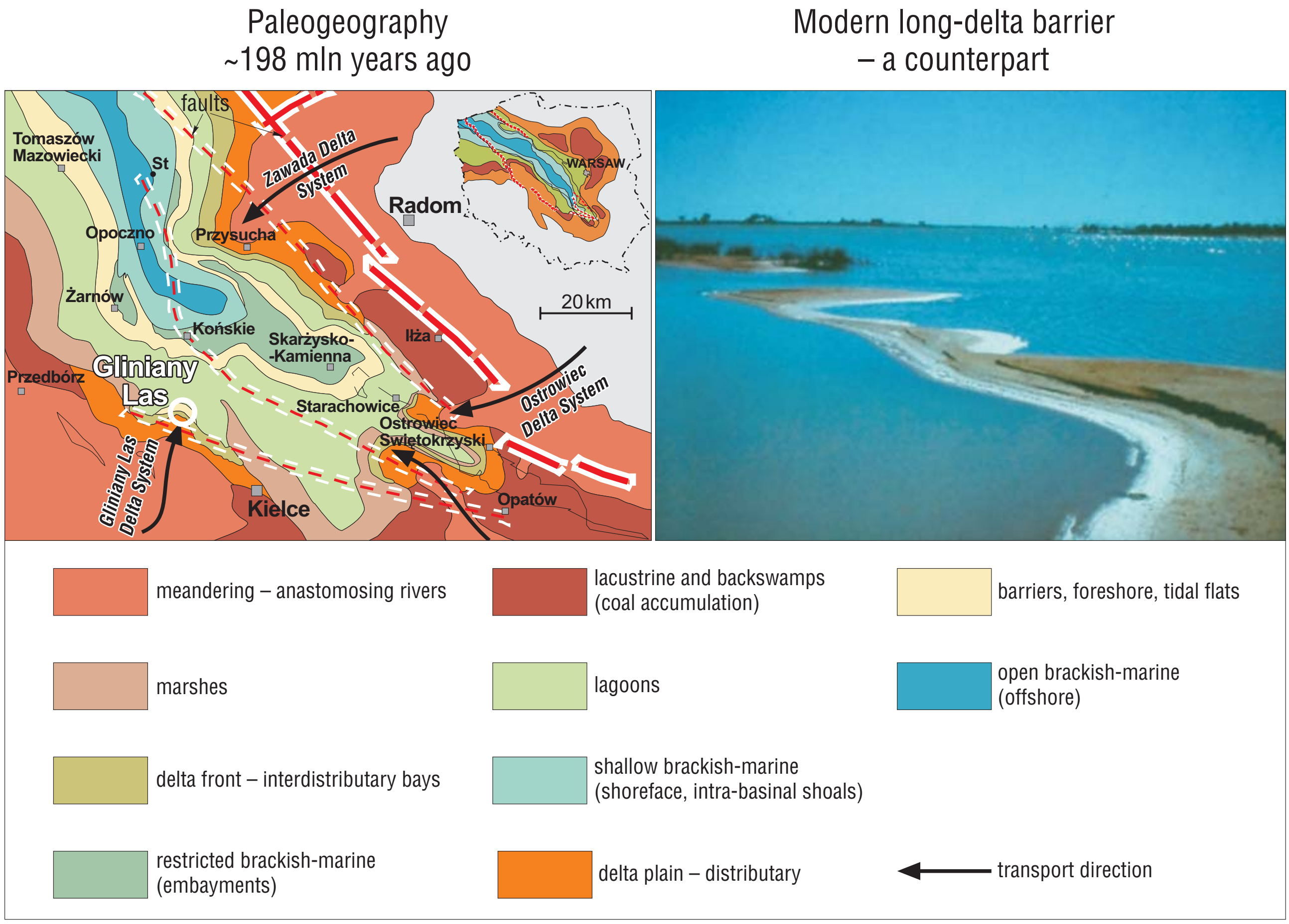

Fig. 6. Late Hettangian (Early Jurassic) paleogeopraphy of Poland and Świętokrzyskie (Holy Cross) Mountains area, with location of Gliniany Las marked — a proposal of educational plate at the site

Site management plans are important as they can clearly define what action is required to manage and maintain geological sites. Several major factors should be considered within the development of a site management plan, such as detailed description of the important geological features, detailed map of the site, protection system, land ownership, potential threats and management issues, other conservation interests such as archaeological and biological ones, educational potential including plans of educational paths, frequency of subsequent maintenance works and others.

Geosites combining geological and archaeological values

Kamienna Valley Geopark will integrate many scientific and education fields, first of all archaeology and history — from the Paleolithic through Neolithic, Roman, Medieval to modern times. Ore deposits, such as iron, have been mined here for thousands of years and, more recently, the Industrial Revolution fed on rich natural resources of Kamienna Valley.

Ochre and hematite was one of the first pursuits of mankind as these were the natural dyes necessary for rituals, such as funeral rites. The oldest known underground mine constructions (with artificial roofing an supports) were built in Rydno as early as in Paleolithic times (about 10,000 years ago). Rydno (a suburb of Skarżysko Kamienna town) is now an archaeological reserve at the Kamienna River. However, this unique reserve can be exposed and developed as tourist site not before an appropriate protection, monitoring and maintenance is provided.

World famous Krzemionki Opatowskie flint mines near Ostrowiec Świętokrzyski (now archaeological/geological reserve and underground museum visited each year by thousands of tourists) were exploited *c.* 3900 to 1600 BC (radiocarbon dating) by different peoples who left artifacts categorized by archaeologists into cultures, e.g., the Funnelbeaker culture, Globular Amphora Culture, and Bell-Beaker (Mierzanowice) culture (Bąbel, www.krzemionki.pl). It is possible that deposits of striped flint were known even earlier to Mesolithic hunters. Its perfectly preserved ground landscape and underground structure give it extraordinary importance. The mines were found on July 19, 1922 by the celebrated geologist Jan Samsonowicz. Axes made of flint, used mostly for cutting down trees and clearing land as well as for cutting wood, were distributed for a range of 250 km from the mines (Funnelbeaker Culture, *c.* 3900–2900 BC).

The number of mining units is estimated at over five thousand. The advance of more complex flint-mining technology in the Neolithic Age resulted in the development of specialization: This is when professional flint miners emerged. Selected half-finished products and roughly shaped lumps were taken for further working in production settlements located in the basin of the Kamienna river, where, for instance, axes were polished and completed. Symbols representing deities worshipped by the miners, made in charcoal on rock faces and pillars, were found in the mine (Bąbel, www.krzemionki.pl).

The mining field in Krzemionki is located on Jurassic (upper Oxfordian) limestone terrain on the edge of a syncline. The parabolic field is *c*. 5 km long and from 20 to 220 m wide, covering an area of *c*. 785,000 m^2. In late Oxfordian times, the Krzemionki/Bałtów area was situated within an inner carbonate platform, where oolithic barrier/lagoonal depositional systems developed (Gutowski, 1998, 2004).

Flint horizons have a regionally consistent position in the profile, which is probably connected with relative sea-level falls. A crucial role in the silica precipitation was played by the presence of crustacean burrows and these Jurassic crustaceans could be named "the first miners of Krzemionki Opatowskie", like the title of current geological exhibition in the mine museum says (Pieńkowski & Gutowski, 2004) — Fig. 7.

Fig. 7. Network of *Thalassinoides* isp. and *Spongeliomorpha* isp. burrows in the Krzemionki Neolithic Flint Mine — fragment of underground educational path showing the works of "oldest miners" of this site — Late Jurassic crustaceans. Photo by J. Gutowski

Kamienna Valley is also known as the largest iron metallurgy district in central-eastern Europe in Roman times. Thousands of slagy-pit furnaces have been found in the region, one of the most spectacular metallurgical field was found near Szwarszowice (Fig. 1). The Museum of Nature and Technology in Starachowice (proposed administrative and educational centre of the future Kamienna Valley Geopark), organized itself in perfectly preserved, unique steel mill of the 19^{th}–20^{th} century, organized archaeological park (Fig. 12B). Every year the reenactment event called "Iron Roots" is being organized. Museum of Nature and Technology in Starachowice hosts also a big paleontological collection (including rich collection of Triassic reptile footprints from Wióry, Baranów and Kopulak) and geological exhibition.

Dinosaur geosites

Since many centuries, folk tales about „devil's footprints" left in stone circulated in the Kielce area. The devils usually guarded buried treasures in mines, or attempted to build a castle overnight for someone who sold his soul (and as usually, the devil would drop the last stone at dawn with his feet or hands imprinted in rock). Interestingly, shapes of the alleged "devil's footprints" went down to the iconography — and as the most characteristic footprints possessed three digits, consequently the devil was pictured with bird-like feet. It was against the traditional iconography (based on the Israel's scapegoat tradition, attributing devils with rather hoof-shaped feet), but in terms of comparable anatomy and phylogenesis — it is quite correct! It seems that the local folklore inspired the great Polish poet Adam Mickiewicz, who in one of his ballads ("Pan Twardowski", written in 1820) described one of the devils, namely *Mephistophele*, as having sparrow-hawk feet instead of traditional split hooves. In 1959, geologist Władysław Karaszewski from the Polish Geological Institute recognized Mesozoic reptilian tracks in these imprints (Karaszewski, 1975).

The last two decades greatly increased our knowledge about Polish dinosaurs. The search for dinosaur tracks led by the Polish Geological Institute benefited from paleoenvironmental restorations of Jurassic localities (Pieńkowski, 1991, 2004a — Figs. 5, 6) and paleoichnological research (Pieńkowski & Gierliński, 1987; Gierliński, 1991; Gierliński & Pieńkowski, 1999; Gierliński et al., 2001, 2004; Gierliński & Niedźwiedzki, 2002). These studies resulted in recognition of many forms of dinosaur tracks in the Holy Cross Mountains Region. Early Jurassic strata dating back to about 200 million years preserved footprints of early sauropods (the long-necked herbivores that became the largest land animals in the history of our planet), thyreophorans (armoured ornithischians) and theropods (carnivorous dinosaurs). Early mammalian footprints have been also discovered (Gierliński et al., 2004).

It has been long asserted that in the Late Jurassic the territory of Poland was completely submerged under vast seas. Recently, however, Upper Jurassic strata yielded footprints of stegosaurs (advanced thyreophorans with spiky tail), ornithopods (mostly bipedal ornithischians), and theropods (Gierliński & Sabath, 2002). These footprints are exposed in Bałtów and extensive ecological paths have been arranged there. Also, well preserved pterosaur footprints have been found (Pieńkowski & Niedźwiedzki, 2005).

Dinosaur tracksites occur in various sedimentary environments, ranging from the alluvial-lacustrine to deltaic, barrier-lagoonal and foreshore-tidal ones. Different dinosaur assemblages occurred in different environments, which allowed creation of "dinoichnofacies" concept (Gierliński & Pieńkowski, 1999). Most famous dinosaur track bearing sites are Gliniany Las (late Hettangian barrier/lagoon environment), Sołtyków (early Hettangian alluvial plain — Figs. 2, 5, 12A) and Gromadzice (mid-Hettangian deltaic system).

The Sołtyków Jets nature reserve ("Gagaty Sołtykowskie") is located in the pre-existing brick pit, Stąporków Forestry District, near little town of Stąporków, east of the town Skarżysko-Kamienna. This nature reserve reveals a unique record of an Early Jurassic alluvial plain ecosystem (braided and meandering river channels with floodplain, lakes and bogs — Figs. 2, 5, 12A). Geological records of ancient ecosystems are particularly important for nature protection and ecological education because they allow to understand present-day ecosystems and to predict their future evolution. A rich variety of plant remains (Reymanówna, 1991; Wcisło-Luraniec, 1991; Ziaja, 1991), insects

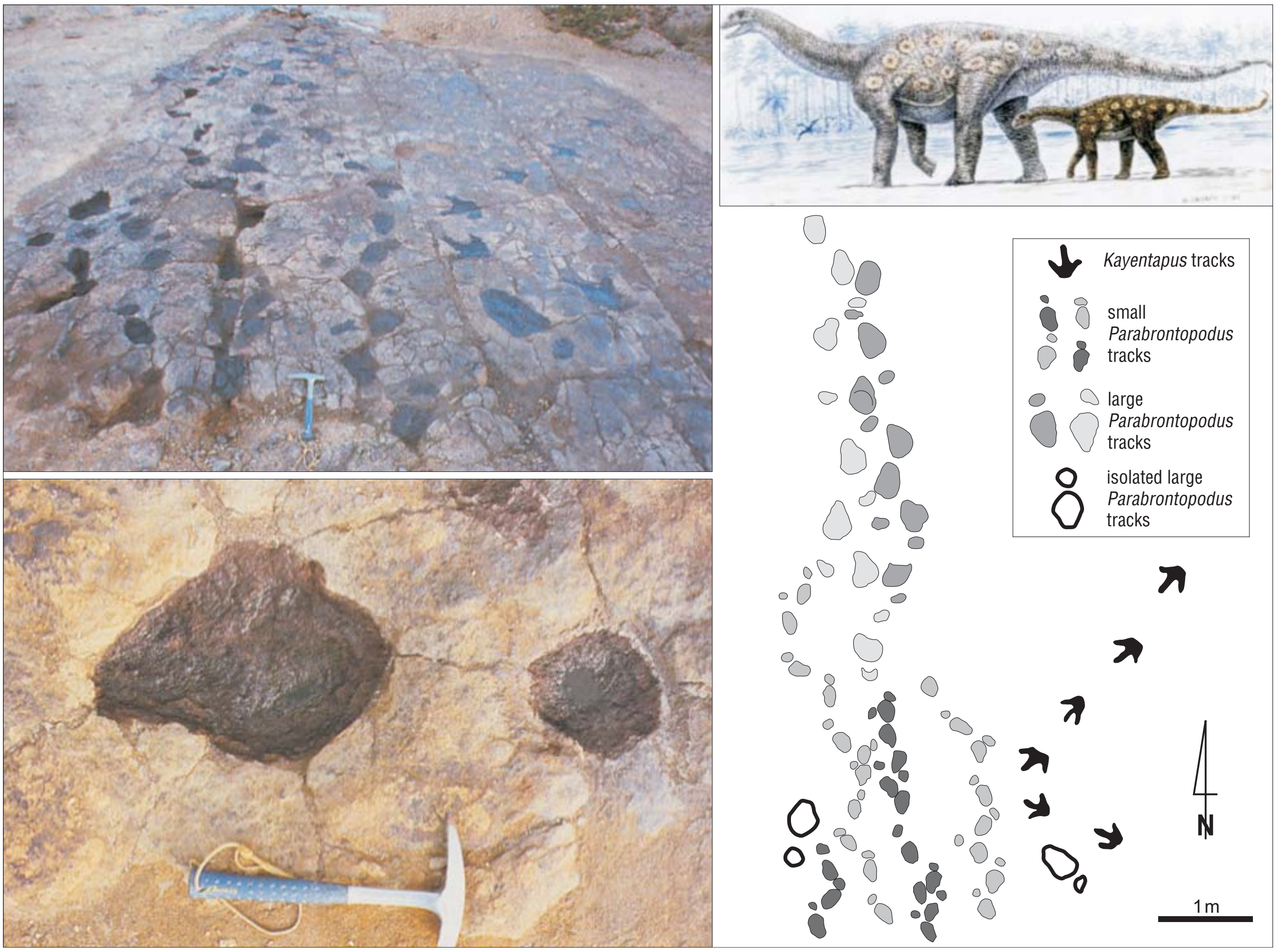

Fig. 8. Parallel trackways of sauropods (both adult and juvenile ones) and theropods in Sołtyków Jet Reserve and map of the trackways (after Gierliński & Pieńkowski, 1999). Picture of adult and juvenile sauropod by Karol Sabath

(Wegierek & Zherikhin, 1997), bivalves (Pieńkowski, 2004a, b), invertebrate trace fossils (Pieńkowski & Niedźwiedzki, 2008), dinosaur nests (Pieńkowski, 1998) and footprints (including the oldest known evidence for herd life of dinosaurs — Fig. 8, perfectly preserved giant tracks of an allosauroid, the greatest predator that ever lived in the area of Poland — Fig. 9; Gierliński et al., 2001, 2004), footprints of early mammals (Gierliński et al., 2004) and bone fragments of dinosaurs (Niedźwiedzki, 2007) are the most interesting geological treasures of this site. An area with the earliest known record of gregarious habits of dinosaurs (parallel paths of two adult and three juvenile sauropods — Gierliński & Pieńkowski, 1999) has been made accessible for tourists. Due to the efforts of the Polish Geological Institute, Chief Nature Conservator and Stąporków Forest Inspectorate, a unique surface with dinosaur footprints was secured at Sołtyków in 1999. It was roofed over and equipped with an information board.

Dinosaur and other tetrapod footprints are associated by unique and very rich invertebrate trace fossil assemblages (Pieńkowski & Niedźwiedzki, 2008). They span environments from shallow lacustrine to different subaerial fluvial environments. Bivalve burrows and traces, oligochaetae, crustacean, and insect burrows, plant roots, vertebrate tracks and other types of trace fossils record information on biodiversity and paleoecological conditions. Various structures attributed to insect burrows (vertical to subvertical tunnels), chambered insect nests or other nests with septa, earthworm burrows as well as enigmatic radial chambers point to rapid evolution of the continental ecosystem in Early Jurassic times.

Fig. 9. *Megalosauripus* sp. (sensu Lockley) — the biggest Early Jurassic theropod footprint, in the same time the trace of the biggest land predator, which ever lived on the territory which is now Poland. Photo G. Gierliński

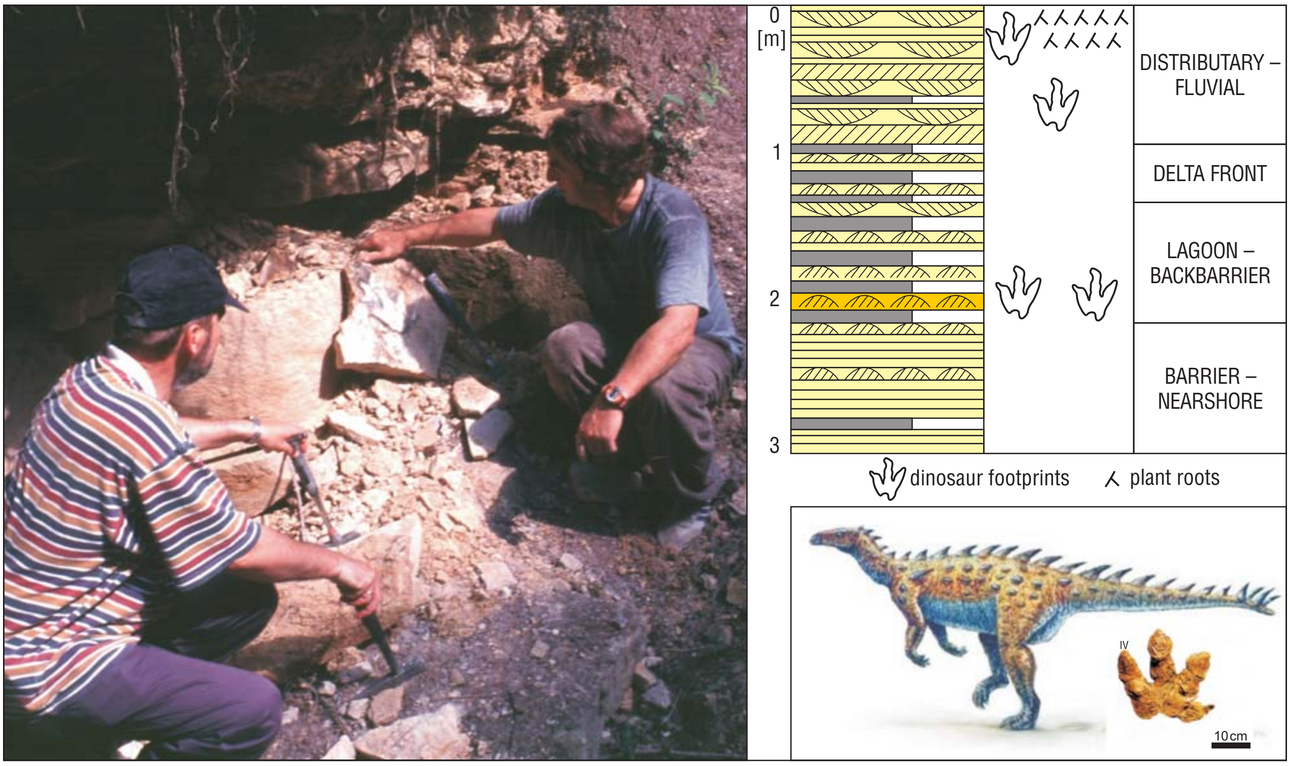

Fig. 10. Gliniany Las site — this humble, small quarry exposing the Late Hettangian barrier deposits yielded the biggest number of well-preserved dinosaur footprints in Poland. Its permanent protection in a roofed museum is necessary. Profile after Pieńkowski (1985), remaining explanation — see Fig. 2. Picture of trace maker of *Moyenisauropus karaszewskii* tracks — by Karol Sabath. Photo by G. Gierliński

There are also threats for this unique sites. Natural vegetation grows rapidly on and in front of disused clay pit in Sołtyków, concealing the interest features (compare Fig 2 and Fig. 12A). Ongoing vegetation management is necessary to maintain clean faces. Another threat is landslides and illegal exploitation of jet (which has been terminated in recent years, but the trenches left by collectors can be dangerous for people and animals).

Another famous dinosaur tracksite is Gliniany Las, a small village in the community of Mniów, where small disused quarry revealed the Lower Jurassic/Upper Hettangian barrier deposits (Fig. 6). So far, this small outcrop has yielded the biggest number of well-preserved dinosaur footprints (Gierliński, 1991; Fig. 10). However, this unique reserve can be exposed and developed as tourist site not before an appropriate protection, monitoring and maintenance is provided. Therefore, idea of exposing the dinosaur track-bearing surface and organizing an *in situ* protection within a museum building was conceived by geologists, the Świętokrzyskie Voivodship, Mniów Community and business. The technical project is already prepared.

Other footprint localities, e.g., Gromadzice near Ostrowiec Świętokrzyski and those discovered in the last two years in Podole near Opatów are not so well accessible. A buyout procedures will have to be initiated for acquisition of private land in these sites. Local communities are interested in that, but they need financial support. Local business seem to be the most promising option.

Educational centers

The *sine qua non* of the project's success is to popularize the knowledge about geology of this region. Fortunately, there is an existing framework of educational centers — Museum of Nature and Technology in Starachowice (www.ekomuzeum.pl) and dinosaur Jurassic Park in Bałtów (www.baltowskipark.pl). Similarly, Agroklub in Kontrewers (very meritorious in the field of nature protection in the region — www.czterokolowce.pl) can be important as potential information, conference and agrotouristic centers.

The Museum of Nature and Technology in Starachowice, located in an old and unique metallurgical plant (the only 13th century object of that kind preserved intact to our times), exhibits also Early and Late Jurassic dinosaur footprints and a very large collection of vertebrate footprints from Wióry near Ostrowiec Świętokrzyski, dating back to the very beginning of the Mesozoic era, just after the mass extinction that paved the way for the evolution of dinosaurs and mammals.

In July, 2003, a life size model of an allosaur made by Krzysztof Kuchnio standed in the village of Bałtów (Fig. 11). This event commenced the Bałtów Jurassic Park, one of the most interesting (and profitable) business activities related to paleontology, dinosaurs and geotourism. The Polish Geological Institute covered this initiative with scientific supervision and support. As a result, the Bałtów Jurassic Park became one of most famous touristic destination in the region and Poland contributing to the whole regional development. In Bałtów, both business and local community association ("Delta", "Bałt") have already prepared a number of geosites and provided them with access roads, pedestrian paths and comprehensive information.

The Starachowice Museum of Nature and Technology and the Bałtów Jurassic Park are already existing elements of the future Kamienna Valley Geopark.

These entities, being in contact with the Polish Geological Institute, other scientific organizations (particularly archaeological ones) are capable of performing various roles of museums, educational and geotouristic centers. Additionally, other centre is about to be raised in Gliniany Las.

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Fig. 11. The Bałtów Jurassic Park (model of an allosaur) is the biggest geotouristic attraction in the region, particularly for school children. Photo by G. Pieńkowski

Fig. 12. Master classes performed during school excursions in the future Kamienna River Geopark yielded important information concerning future educational systems and attractiveness of particular geosites, their presentation and activities: **A** — Individual searching for fossils — the most attractive activity of an excursion in the students' oppinion. Note degradation of the outcrop (Sołtyków Jet Reserve), which occurred in the past thirty years (compare with Fig. 2) due to weathering processes, landslides and vegetation overgrowth; **B** — Interactive lesson in the archaeological park in Starachowice — reenactmen of ancient iron production in the slaggy-pit furnaces — second most attractive activity; **C** — Palaeontological works — preparing plaster casts of dinosaur footprints for school collection — third on the list of most attractive activities; **D** — Transportation in a special dinobus — regarded as an attractive and important part of the excursion (total number of enlisted activities — 15). Photo by G. Pieńkowski

Several sites with dinosaur footprints were provided with information boards within a limited project supported by the Voivodeship Fund for Environmental Protection and Water Management in Kielce within a Dinopark network. Within the same support scheme, a brochure (tourist guidebook) on tracking dinosaurs in the Świętokrzyskie (Holy Cross) Mountains have been published (Gierliński et al., 2006). However, uniform information boards, leaflets, guides and digital information must be prepared for the whole geopark and its geosites. It is also necessary to conduct groundworks, to design didactic ecological paths and install unified information boards.

Conclusions — next steps

Based on existing natural heritage, scientific knowledge, previous initiatives, governmental and local community support, business activities one has to organize a meeting of all interested parties to prepare a "road map" towards organization of the Kamienna Valley Geopark. Organizational, financing and particularly land buyout procedures will be certainly the most difficult task. However, it is a common interest to establish this geopark to protect the unique abiotic environment in this region and combine its geological, archaeological, historical and cultural assents in one comprehensive scheme. This will enable further promotion and development of tourism and local business, which should play a crucial role in regional development of one of the poorest but most interesting regions in Poland.

Educational functions of the Kamienna Valley geopark should be developed in form of guides for teachers. With these guides the teachers should be able to run the field courses, choosing their own routes and themes for students of different levels — from grammar school to academic level. Some "master classes" (at the level of secondary school) have been already performed, yielding valuable information. Master classes run by geologists and archaeologists showed how to run field lessons, which geosites and activities were most interesting for students and what educational methods were most effective (Fig. 12). Master classes allow teachers to learn from scientists how to guide their students to the field. In return, scientists can learn what is most relevant and best adopted by the students. Future guides and handbooks should be prepared as a result of cooperation between scientists (geologists, archaeologists, historians and others) and experienced teachers who could suggest most valuable educational themes and methods.

Success of the Kamienna Valley geopark project will serve well to the future projects regarding next geoparks and protection of geodiversity in Poland.

References:

ALEXANDROWICZ Z. 2006 — Geoparki — nowe wyzwanie dla ochrony dziedzictwa geologicznego. Prz. Geol., 54: 36–41.

GIERLIŃSKI G. 1991 — New dinosaur ichnotaxa from the Early Jurassic of the Holy Cross Mountains, Poland. Palaeogeogr., Palaeoclim., Palaeoecol., 85, 1–2: 137–148.

GIERLIŃSKI G. & NIEDŹWIEDZKI G. 2002 — Enigmatic dinosaur footprints from the Lower Jurassic of Poland. Geol. Quart., 46: 467–472.

GIERLIŃSKI G. & PIEŃKOWSKI G. 1999 — Dinosaur track assemblages from the Hettangian of Poland. Geol. Quart., 43: 329–346.

GIERLIŃSKI G., NIEDŹWIEDZKI G. & PIEŃKOWSKI G. 2001 — Gigantic footprint of theropod dinosaur in the Early Jurassic of Poland. Acta Palaeont. Pol., 46: 441–446.

GIERLIŃSKI G., PIEŃKOWSKI G. & NIEDŹWIEDZKI G. 2004 — Tetrapod track assemblage in the Hettangian of Sołtyków, Poland, and its paleoenvironmental background. Ichnos, 11: 195–213.

GIERLIŃSKI G. & SABATH K. 2002 — A probable stegosaurian track from the Late Jurassic of Poland. Acta Palaeont. Pol., 47: 561–564.

GIERLIŃSKI G., SABATH K. & PLOCH I. 2006 — Tracking Dinosaurs in the Holy Cross Montains. Tourist Guidebook, Polish Geological Institute: 17.

GRAY M. 2004 — Geodiversity — valuing and conserving abiotic natura. Chichester, Wiley & Sons.

GUTOWSKI J. 1998 — Oxfordian and Kimmeridgian of the northeastern margin of the Holy Cross Mountains, Central Poland. Geol. Quart., 42: 59–72.

GUTOWSKI J. 2004 — Dynamika rozwoju utworów koralowych środkowego oksfordu okolic Bałtowa. Tomy Jurajskie, 2: 17–28.

KARASZEWSKI W. 1975 — Footprints of Pentadactyl Dinosaurs in the Lower Jurassic of Poland. Bull. Acad. Pol. Sc. Sér. Sc. Terre, 23, 2: 133–136.

KOZŁOWSKI S. (red.) 1998 — Ochrona litosfery. Państw. Inst. Geol., Warszawa.

KOZŁOWSKI S. 2004 — Geodiversity. The concept and scope of geodiversity. Prz. Geol., 52: 833–837.

KOZŁOWSKI S., MIGASZEWSKI Z.M. & GAŁUSZKA A. 2004 — Znaczenie georóżnorodności w holistycznej wizji przyrody. Prz. Geol., 52: 291–294.

NIEDŹWIEDZKI G. 2007 — Świętokrzyski park jurajski. Rzeczpospolita, 19.07.2007.

PIEŃKOWSKI G. 1985 — Early Liassic trace fossils assemblages from the Holy Cross Mountains, Poland: their distribution in continental and marginal marine environments. [In:] H. Allen Curran (ed.), Biogenic Structures: Their Use in Interpreting Depositional Environments. Soc. Econ. Paleont. Miner. Spec. Publ., 35: 37–51.

PIEŃKOWSKI G. 1991 — Eustatically — controlled sedimentation in the Hettangian-Sinemurian (Early Jurassic) of Poland and Sweden. Sedimentology, 38: 503–518.

PIEŃKOWSKI G. 1998 — Dinosaur nesting ground from the Early Jurassic fluvial deposits, Holy Cross Mountains (Poland). Geol. Quart., 42: 461–476.

PIEŃKOWSKI G. 2004a — The epicontinental Lower Jurassic of Poland. Polish Geological Institute Sp. Papers, 12: 1–156.

PIEŃKOWSKI G. 2004b — Sołtyków — unikalny zapis paleoekologiczny wczesnojurajskich utworów kontynentalnych. Tomy Jurajskie, 2: 1–16.

PIEŃKOWSKI G. & GIERLIŃSKI G. 1987 — New finds of dinosaur footprints in Liassic of the Holy Cross Mts. and its palaeoenvironmental background. Prz. Geol., 35: 199–205.

PIEŃKOWSKI G. & GUTOWSKI J. 2004 — Genesis of the Upper Oxfordian flints in Krzemionki Opatowskie (Poland) (in Polish, English abstract). Tomy Jurajskie, 2: 101–108.

PIEŃKOWSKI G. & NIEDŹWIEDZKI G. 2005 — Pterosaur tracks from the early Kimmeridgian intertidal deposits of Wierzbica, Poland. Geol. Quart., 49: 339–346.

PIEŃKOWSKI G. & NIEDŹWIEDZKI G. 2008 — Invertabrate trace fossil assemblages from the Lower Hettangian of Sołtyków, Holy Cross Mountains, Poland. Volumina Jurassica V, Proceedings of the 7th International Congress on the Jurassic System, September 6–18, 2006, Kraków, Poland.

PROSSER C., MURPHY M. & LARWOOD J. 2006 — Geological conservation — a guide to good practice. English Nature, External Relations Team, Peterborough.

REYMANÓWNA M. 1991 — Two conifers from the Liassic flora of Odrowąż in Poland. [In:] J. Kovar-Eder (ed.), Palaeovegetational development in Europe and Regions relevant to its palaeofloristic evolution. Proceedings of the Pan-European Palaeobotanical Conference, Vienna, 19–23 September 1991. Naturhistorisches Museum, Wien: 307–310.

STACE H. & LARWOOD J.G. 2006 — Natural foundations geodiversity for people, places and nature. English Nature, Peterborough.

WCISŁO-LURANIEC E. 1991 — Flora from Odrowąż in Poland — a typical Lower Liassic European flora. [In:] J. Kovar-Eder (ed.), Palaeovegetational Development in Europe and Regions Relevant to its Palaeofloristic Evolution. Proceedings of the Pan-European Palaeobotanical Conference, Vienna, 19–23 September 1991. Naturhistorisches Museum, Wien: 307–311.

WEGIEREK P. & ZHERIKHIN V. 1997 — An Early Jurassic insect fauna in the Holy Cross Mountains. Acta Palaeont. Pol., 42 : 539–543.

WRÓBLEWSKI T. 2000 — Ochrona georóżnorodności w Górach Świętokrzyskich z mapą w skali 1 : 300 000. Państw. Inst. Geol.

ZIAJA J. 1991 — The Lower Liassic microflora from Odrowąż in Poland. [In:] J. Kovar-Eder (ed.), Palaeovegetational development in Europe and Regions relevant to its palaeofloristic evolution, Proceedings of the Pan-European Palaeobotanical Conference, Vienna, 19–23 September 1991. Naturhistorisches Museum, Wien: 337–339.