ProGEO NEWS

No.1 2000

Dinosaur footprints from one of the sites on the pre-symposium fieldtrip
Photo: V. Makarikhin

ProGEO 99

Excursions on the III International Symposium ProGEO – Spain, November 1999

This symposium was a great achievement for the organisers and ProGEO. Full report from the event is given in the proceedings (see the last issue of ProGEO NEWS).

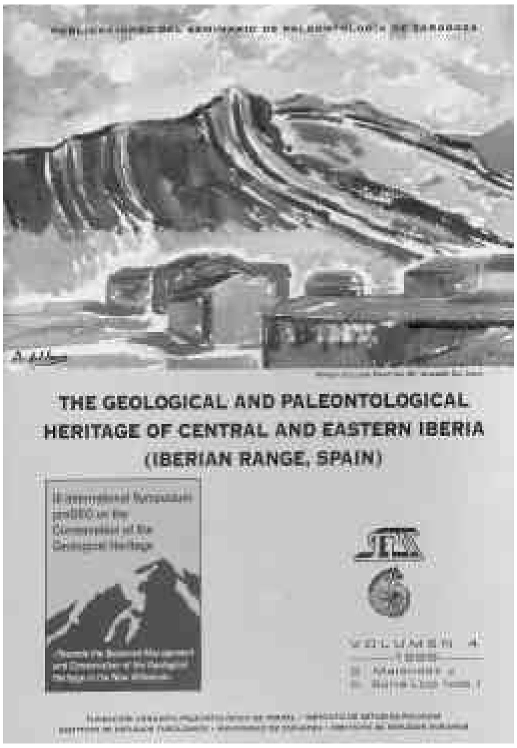
In relation to the symposium both a pre– and postsymposium excursion was arranged. These two excursions gave a very good overview of the geology of the central and eastern Iberia and the work with geoconservation in these districts.

Amongst interesting inputs of geology and geoconservation the participants experienced a good snowy Spanish winter on the pre-excursion and crispy clear and frosty mornings on the post-excursion. This was truly a contrast to how at least we from the north are used to think about travels in Spain.

The excursions are well documented by a very good guidebook published during the event. This book gives good overviews, in depth texts and sketches as well as a lot of relevant references.

Spanish winter on the pre-symposium excursion

Photo: V. Makarikhin



Meléndez, G. & Soria-Llop, C. (eds.). 1999. The geological and paleontoligal heritage og central and eastern Iberia (Iberia range, Spain). Publ. Del seminario de paleontologia de Zaragoza. Vol. 4. ISBN: 84-7820-370-2: 1-180.

The logo

Use of our common symbol

During the last five years or so the European Association for the Conservation of the Geological heritage, ProGEO has used a logotype to symbolise its protective aspect.

The logotype is composed of three components, a shelter, a symbolic geological feature and the text/ letters ProGEO. All these together constitute the ProGEO logo.

Since the meeting when the logotype was accepted, several varieties have been seen around.

I would therefore urge all potential users to adopt the design agreed to and also seen on the ProGEO front homepage.

Lars Karis

Walter Krieg

Walter demonstrating an information poster at a protected glacial pothole-site in Vorarlberg during the ProGEO meeting in 1989. Photo: Lars Erikstad

On the 9th of January we lost our second president, Walter Krieg. An accident in December 1998 was the beginning of a long period of illness and ended fatal. At first he seemed to recovered quickly from this accident. But after the summer of 1999 he went into a coma and died on 9 January 2000 at the age of 69.

Walter studied German and Geography on the University of Graz and did a doctors on the carstic features on the eastern Dachsteinstock (1953). After his marriage with Ruth in 1955 he went to Bregenz and worked on a Geoseismic-project for the Vorarlberger Erdölgesellschaft and from 1961 on as a teacher in German and Geography in the Gymnasium in Dornbirn. His interest in education dates from the very beginning. In his birthplace Graz he was active for the county natural museum. And once in Vorarlberg he worked on archaeological and palaeontological excavations and assisted the director of the «Vorarlberger Naturschau», a natural history museum in Dornbirn.

In 1967 he became director of this museum. And that is where I met Walter for the first time. As physical geography students from the University of Amsterdam we had our first practical fieldwork in Vorarlberg. And of course during the preparatory excursion we had to visit the Vorarlberger Naturschau. Walter let us in the secrets of the geo(morph)ology of Vorarlberg. During this fieldwork period I attended one of my most exciting experiences, a cave excursion with Walter to the Schneckenloch (Snail cave), creeping through very narrow passages was not a daily business to me. After my studies and in the meanwhile active in the field of geoconservation I renewed the contact with Walter.

Walter was well known in Vorarlberg. He was not only the director of the Vorarlberger Naturschau. He was an active nature conservationist. He advised the Bundesland Government in nature conservation matters and did this in his own way. We experienced that many years later when in 1989 we visited Austria as the European Working Group on Earth- Science Conservation. Walter was typically the man of the dialog in stead of the confrontation. In the battle between nature and human society he co-operated harmoniously with developers and companies to find the best solution for nature in general and the geological heritage in particular and the development of the people of Vorarlberg. As many involved conservationist he did not stop his activities after his retirement in 1993. His death is a great lost for Vorarlberg.

But it is not only a loss for our Austrian colleagues. When I contacted earth scientists in Europe to start a European Group on geoconservation, Walter was one of the first who replied enthusiastically. And when the Working Group became active, Walter as an older and wiser geoconservationist was of great help for all of us. In 1993 after George Black's retirement as a president, Walter was his natural successor (until 1995). With his vast experiences he helped the Working Group through a difficult period from a working group to its transition into the association.

Walter was in his practical and pragmatic way an example for all of us. ProGEO miss his friendship and good advises.

Gerard Gonggrijp

Earth heritage conservation in England

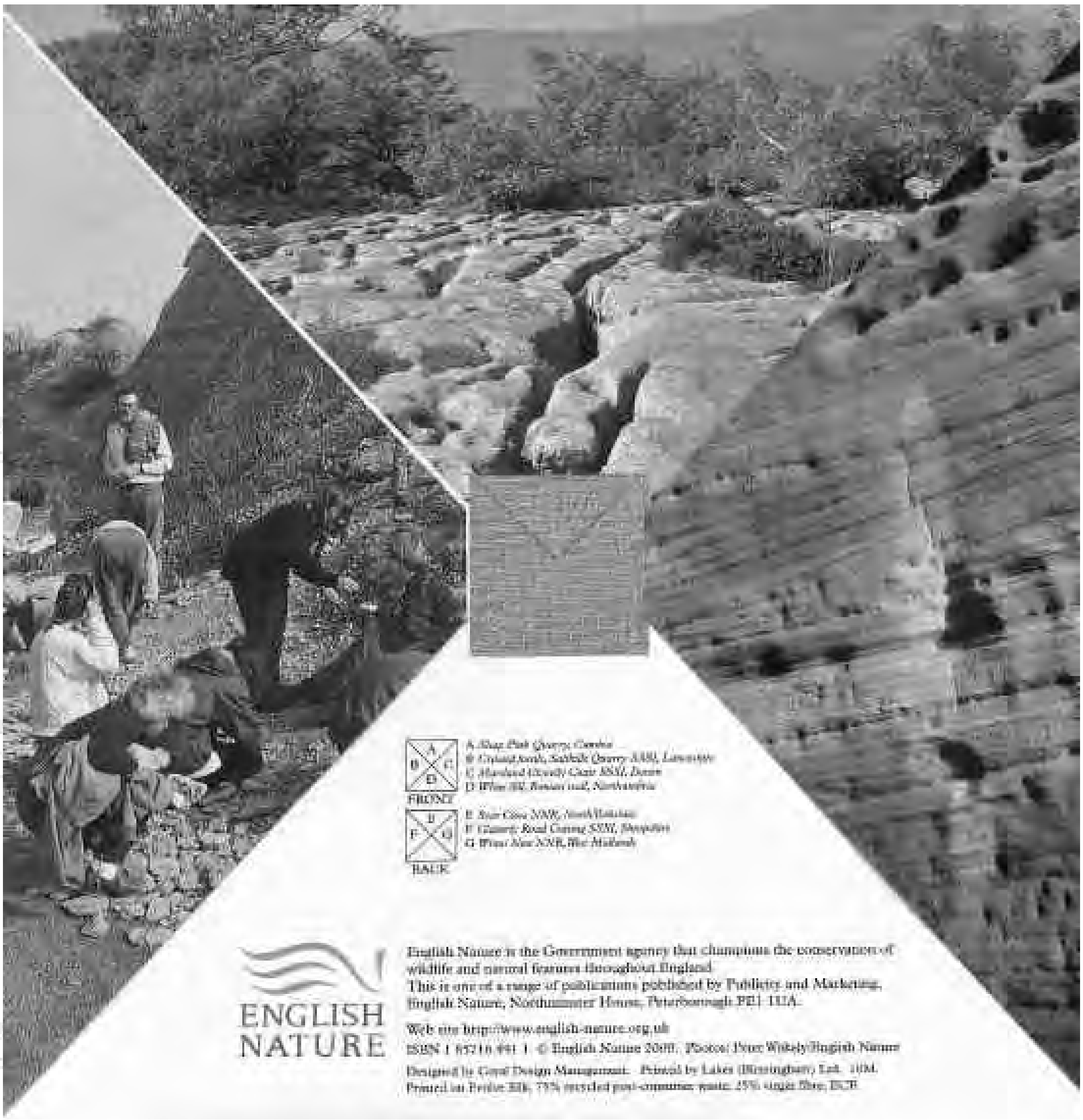
The Past is the Key to the Future

Our Earth heritage enables us to unravel the past. It is rich in evidence of changing climates, shifting boundaries between land and sea and extinction events, and illustrates the long periods of time over which the natural resources on which society depends were formed. Today, it is these same environmental changes, along with the sustainable use of natural resources, that provide some of the greatest challenges facing society.

Learning about the past, through using our Earth heritage, can help provide a key for us to understand, explain and plan for future environmental change: the past is the key to the future.

'The past is the key to the future' provides the philosophy and framework for English Nature's Earth heritage conservation work over the next five years. As England's statutory nature conservation service, English Nature has been responsible for the designation and safeguard of over 1300 Earth heritage Site of Special Scientific Interest. However, securing the long-term future of these sites requires that a wide audience of decision makers and the general public appreciate these sites and see them as a valuable resource.

English Nature's new framework, 'The past is the key to the future' seeks to do just this. Through three themes 'Learning from the past', 'Enjoying the present' and 'Influencing the future' it builds on England's existing Earth heritage conservation foundations, and takes up the challenges and opportunities we now face to widen



The Past is the Key to the Future – information leaflet from English Nature understanding of, and support for, our Earth heritage resource and the need for its conservation.

1) Learning from the past: This theme is about ensuring that the best of our Earth heritage is protected, enhanced and managed so that it is safeguarded and available for scientific study and use for education. The right sites need to be conserved and available for research, and knowledge gained from the resource needs to be widely disseminated. Work here includes:

Ensuring that the Earth heritage SSSI series remains scientifically credible and is safeguarded through the continued provision of high quality site management advice at a national and local level.

Promoting a sustainable approach to the management of our Earth heritage - aiming to ensure that the resource available now will still be available in the future.

Undertaking a major site enhancement initiative to improve the condition of Earth heritage SSSIs.

Continuing to support the Joint Nature Conservation Council in the publication of the GCR volume series and in the maintenance of a Great Britain-wide GCR site database.

2) Enjoying the present: The aim of this theme is to raise awareness of our Earth heritage amongst decision makers and the general public, and to encourage more people to become involved in its conservation. A partnership approach and use of new technology will be central to this work. Sites will be promoted widely, and links between Earth heritage, local landscape, wildlife and people will be emphasized. Work includes:

Undertaking a major promotion and interpretation initiative celebrating the rich and varied Earth heritage within the SSSI series and network of National Nature Reserves.

Further developing and exploiting the links between Earth heritage, landscape and wildlife and between our Earth heritage and the built environment.

Disseminating information about managing Earth heritage sites through the publication, with partners, of the *Earth heritage* magazine and through articles in other key publications.

Developing opportunities for increased sponsorship of Earth heritage conservation by industry.

Developing new training programmes to raise awareness of Earth heritage and Earth heritage conservation amongst targeted audiences.

3) Influencing the future: Under this theme, we will continue to work with partners and stakeholders who are influential in helping to deliver Earth heritage conservation. We seek to apply knowledge of Earth science to address broader issues, using our expertise to influence policy and practice in the mineral, waste and energy sectors, and in relation to issues such as climate change, where knowledge of the past is invaluable in helping to influence the future. Work includes:

Continuing to support and work closely with others involved in Earth heritage conservation in England (including the RIGS movement, the Geoconservation Commission, the Geologists' Association and RSNC), and strengthen our involvement with practitioners at a European level.

Encouraging the sharing of knowledge and the promotion of Earth heritage conservation in its widest context.

Widening the application of our Earth heritage expertise to influence changes in policy and practice in key industry sectors such as minerals, waste and energy.

Promoting the use of Earth heritage knowledge in understanding future environmental change, and use this knowledge to influence future development of nature conservation policy.

Our Earth heritage is a valuable resource. It is diverse, it underpins and shapes our environment and influences every aspect of our lives. Its conservation is essential so that today, and for generations to come, it will remain available for everyone to learn from and enjoy. As we settle into a new millennium our message is clear. Understanding and conserving our past - our Earth heritage - is vital for the future conservation and management of our environment and its natural resources. *'The past is the key to the future*'.

Copies of the document along with supporting postcards are available from English Nature.

Colin Prosser & Jonathan Larwood,
English Nature

Further reading

King, A.H., Prosser, C.D.**,** and Moat, T. 1996. Towards the Millennium - Conserving England's Earth Heritage. Earth Heritage, **5**, pp. 10-11.

Ellis, N.V. (Ed), Bowen, D.Q., Campbell, S., Knill, J.L., McKirdy, A.P., Prosser, C.D., Vincent, M.A. and Wilson, R.C.L. 1996. An Introduction to the Geological Conservation Review. GCR Series No **1**, Joint Nature Conservation Committee, Peterborough.

Geological heritage conservation in Albania

The aim of this paper is to present the achievements on the Geological Heritage Conservation in Albania and the new tasks for the implementation of international conventions on biodiversity and geological heritage signed by the Albanian State.

Since ancient times the Selenica asphalt deposits in the Ilirian regions, coals in the Korca region, cherts and iron and copper ores and gold linked with them in Mirdita region were known and used.

Many written testimonies by erudite persons, travellers and ancient philosophers, archeological works and studies support this. The first publication about Selenica asphalt deposit belongs to Aristotle. Amongst others he pointed: *"This is a fire flaming continuously, it has a sulphur smell and many large willows and verdure sprout round would surprise the people passing by".* Albanian people have since the old times respected and evaluated natural beauties. They have been careful to protect high forests, cold water springs and high old trees next to the springs, wild animals, birds etc. Olive trees was considered a symbol of life. Thermal underground springs in Elbasan, Peshkopi, Diber, Leskovik, Permeti were known and used since the ancient times as bath-cure against the skin illnesses.

The first data of directly geological-geographical character about Albania were presented at the end of the nineteenth century and during the beginning of the twentieth century by foreign geographers and geologists. Concerning geological heritage we can note that the first findings

Part of the Komani site with foldings of marly limestones of different colours.

and examinations of *Barbatica Albanica* by Openheim in Drenova coal mine (Korca region) in molasse formations of Miocene was done in 1896 (P. Pashko, 1977); and first findings, examinations and publication of Triassic *ammonite* collections from the Kcira section (Puka region) was done in 1911 by F. Nopca and Gustav Van Arthaber. They determined 5 families, 5 subfamilies and 49 species of *ammonites* of important paleontological value, the Shkoder-Peja (Scutari-Pec) regional transversal fault and some other geological and geomorphological phenomena.

After the foundation of the Geological Survey of Albania in 1952, a period of intensive development of geological work especially linked to prospecting of mineral ores and raw materials began. This included geological surveys and mapping all over Albania. At the same time some capital and monographic works were carried out. These led to the discovery of many geological phenomena of regional importance. This period continued up to 1990 under the office for protection of the underground wealth in the Ministry of Industry and Mines.

In 1947 the law for declaration of all natural wealth in Albania with state ownership was accepted. Later legislation for protection of forests, flora and fauna, declaring some surface as woodlands, hunting lands, national parks, local and recreative parks etc were implemented as well. Concerning natural monuments of geological-geomorphologic character, they were included in laws and decisions for prospecting and exploration of mineral

Ksamili Islands at the southernmost port of the Jinian riviera. All photos: A. Ser-

Shopeti Gorge – one of the outstanding geomorphological sites in Albania.

ores and raw materials. In 1971 law Nr4874 for "The Protection of Cultural Heritage and Natural Wealths in Albania" was accepted.

ProGEO (The European Association for Geological Heritage Conservation) as promontory for Geological Heritage Conservation in Albania.

For the first time Geological Conservation in Albania was presented at the subregional meeting of ProGEO in May 1995, in Sofia, Bulgaria by A. Serjani and F. Cara. In November the same year contributions on Geological Heritage Conservation in Albania (A. Serjani), on the legislation for protection of natural monuments (S. Hanaj), and about Bulqiza chromite deposit as unique geosite in Europe (Dobi et al) were presented to the First National conference: "Geology Environment and Civil society" held in Tirana. At the Second National Conference in November 1997 questions of ecogeology and classification of geological sites of Albania (Serjani, A., Jozja, N. And Neziraj, A.), geotops of Ionian Riviera (Durmishi, C., Konomi, N. And Kanani, J.) and paleontological sites (Myftari, S.) were presented and discussed.

In the meetings held in Roma, Tallin, Bellogradchik and Madrid the geological heritage conservation in Albania has been presented in complete form within the framework of the ProGEO Strategy. Separate papers were also prepared and presented to the 8th international Geological Congress in Patra, Greece (Serjani, A. Et al.) and to the Carpatho- Balcan Geological Congress of Association in Wien (Durmishi, C.).

Some geotrips to geological sites have also been organised over the last years. At the end of 1997 "Union of Albanian Geologists for the Geological Science Heritage" was founded as a nongovernment organisation. Amongst actively working specialists on geological heritage conservation in Albania, the following can be listed: Adil Neziraj (geologist), Dede Marku (paleontologist), Halil Hallaci (geologist), Agim Pirdeni (paleontologist) Nevila Jozja (geologist) in Institute of Geological Research, Tirana. Cerciz Durmishi (sedimentologist), Geological Survey of Albania, Rruga e Kavajes, Nr. 153, Tirana, Albania. Farudin Krudaj (geographer), Arqile Berxolli (geographer, Geographical Center of Academy of Sciences, Tirana, Albania.

Geological survey of Albania main supporter for Geological Heritage conservation. In 1998 the first official project on Geological Heritage conservation in Albania was undertaken by the Geological Research Institute and supported by the Geological Survey of Albania. In Albania there are some state institutional organisations dealing with natural monuments and environmental protection such as: the Committee of Environmental Preservation and Protection at the Ministry of Health and Environment, the Centre of Geographical Studies of Academy of Sciences of Albania, the Tourist Committee of Albania etc. Up to now projects on geological heritage conservation in Albania are mainly been supported by the Geological Survey.

The workshop: "Geology, Territory and Environment" was held in October, 1998. Here lectures on geomonumental values of Albania was presented. Many geologists from different enterprises and geological centres all over Albania participated.

At the end of 1999 we finished the first Study on Geological Heritage Conservation in Albania and the first Inventory of Geological Sites. During this year a map of the first Inventory of Geological sites of Albania will be compiled in the scale 1:200000. New project on the main Geoparks and Geosites and will also be undertaken.

Albania is a rich country in geological sites of local, national and regional importance. That is why we hope for good possibilities for the development of geotouristic industry and educational, didactical and training activities. New projects on exploration of caves, canyons, waterfalls, glacial and erosional phenomena in high mountainous geographical-geological units of Albania must be undertaken in co-operation with foreign institutions from the European countries. We give priority to our efforts for the development of the scientific and practical activities on geological heritage conservation in Albania, according to the Pan-European Strategy of nature protection joint with the UNESCO, IUGS and ProGEO programs.

Afat Serjani

Erratic boulders

Erratic boulders are boulders found far away from their original 'birthplace' situation. Water or ice has transported these erratics. Human transport, popular for ages –think of the use as ballast stones for ships- is definitely not included. The term is mostly being used for the ice transport.

In the countries covered by glaciers during the various ice ages erratic boulders have a special interest. Already for centuries people have wondered about their origin. Giants, the Flood and other events have been suggested to explain their presence.

Many of these stones, telling the story of glacial (and sometimes fluvial) transport have disappeared. They were used as building stones, crushed and used for dikes, roads etc. However still a lot of them survived and are incorporated in prehistorically graves, erected as memory stones, hidden in boulder clay or just somewhere in the field. Nowadays erratic boulders are very popular. Many gardens are decorated by impressive pieces. This is a pity. However this popularity can help to draw the attention from the decorative aspect of the stones to the informative aspect. For these stones tell the story of special events in the past. They have an evident scientific and educational value, besides being beautiful and sometimes impressive.

In some countries (Switzerland) these boulders have been protected for a long time. But elsewhere the landowners are free to do what ever they want to do with the boulders. Therefore many of the boulders disappear from their original position and are being sold. But not only the owners are transporting these witnesses of the ice ages, also geoconservationists are guilty. Very often the boulders are being used for 'boulder monuments', geological monuments presenting the wonders of the ice age. And in fact the importance of the erratics is the relation with their finding locality. This in situ place makes it possible to reconstruct the very complicated ice movements during the ice ages. Human transport –especially without documentation- frustrates the sorting out of the glacial history.
In my opinion it is time to formulate some code of conduct for this special kind of heritage.

- Big boulders, especially keystones (dimensions per country or region) should be protected in situ, as nature monuments and transport should not be allowed.
- If possible, transported stones should be replaced at their original location. Stones transported and of cultural historical value too are of course excluded.
- The in situ position of important big erratic boulders, which have been transported and can not be returned should be documented.
- If boulders emerge in glacial areas because of winning, infrastructure works, buildings etc., the boulder collection should be saved and placed in the neighbourhood of the original site or if this is not possible in a nearby village as a geological or cultural/ geological monument.
- Small keystones should be documented as much as possible.

Suggestions and comments are welcome

Dutch example dealing with some of the problem.

On the 17th of November l999 an interesting boulder monument -erratic boulder island- has been opened. Its history starts in 1845. During the realisation of a railway transect through an ice pushed ridge (Saalian) near Maarn (30km east from Utrecht) many boulders appeared. The collection increased enormously when the Railway Company started to exploit sand in the railway transect. The beautifully pushed river sediments and the various boulders attracted several geologists. In 1917 the nature conservation organisation 'Natuurmonumenten' made a deal with the railway company

Erratic boulder display on a protected site in the Netherlands. From the very first ProGEO meeting in 1988. Photo: Lars Erikstad.

for the protection of the boulders, located in the transect. From that moment on this organisation was the owner of a nice collection of erratics, not only originating from the north and transported by the Saalian ice cap, but also consisting of big boulders transported by –probably- drifting ice in the rivers Rhine and Meuse and picked up in Germany, Belgium and France.

Geology students from Utrecht and many other interested persons often visited the monument in the vicinity of the railway station, situated in the transect, an excellent location. After the removal of the station Maarn in 1972 the boulders were placed in very unfavourable position in a nearby nature reserve on the ice pushed ridge in Doorn. After some years they could only be admired for their mosses and lichens cover. This neglect was the reason for the author to contact 'Natuurmonumenten' in order to improve the situation. An arrangement and management plan was presented, however it stranded in the bureaucracy. After that a new attempt to save the boulders from 'green power' has been tried The municipality of Maarn was willing to adopt the boulders and wanted them to return to Maarn. However this plan failed because the authorities and the expert could not agree on the final location of the boulders. The discussion was a fundamental one. In my opine erratic boulders should be placed in:

- a geogenetic right environment; on the ice-pushed ridge or
- a neutral environment like a lawn in the village
-

The location proposed by the municipality, an active wind-blown sand area was absolutely the wrong place, for there is no relation at all between the boulders and the proposed 'desert'.

In the middle of the 90ties the exploitation of sand in the rail way transect moved to an 'old part'. And there a big surprise turned up. Hundreds of big boulders, which were not transportable in the beginning of the exploitation and therefore buried, emerged during the winning. This unique collection of over 600 boulders was saved by local earth scientists with the help of the municipality (new major), the financial support of the Province of Utrecht and the excellent co-operation of the owner.

The Maarn collection is a unique one. It is the biggest collection of big boulders in The Netherlands and it is the only place were you can find a collection originated from a relatively small area of Stockholm, Uppland and a part of the adjacent Baltic Sea. This indicates a very special geogenetic history.

Thanks to the excellent co-operation of Natuurmonumenten, their collection together with the new one could be located where it belongs: in the former sand pit in the railway transect. The boulders form a compass card on a small island in a lake, caused by the exploitation. The entrance is formed by the old collection. Key boulders, igneous rocks, sedimentary rocks and metamorphic rocks have filled the four segments of the compass. The southern erratic boulders form an arrow to the south.

Displays, a leaflet and a special issue of the journal of the Dutch Geological Society inform the public on features like geological monuments, erratic boulders, keyboulders, etc.

There are even plans to buy or exchange important boulders originating from the area and to return them to the transect.

Gerard Gonggrijp

ProGEO New Publication

Geologia Innsubrica, Vol. 4/1 (1999) ISSN 1420-9500

contains the proceedings from the symposium on Geotopes on the 178 yearly meeting of the Swiss Academy of natural sciences.

The proceedings are in English, French, German and Italian.

ProGEO New web-address

Our high quality website has now got a new address. Here you can find among a lot of other things old issues of ProGEO NEWS

http://www.sgu.se/hotell/progeo

EARTHQUAKE ON 12 APRIL, 1998

In the upper SOCA (Slovenia) - damage to nature

The earthquake at 10:55 UTC on 12 April, 1998 with its epicentre in the Julian Alps in north-eastern Slovenia was the strongest earthquake noticed by Slovenia this century. The epicentre was at a depth of approximately 15 km, with its co-ordinates being 46.320 N and 13.662 E. The moment magnitude was 5.8, while the strongest effects were between VII and VIII EMS. The fault plane solution of the main shock and aftershock distribution show the emergence of an earthquake fault rupture which did not reach the surface, running in a northwest-southeast direction in the area between the Lepena valley and the Krn mountain range. The earthquake was felt by inhabitants across all of Slovenia and those living in certain parts of Croatia, Bosnia and Herzegovina, Hungary, Austria, Switzerland, Italy, Slovakia, the Czech Republic and Germany. In the following months, the temporary observatories set up in the epicentral area registered several thousand aftershocks. With a local magnitude of 4.2, the strongest aftershock took place on 6 May.

Earthquake in the alpine region

The characteristics and influences of earthquakes in the Alpine world differ in many ways from the characteristics of those appearing in planes, along the coast, in hilly areas and other mountainous areas. The main feature of the Alpine region is its structure, as it is composed of hard rock, forming very steep, even sub-vertical slopes. The next characteristic is sparse settlement, except in the Alpine valleys.

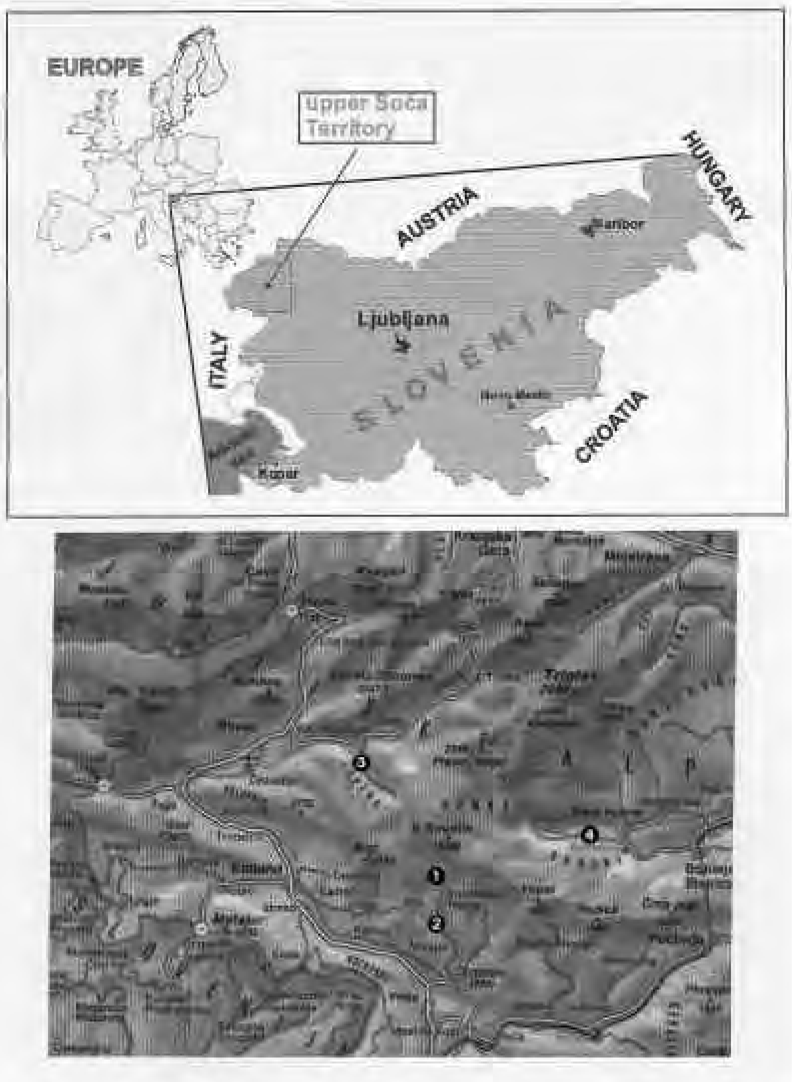
An earthquake in the Alpine area causes many phenomena unique to this region. The threat to nature, fauna, flora and people caused by an earthquake is in many ways different from the threat in other areas. Above all, there is secondary threat due to the unstableness of the steep slopes, e.g. falls and slides of rock masses. Besides, in the Alpine area this secondary threat is extended to a longer period of several years, when rockfalls and other rock instability phenomena can appear during aftershocks, rain, wind, avalanches or when walking or climbing over unstable areas.

Reasons for the earthquake

The seismic map of Slovenia, prescribed for civil engineering, shows that even stronger earthquakes are possible in this area. Accordingly, the earthquake came as no surprise for seismologists. Judging by released earthquake energy in the past, we assess that earthquakes of up to level IX EMS can occur in this area.

The main reason for the appearance of such earthquakes are movements of large tectonic plates, in this case the African and Eurasian plates. The often mentioned African plate exerts pressure upon the Eurasian plate, which in geological history led to the rising up of the Alps. Between the both plates lies a smaller Adriatic plate, on whose margin also lies the Slovenian territory. The geological structures of our territory cause the entire Slovenian territory to be seismologically active. In the countries to the north of Slovenia, earthquakes are considerably less frequent and they are also weaker, while in the south seismologic activity is greater. The Adriatic plate runs in a north-east direction. The Dinaric structures of this area are divided into the South Alps and the External Dinarides.

The External Dinarides take up the whole area of south-



Position of damaged area in the upper Soca Territory (Slovenia).

western Slovenia, with the Julian Alps pushing towards them from the north. The very epicentral area is the meeting point of the pushed together structures extending in an east- west direction, pushing from north to south, and the Dinaric structures in a northwest-southeast direction. The last earthquake most probably occurred along the joint extending in the Dinaric direction. This will be revealed by further research.

The seismological structure of the area

The effects of an earthquake also depend on the local ground structure, as they can increase in low quality ground. An epicentral area is mostly composed of carbonate rock (limestone and dolomites), somewhere transforming into marl. Carbonate rock is favourable ground, while marl in somewhat worse. In seismogeological terms, the worst ground is river and creak alluvium and sloping talus.

The alluvium of the Soca and its tributaries build terraces composed of gravel, sand and, more rarely, conglomerate. Talus and glacier morainic gravel is also dangerous. As shown by the extent of damage, it is the largest in these very areas. All of the most damaged locations are, without exception, built on such sediments. After inspecting the area, we found that most damage had occurred in the narrow strip in the Dinaric northwest-southeast direction. In some areas, the specific local geological situation further increased the effects. The greatest effects on buildings were seen in the villages Spodnje Drežniške Ravne, Magozd, Lepena and Tolminske Ravne and on the mountains Polog and Javorca, where it was assessed that the earthquake achieved effects between levels VII and VIII of EMS. There were somewhat less strong effects in Mala vas in Bovec, Kal-Koritnica, Zgornje Drežniške Ravne, Jezerca, Krn, etc. The biggest effects on nature were felt in the Lepena valley, on the south-western slopes of Krn and at the source of the Tolminka, where huge rockfalls slid into the valleys.

Figure 1. The cracks in partly agglutinated gravel on the slopes along the path leading to the source of the Tolminka river are characteristic of level VI EMS. All photos: R. Vidrih

Changes in nature after an earthquake

After the earthquake in Posocje, we observed many natural phenomena. There were over 100 large phenomena like rockfalls and landslides. They can be roughly divided into the phenomena of a lost equilibrium and the appearance of damage to the rock itself. Both phenomena are connected when the damage to the rock is the cause of the loss of the natural equilibrium. The loss of the natural equilibrium can be further divided into falls, slides, rolling and bouncing of stones, rock and gravel on one hand and phenomena of cracked rock – rockfalls, planar and wedge-shaped landslides – on the other hand. Rockfalls and landslides differ according to their size. Their dimensions are from small, through medium and large to regional. The higher the intensity of an earthquake, the higher the number of phenomena and the more large-scale phenomena. Below is the list of phenomena observed according to the classification into related groups and with regard to earthquake intensity.

Phenomena occurring to rock during earthquakes

a. Phenomena of losing the natural equilibrium of rock

1. **Phenomena in poor rock and in slope deposits**
   Falls of individual stones
   Falls of individual rock blocks
   Slides of talus and weathering cover
   Landslides
   Mud and stone flows
   Large crumbling of stones
   Large falls of rocks blocks
2. **Phenomena in massive rock**
   Rockfalls
   Planar failures
   Wedge Failures

b. Damages to rock itself

Openings of short fresh joints in the rock
Movements of rock blocks on gently sloping or level areas
Openings of long fresh joints
Rock blocks turning over
Splitting of rock blocks

Figure 2. The largest rockfalls (levels VII-VIII EMS) include those on Osojnica. The top ot the mountain fell apart and crashed into the valley on three slopes.

Selected cases of landslides and rock falls in POSOCJE

Lepena valley Various cases of planar landslides occurred in the Krn Mountain Range and on the mountain of Lemež rising above the Lepena valley. Huge volumes of rock dropped down the slopes and destroyed everything in its way. From Mount Lemež, high above the end of the Lepena valley, a large rockfall was released during the earthquake. It appeared in the area where the soil is highly ruptured. Due to the physical rock-disintegration like the influence of frost, joint systems are additionally stressed and the shear strength at the cracks is lowered. During the vibrations of earthquake shocks, slides appeared. First, the broken off material slid along the first failure plane over the overhang to the second plate of bedded limestones, smoothed by very old rockfalls and snow. On the right, it bounced from the vertical faces so that the strip of falling rocks became very narrow. The significantly crumbled material fell over the last overhang to the scree. The smooth steep plates of layers and the in-between overhangs, cleared from all obstacles due to avalanches, did not in any way stop the falling mass; consequently, its speed, sliding and falling from more than 2000 m above the sea level where the rockfall appeared in the valley, was extraordinarily high. Upon the final blow on the scree, there was a terrible noise, joining the noise of the earthquake. Rocks and stones crushed into smaller parts and a yellow cloud rose to darken the entire Lepena valley. This was added by an air shock similar to those appearing upon explosions. The strong wind of the shock wave of a speed higher than 300 km/h overturned all spruce trees growing directly under the scree and then blew the spruce forest over in two parts. The first, narrow, around 15-metre wide blast blew through the high spruce forest and broke the top parts of the tree crowns or turned the trees over. This resulted in a narrow, impassable "clearing" of fallen trees, all lying in the same direction, which proves the extraordinary strength of the wind. The second part of the blast followed the creek bed springing from under the scree, it blew over spruces along the left bank and hit the grasslands at a farm. Here, a powerful wind gust pushed a shed's entire roof onto the ground.

Krn Mountain ange Typical landslides according to different systems of cracks appeared on the Krn Mountain Range. This includes large rockfalls changing the appearance of Mount Krn, as an entire slope on its south-western side fell into the valley. When after fourteen days we inspected the rockfall from a close range, large and small stones were still constantly falling into the valley.

Osojnica and the Tolminka river Seismologic activity was especially intensive in the wider area in the vicinity of the source of the Tolminka river. There were many rockfalls, from small to very large. Rockfalls mostly belong to slides along different systems of cracks or slides in heavily cracked rock. Such rockfalls are characterised by very irregular failure cracks. They appeared because the soil in this area was tectonically highly damaged and dolomitised. In geological terms, one of the most magnificent views is the one to Osojnica, which literally split in three places. The largest rockfall dropped on Mount Polog, from where there is a path to the source of the Tolminka. A somewhat smaller rockfall endangered the hunting lodge at the source of the Tolminka and the third one appeared on the opposite side. The view of Osojnica from the air shows that the mountain lost its top and three slopes (fig. 1, 2).

Mud-stone flow in Lepena The mud-stone flow from the left slope of Lepena appeared when the stones deposited in the steep ravine were released during the earthquake and started to roll down the ravine. Stone flows are characteristic of areas of the Himalayan mountain range. In Slovenia, they have not yet been described. During this, rocks and stones of average dimensions from some decimetres to some centimetres started to mix with snow which also filled the ravine in a thick layer. In the lower parts of the ravine, the increasingly fast rolling and sliding mass of snow and blocks of stone, already closing the Lepena valley, also started to skim off the ground clay of weathering cover deposited in several metre thick layers. The mixture of snow, gravel, stones and rocks produced a muddy mass which, after falling out of the ravine,

Figure 3. In the area where damage to buildings was assessed as level VII EMS, interesting phenomena appeared in nature. At the head of the Lepena valley, a mudstone flow appeared which is very rare in Slovenia. The appearance of similar phenomena is assessed as level VII of the EMS.

spread out over the valley. The quickly falling mixture of earth, snow, rocks and stone resulted in a slowly flowing mass, rapidly losing water when moving over the grass valley slopes and thus becoming increasingly thick and slow. When the stony, muddy flow stopped, the remaining water drew out of it, leaving behind hard dense earth and stone material (fig. 3).

Lake Bohinj Only a detailed study involving drilling of the ground composition deep under the surface could answer the question of how the slide of part of the Lake Bohinj coast of a length of 100 m occurred. The most probable mechanism that can be envisaged on the basis of the field inspection is that, among the layers of glacier morainic alluvia and talus which otherwise represent the majority of the lake coast, at the site of the slide at a depth of several metres there is a layer of small-grained loosely-deposited lake sediment, impregnated with water. During the earthquake, along this layer, all layers above it slid towards the lake, producing a vertical crack (fig. 4).

Causes of the phenomena occurring in rock during the earthquake

The Alpine area in Slovenia is mostly composed of limestone and less of dolomites. Marl, sandstone, breccia and tuff are rare. Apart from earthquake intensity, the type of damage to rocks mostly depends on the level and type of cracks in a rock. The main features of joints (according to the ISRM instructions) are described by their ten characteristics:

- Direction of joints with regard to the direction of the slope
- Number of joint systems
- Frequency of joints and size of blocks
- Spatial extent and length of joints
- Level of roughness and undulation of joints
- Cohesive strength along joints
- Strength of walls along joints
- Openness and filling of joints

These characteristics of joints define the possibility of the appearance of rockfalls or rock failures. It is typical of the Slovenian Alpine region that rocks are mostly cracked in three perpendicular systems, one of them normally being the direction of the layers. The cracks are mainly between 10 and 50 cm apart from each other. The level of roughness of cracks is lower and their undulation is higher, with cracks mostly not being filled out. Locally, tectonic activity causes smooth tectonic slides or highly crushed zones.

With the appearance of the loss of the natural equilibrium, the ground morphology must also be taken into account. For the emergence of rockfalls, the slope must be vertically or subvertically inclined; for rock planar or wedge failure, it must usually also be inclined by more than 45°.

Conclusion

The earthquake in upper Soca Territory in the Alpine region of the carbonate Julian Alps showed that when forecasting and studying the consequences of earthquakes in the Alpine region, great attention must be paid to the effects of earthquakes on nature. Apart from knowledge regarding the effects of earthquakes on nature and structures, one must use as a basic tool knowledge of rock mechanics for jointed rock masses. On this basis, we can:

Figure 4. The earthquake effects on buildings and people in Bohinjski kot were assessed at levels VI-VII EMS, which is confirmed by the damage to nature. A good example is the sliding of part of the Lake Bohinj coast into the water.

- In sparsely settled areas, define the earthquake epicentre more precisely on the basis of the phenomena in the rocks,
- Define the critical areas where new unstable phenomena can be released, endangering living and non-living nature,
- Draw maps forecasting the hazard, vulnerability and risk due to the loss of the natural equilibrium during an earthquake and propose rehabilitation, protection or moving away from the threatened areas, and
- For tourist and sports activities connected to the Alpine region, warn where accidents can happen due to damaged or collapsed protection on mountain pathes, unstable blocks on the slopesetc.

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