Special Proceedings of the Reading Geological Society

Field Trip to the Tatra Mountains, Zakopane, Poland 22nd - 29th August 2000

Contents

Introduction

This field trip was the third of a series of overseas trips undertaken by the RGS at two yearly intervals. These originated from our celebration of twenty years of the RGS in 1996 and this trip occurred in our twenty-fourth year.

Following up contacts made with other societies, our chairman, David Ward, found an excellent, English speaking Polish geologist to lead the members on a varied set of itineraries in the Tatra Mountains in south-eastern Poland (near the Czechoslovakian border). Our guide, Marek Awdankiewicz, produced a detailed handout with an outline of the geology of the region, 6 itineraries and a geological map. This handout is included in these proceedings following the members notes.

After contact was made, our field secretary, Chris Fone, began the arduous task of fixing dates and making the travel and accommodation arrangements. Because of the number of places needed to be filled to optimise the cost per person, places were offered to members of other geological societies, and several places were taken. This organisation was also done by Chris.

On the 22nd August 2000, the party of 21 set out via coach to Gatwick, plane to Krakow, then coach, again, to Zakopane. The next few days were spent in a mixture of geological excursions, sight-seeing, and evening revelry until the return, by the reverse route, to Reading on 29th August. On each of the first five days of the week, one of Marek's itineraries was explored while on the last day in the field the members had the choice of a walk along the Chocholowska Valley or a visit to the Wieliczka Salt Mine.

This proceedings is a chronicle of the members' reports on the excursions, the geology and other events. It is presented as a series of half-day reports - morning and afternoon - with an occasional evening report. Because of the number, quality and different styles of the contributions, most part-days are represented by two or more reports of the events.

Throughout the reports, references are made to the locations in Marek's itineraries. These are indicated by the Itinerary letter and location number from the handout - e.g. A1. Where members have used other notations in text or figures then these have been equated, at the end of the particular report, to handout locations.

The sequence of this proceedings, then, is the set of reports of the trip by the members, the geological map and key, a glossary of words and terms developed from various sources and, finally, the handout from Marek.

The members and others attending the trip were: Ailsa Davies, Irene Davison, David and June England and Susannah England (a guest), Chris and Clare Fone, Carole Gregory, John and Anne Halliburton (Shropshire Geological Society (SGS)), Gordon Hillier (SGS), Christine Hooper, Malcolm and Jennifer Iosson, Marion Marrack (SGS), David Riley, Gilia Slocock (OUGA), Diana Smith (OUGA), David and Joyce Ward, John Wardill.

Those contributing to these proceedings were: Ailsa Davies, Irene Davison, David and June England, Carole Gregory, Gordon Hillier, Christine Hooper, Malcolm Iosson, David Riley, Gilia Slocock, David Ward and John Wardill

Special thanks to David Ward for his initiative, Chris Fone for the organisation, Marek Awdankiewicz for his handout and guidance, and to Anya of the tour company.

Roger York
Editor

Members Reports

Day 1, Wednesday 23rd August - Morning

After breakfast at 08:00 we assembled bright eyed and enthusiastic in one of the hotel conference rooms to meet our leader Marek Awdankiewicz. The handout that he had given us gave us the geological background and the proposed itineraries so we were well supplied with information including very useful diagrams and maps.

At 9:30 the talking was over and we boarded the bus for the first day out in the Tatra Mountains. The day was spent in the Koscieliska Valley approximately 7 km from Zacopane. With 13 stops listed on the itinerary we were in for a busy day, although we didn't stop at them all!

The first stop was at the entrance to the park and here we looked the Eocene nummulitic dolomites of the Podhale Basin. Moving from here the valley was relatively flat and the paths well laid – just as well as there were a lot of people out for a walk in the sunshine. Marek explained that where the rocks were soft, mainly flysh deposits and marls, the valley was broad but the hard more resistant rocks, limestones and dolomites, created narrow parts to the valleys known as 'gates'. Further up the valley we came to old metal mines at Ornak. There was little evidence on the surface, just a few undulations in the ground. Copper and silver ores had been worked with the mines finally closing in the 18th century. A small chapel had been built for the miners who had lost their lives in the mining operation.

A karst spring at Lodowe Zrodlo was the next feature to catch our attention. This had formed at the upper thrust plain of the Regle nappe. Here the underground water flow is from the east whereas the surface flow is from the north. Continuing up the valley we were to see several cave entrances in the limestone. The limestone contained crinoids, reef deposits and was bioturbated although this was difficult to see and so necessitated some scrambling over the rocks to find a suitable place to crouch down with a hand lens. This was Triassic limestone, not seen in the UK.

Having admired the caves from the safety of the footpath it was, of course, essential for the more foolhardy members of the expedition to gain access to one. As the Poles had very kindly provided chains to help with the climb we joined the queue of eager visitors waiting to climb up the cliff to the cave entrance (it was really a tunnel!). The cave was without lighting and underfoot was wet and muddy – the chains continued and were vital to ensure navigation through to the other side. The few torches to hand proved to be very useful and finally all members scrambled safely through to the other side and daylight. Little geology was seen on the way. The walk down the other side was gentle and so we managed to stop to look at Cretaceous Marls which had been laid down by turbidites. These were extremely faulted and folded – or jumbled!

Our little adventure over, we met up with those wise members of the group who had walked round the hill and set off for lunch.

Reported by Ailsa Davies

The Koscieliska Valley

This valley, as well as most of the following itineraries, is in the Tatras National Park (Tatrzanski Park Narodowy), the entrances to which are marked by imposing wooden gatehouses and arches, often combining a bar and gift shop.

The Poles seem to be a very well disciplined nation - there were a great many signs telling us what we could, and could not do and during the week, virtually everyone we saw was keeping to the rules.

(A1) Kiry-exposure on the east side of the entrance
This was a nummulitic limestone, resting on conglomerates, and with dolomatisation in places - explained as a shallow marine deposit, of Eocene age and the youngest rock we would see in this

valley. It is part of a nappe formed of the Podhale Palaeogene Flysh, the rock sequence which lies directly to the north of the Tatras.

The rocks to the south are of the Regle Series of nappes, formed from Triassic, Jurassic and Cretaceous sediments, which have been folded into recumbent folds to the north, and then thrust many kilometres north.

The Koscieliska valley runs north-south, so provides excellent exposures through the complete sequence. The valley is startlingly beautiful, consisting of small meadows, separated by narrow gorges in limestones and dolomites, where the more resistant rocks lay across the valley in east-west directions.

(A2) Brama Kantaka
This was the first of a series of narrow gorges, the rock being a Jurassic marine crinoidal bioclastic limestone, dipping gently to the north (but this dip was, of course, the nappe structure).

Marek explained that the sequence here was as follows: -
Jurassic Limestone as described above, of the Choc Nappe
Shales immediately below, eroded to form the meadow
Alluvial fans of material from the side valleys overlie the shales in places

(A2) Wyznia Kira Mietusia
At the south end of the meadow below the above site, a small exposure on the east side showed finely bedded marls and thin limestones, these being of Upper Jurassic-Cretaceous age, and part of the next nappe, the Krizna.

The path here entered a wood, and Marek pointed out various faint trenches, relics, we were told, of 18th Century metal works, but not very inspiring. The works smelted iron and manganese from the Jurassic limestones, and some sulphides from the basement for copper and silver.

Passing out of the wood, another pass narrowed the valley in front of us. The cliff face on the east side showed at the base a thrust plane, where the Regle nappes had slipped over themselves - at the base a karst spring emerged, fed from the very extensive underground cave systems.

(A3) Lodowe Zrodlo
A path to the east headed uphill a short distance, to arrive at a considerable spring - this had a maximum flow of 600 litres a second in Spring but was issuing quietly during our examination. Marek explained that this was also supplied by the cave system, in this case from a valley to the east. The spring issues from near to the thrust plane at the base of the Regle series.

We retraced our steps to the main path, and continued south to the next pass, where again limestone and dolomite cliffs walled in the path.

(A4) Brama Kraszewskiego
The east side of the pass was a shear cliff in white Jurassic crinoidal limestone of the Choc Nappe, we were able to identify crinoids, corals and bioturbation by some animal that left 0.5 cm wide burrows. The cliff contains a cave of 5 km length and the cliff face showed two marked features, dipping to the north at about 25^{o}. There was considerable debate as to whether they were bedding planes or faults, not resolved until we had progressed to the next outcrop, where distinct bedding could be confirmed by the presence of stylolites.

(A5) Polana Pisana
The valley suddenly widened after the pass, giving onto the grass-covered meadow we had now come to expect. The soft marls responsible for the topography were Mid-Cretaceous, and were an autochthonous deposit of the Kominy Tylkowe series. Exposed in the hillsides above the tree-line to the east were Triassic and Jurassic limestones and dolomites of the Czerwone Wierchy nappe -

massive perpendicular cliffs of white and buff rocks, showing dips, of either bedding or thrust planes, to the north.

(A6) Smocza Jama
Another east trending path took the party into a very narrow gorge, clearly the result of a cave collapse, which wound its way eastward and uphill to a narrow valley. Curiously, the sides of the gorge were lined in many places with sticks, 2 to 3 cm diameter and 25 cm long, which had clearly been placed carefully so that they leaned against the walls of the gorge. No explanation from Marek or the members was forthcoming for this phenomenon.

The narrow valley terminated abruptly, and the way forward was up a ladder, then up a shoulder with a chain handrail, then into a cave. Marek assured us that the ascent was easy, and hoards of local kids (and their parents) were making the ascent, but not all of the RGS were interested in this display of macho activity.

The cave was on a thrust plane which could be traced about half way through the cave, at which point a combination of mud, lack of light and, possibly, a sense of self-preservation, tended to deflect members from the study. On emerging, the exit was seen to be made of beautiful pink limestone with white veins, polished by a million boots.

The cave, after 100 m, emerged into the next valley and a path led down to the main path up the Koscieliska valley, at a point we had passed a little earlier. On the way, to the south of the path, there was a small outcrop of brown marls heavily faulted with some rotation of the blocks. Marek explained that these were Cretaceous, of turbiditic origin.

(A7) Skala Pisana
This cave was the next stop, a further 500 m up the valley, and yet again a stream issued from it. This cave is floored in the Marls, hence the control of water table, and is roofed in Jurassic limestones of autochthonous Kominy Tylkowe series.

Reported by David Ward

Day 1, Wednesday 23rd August – Afternoon

After a very long morning and a few rumbling tums, we were all looking forward to our first experience of lunch in a Polish mountain tea house. Imagine our dismay when arriving in the clearing, to find the tea house and its surrounding grounds overwhelmed by tourists. It looked as though everyone and his dog had got there first, and that we would be very lucky indeed to find sustenance. But here came our first surprise, not only was there plenty of food, but it was quickly and efficiently provided and delicious. A variety of fare including goulash soup, Polish sausage, wonderful brown bread, ham and cheese was consumed. Sitting on a wooden bench outside a traditional wooden mountain hut in the warm sunshine, surrounded by Polish families all enjoying their beautiful countryside, with not a burger in sight!

Having sated our hunger there was time to reflect on our morning activities and to learn a little of the building, which was our tea house. This particular structure was not very old, but had been built in traditional style using the rocks and wood found locally. We noted ripple marks in the sandstones which were used to construct some of the walls. The main timber walls were long lengths of pine caulked with straw, which was a feature we saw over and over again during the week. Large overhangs on the roof were to provide protection, as it snows very heavily here in the winter. We were confused by metal rods on the roof coming down the walls, but found out that these were lightning conductors. It appears that every year lightning in these mountains kills people. Last year three people lost their lives through lightning strike.

Anya, our ‘pilote’, rounded us up in a way with which we soon became familiar, to begin the afternoon geology. This involved a steep uphill walk through forest, on a made trail, which provided relatively comfortable walking. Paths like this were encountered throughout our trip, a relic, we wondered, of the days of communism when manual labour was readily available. The path was made up of slabs including specimens of the basement crystalline rocks, mica schists and grits. These proved much more interesting on the way down, when there was less puffing and blowing! The forest was abundant with lichen, a typical result of the purer air of the mountains.

Smreczynski Staw – our objective for the afternoon was a small post glacial lake within moraine deposits. It was almost circular, surrounded by sedge grasses, and with abundant dragonflies. The sedge grasses and soil are gradually encroaching on the lake, and it could be seen that it has already reduced in size. The near horizon was covered in dense pine forests, typical of the vegetation on the

Plate 1: View from Smreczynski Staw

moraine deposits. The middle horizon was the sandstones and shales of the Lower Triassic and the far horizon was the high mountains of the Wierchy series, granites, gneisses and schists. The highest peak in the Tatra mountains was beyond the range that we could see in front of us, and the border with Slovakia on the furthest visible ridge.

During our short time at the lake, two things happened to enliven the proceedings. The first was the arrival of a small film crew, who proceeded to film what we presumed was a training video of mountain rescue. Why they had chosen to trek to the lake to carry this out was not obvious, although the path down would have proved interesting with a stretcher. The second was Marek's first real experience of the doggedness of our Chairman, when he is not convinced by the given explanation for the geology!

The return trip down the valley was carried out with somewhat more alacrity than the upward one. Only a peek or two given to the geology, the quick identification of some missed flora or circling birds, an envious glance at those in horse drawn carriages taking the easy way down. All this as a result of Anya announcing that the coach driver had been waiting for us since 2pm. Not significant unless you understand that we did not leave the lake until 4:15pm and it was an 1.5 hour walk to the coach. The energetic few managed an extra burst of speed and a quick beer at the bottom while the rest of the party caught up!

Reported by Carole Gregory

(A10) Schronpisko na Hall Omak
By now, the sun was high in the sky, and while we were all having a lovely day, serious hunger was about to set in, so arrival at the "Tea Hut" where we were to buy lunch was very welcome. Aided by Anya, soup, bread and butter and various other local dishes were purchased for a trivial number of Zl, and the party then either sat in the sunshine, or on long communal benches inside, to refuel.

A word should be said about Tea Huts. You order food at one window, from an extensive menu, then collect the food from a separate one. Both have long, slow moving queues, and the McDonald ethos has clearly not arrived here. Probably, when it does, a large amount of local character will be lost.

After lunch, Marek explained that the Tea Hut stood on a terminal moraine, delivered by glacier from the upper, southern, part of the valley which was now directly in front of us. Examination of the meadow below the Hut showed rocks of crystalline basement, mica schists, limestones etc.

(A11) Smreczynski Staw
From the Hut we retraced our path a short distance, then took a path to the east. This lead steadily, and in places steeply, uphill requiring several halts to "look at the rocks" but actually to recover our breaths.

The path repaid examination - it had been surfaced with large pieces of the moraine, and without difficulty we were able to find the rocks examined during the morning, plus the granites and schists we would see more of later in the week.

Finally the Staw was reached. Staw is Polish for lake, and this was a very beautiful example, sitting in a glacial basin (or was it dammed by moraines we asked ourselves) and surrounded by conifers.

After a rest, a group photo and discussion on the rock types in the mountains in front of us, we retraced our path to the coach, arriving at 6:00 p.m., only 4 hours late!

This was a matter of concern to the local manager of New Millennium, who arrived after dinner to discuss, I think, a subsidy for "standing time", but was deflected by suggestions that we would try harder. However, future meetings with Teresa Knopp were not looked forward to.

Reported by David Ward

Day 2, Thursday 24th August - Morning

MORSKIE OKO

Another fine day saw an early start. The first stop along the road (Glodówka) gave one of the finest views of the High Tatras from the granites of Giewont (1894 m) and the Lower Regle series to the foreground glacial deposits. The peaks of Resa-Gerlac (2600 m) and Mavran (2100 m) could also be seen through the slight mist.

A short drive brought us to the Wlosienica National Park where we boarded horse-drawn carts for the 7 km. journey through the beautiful wooded valley to the car park. Much amusement was taken in the nappy worn by the horse for the collection of manure, although the passengers at the front were not so amused! From here a walk of 3.5 km, rising 270 m over glacial moraines, took us to the mountain hut and the lake Morskie Oko.

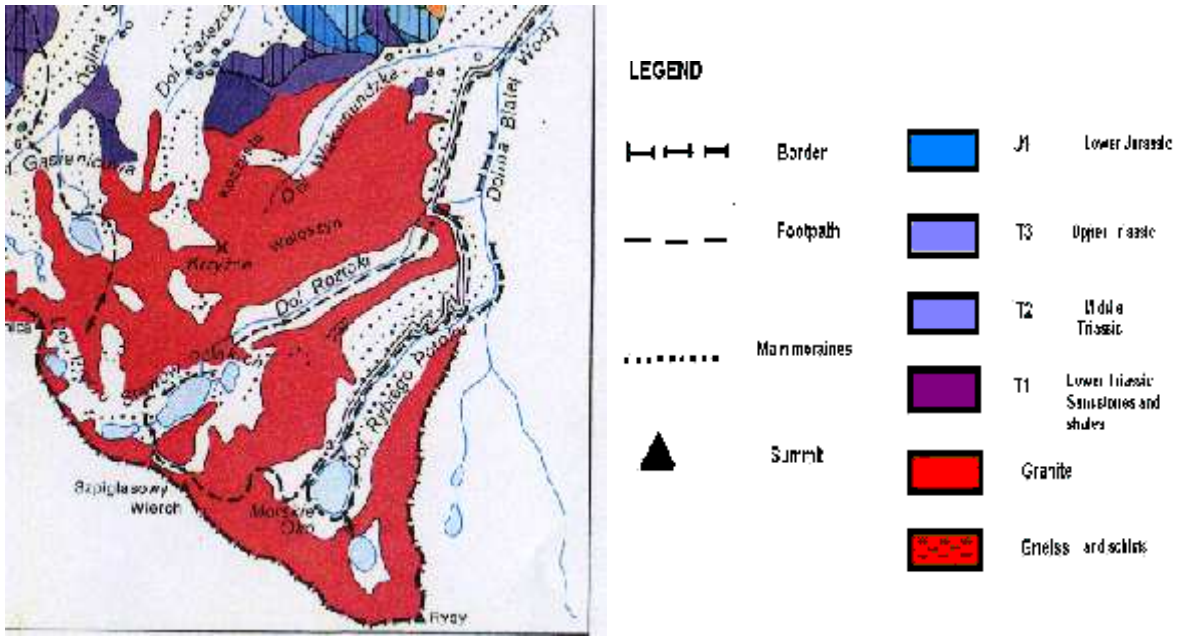


Fig. 1: Map of Morskie Oko

This is a post-glacial lake some 1400 m by 100 m bounded by moraines, formed in the granitoids of the crystalline basement. The valley consists of three hanging valleys and corries. A thrust fault runs through the centre of the valley.

The granitic rocks have a high potassium content and are thought to be formed in the subduction zone and are considered to be magma from melted metamorphic and sedimentary rocks. The grey granites are potassium rich and show mineralisation alignment due to the tectonic stress (the melogranitic granite is related to younger events). In the granites the potassium rich water cools as it moves outward giving potassium feldspars and pegmatites. The epidote and chlorate crystals are from low temperature solution migration.

We proceeded clockwise round the lake; the boulders of the path richly assorted rocks containing epidote, red and pink feldspar, slicken-sides, and the hillside colourful with willow gentian. Haltingly, we climbed a steep 190 m to Czarny Staw Lake where patches of snow still remained in the shadows on the steep sides of the lake. The lip of the lake showed fine glacially polished rocks. The field rocks dipped north-west showing irregular jointing.

The hanging valley to left showed successive glacial retreats to higher levels as the ice retreated. It is thought that the ice did not cover the highest peaks.

Reported by Christine Hooper
Following our, easily achievable, 8:00 start, a journey of about half an hour took us to our first stop.

(D1) Glodowka
This was a vantage point on the road from Zakopane to Lysa Polana, where we were due to meet our second form of transport for the day. Tremendous views to the south showed us a considerable part of the East Tatras range, and Marek was able to point out several mountain tops, including Kaspary Wierch, which we were to visit later in the week. He also explained the main geological features, which included granite topped peaks (sharp) and peaks of crystalline basement schists (rounded), these being more to the west. In the foreground, forests covered the lower slopes and rounded hills, these being Cretaceous - Triassic sediments of the Regle Series, while fields lower down were floored with glacial debris. To sharpen our attention, Marek also mentioned that bears were common in some of the hanging valleys on the mountains.

(D2) Lysa Polana
We had been warned that the Morskie Oko area was especially popular with tourists but, because of the early start, the considerable car park was not at all busy although the gift shops were manned ready for the day.

Travel uphill had been arranged for us in 20-seater open carts, drawn by two large horses. The “postilions” were, we were told, the local “Highlanders”, distinguished by round black hats, off-white teddy-bear trousers and embroidered jackets - an impressive sight!

The nine km journey took one hour and 15 minutes, on a surfaced road through quite dense trees, which would have been a strenuous and boring walk. However, on the cart, the journey was very pleasant, with rare views of towering peaks on each side.

(D4) Morskie Oko
The cart delivered us to Wlosienica, which turned out to be a turning place for the carts, and the place where we had to start walking, the lake being a further km or so uphill.

Moskie Oko is a very fine lake, surrounded by mountains which sweep up from the waters edge. The lake is about 1 km across its longest dimension, a deep blue-black colour and oval shaped. It lies in a glacial basin, with a glacial till dam on top of the north lip and directly beneath the Tea House.

The party enjoyed the view, the by now warm sunshine and Marek's description of the geology.

He explained that the mountains here were composed of granite and granodiorite, subsequently altered by rising magmatic fluids rich in potassium, giving rise to pegmatites. Cooling cracks and mylonitic zones were also to be found. Later weathering of the feldspars gave rise to chlorite and epidote mineralisation, now appearing as blue green and bright green layers on the granites.

The main passes in the mountains all take the courses of major faults or crush zones. During the last Ice Age, there was several 100 m of ice at the place were the lake now is, so with the lake at 1400 m, the peaks (at approximately 2300 m) would have been clear of ice. Three hanging valleys were formed in the main valley, each about 70 m deep.

The party now took a path round the lake on the east side, admiring both the clear water and trout on the way, as well as the rocks in the path, which matched exactly our leader’s description. From the far end of the lake, a steep path lead up to Czarny Staw (Black Lake), which was 190 m above Morskie Oko and a severe climb for Brits, but not so for the local folks. Much notice was taken of the rocks in the path, both because of their mineral composition, but also because of the need to control panting.

By now, 12:30, the path was very busy, with both an up and down traffic, requiring a stop-start form of travel to allow others to pass.

Reported by David Ward

Day 2, Thursday 24 August - Afternoon

The lunch break was taken on the moraine on the northern shore of Czarny Staw (The Black Tarn). Around the tarn, to the east, south and north, the bare escarpment rose almost vertically. We saw the beginnings of several small corries in the rock face at high levels and also features indicating two levels of glaciation.

The ice sheet covering Northern Europe during the Pleistocene did not extend beyond the northern slopes of the Outer Carpathians. In the Inner Carpathians, the snow line probably came down to around 1500 m and glaciers were widespread. The maximum depth of the ice in the area around us seems to have been about 300-400 m. The Czarny Staw and the other tarn (Morskie Oko - 190 m below it) occupy rock basins that were formed by a glacier moving northwards to join another glacier coming down the valley of the Biala Woda to the east. The ice flow then continued in a northerly direction along the valley of the Bialka.

The granitoids of the Tatra mountains were formed during the Variscan orogeny and have been dated to between 300 Ma and 330 Ma. It is believed magma was formed by partial melting of heterogeneous material at a deep level, following a lowering of pressure. This occurred around the time of a tectonic inversion, accompanied by a general uplift in the region, when rocks from lower in the crust were thrust over rocks lying above them. Crystallisation of the magma, which intruded from the south east, took place at a depth of 5-10 km from the surface. In the region of our excursion the rock formed was granite: elsewhere the composition varies towards granodiorite and diorite. Overall, the solidified mass formed a basement complex for Mesozoic sediments.

Late in the Cretaceous the region of the Inner Carpathians was subjected to a strong northward thrust, resulting in the detachment of slices of the crystalline basement and movement, together with the Mesozoic strata, for a few tens of kilometres. This was accompanied by strong folding of the sedimentary rocks and the formation of nappes. The main uplift that gave birth to the Tatra mountains occurred in the late Miocene during the Alpine orogeny.

Throughout the southern part of the Eastern Tatras erosion has removed the sedimentary rocks and also the metamorphic rocks that lay at the top of the granitoids. Today the scenery is dominated by hard, bare rock, sculpted by ice, rising to jagged peaks, whilst the valleys support vegetation growing on Late Tertiary and Quaternary clastic deposits.

We walked back from Czarny Staw and went around the western shore of Morskie Oko. A major fault has been detected running through the middle of Czarny Staw and the south-west of the lower tarn, but there were no obvious signs of this.

Back at the terminal for the horse-drawn carts near the northern shore of Morskie Oko we had a clear view of crystalline caps on mountains in Slovakia on the far side of the Biala Woda valley. These caps are derived from the detached slices of the crystalline basement that were thrust over the Mesozoic sedimentary rocks in the Late Cretaceous.

We rode down the valley, again sitting tightly packed in one of the horse carts. Along the way we stopped at a bridge where a stream (Potok Roztoka) came tumbling down the hillside and plunged from a hanging valley on its way to join the Bialka in the valley below us.

Reported by John Wardill

(D6) Czarny Staw
This is another beautiful lake, dark coloured, surrounded by very steep sided mountains and with a very special peaceful feel to it.

Lunch was now taken, as provided by the hotel - two rolls, one cheese, one ham, a chocolate biscuit, a piece of fruit and a carton of drink - very welcome, although by day 6, somewhat repetitive!

Marek explained the geology in view, granite mountains, upset to the northwest by tectonic events, cut by joints dipping northwest and parallel to the top of the intrusion.

Almost regretfully, we started down, stopping at about the half way mark to consider the boulders beside the path. Marek pointed out the pink feldspars in the granites, a strong indication of potassium alteration, a matter which resulted in much further discussion later in the week.

We looked again at the hanging valleys and Marek pointed out a major fault which runs along the south side of the valley.

On reaching Morskie Oko again, we completed our circumnavigation of the lake, arriving back at the Tea House as the last ice cream was sold - a matter of regret by many members, as the afternoon had been very pleasantly warm.

Downhill to the carts was a pleasant walk, and Marek was able to point out that the mountain on the east of the valley, Szeroka Jaworzynska had a cap of brown rock above a whiter base. The brown was a granite, thrust upon the white Jurassic limestone nappe, a fine example of a major thrust/nappe structure which was one of the main reasons for us coming to the Tatras.

(D3) Wodogrzmoty Mickiewicza
Half way down in the horse cart we stopped to see the waterfall at Wodogrzmoty Mickiewicza, which is in a hanging valley on the side of the Dolina Rybiego Potoku - an attractive fall coming over a ridge in the granite.

Reported by David Ward

Day 2, Thursday 24 August - Evening

The White Trousers

In the evening, six of us, including the chairman and his wife, were seated at a table in the town. (Little did we know that we were about to play a part in the local custom of beer throwing). Eventually, the waitress, dressed in regional costume, came with our order: 6 large glasses arranged around a circular tray balanced on one hand. She leant over the table and served those sitting to her right - one, two, three; all taken from the same side of the tray. As she grasped the third glass, the tray tipped suddenly to the left, discharging the contents of the remaining three glasses onto the table below. The operation *appeared* to be an accident.

A miniature tsunami flowed inexorably towards David Riley. We watched in silence as it poured over the edge of the table into his lap. David leapt to his feet - but too late!. He stood there, a very sodden sight. Our young waitress disappeared without a word and was soon replaced by a man armed with bucket and mop. It quickly transpired that he had not come to dry out David, but merely to remove the excess liquor from the floor, presumably to ensure that the gentle descent of liquid from the waist was not opposed by dampness rising from the feet. At this point, David, in great good humour and greatly encouraged by the other members of our party, began to examine several pairs of trousers hanging from the rafters. We had seen trousers like this before: they were white, probably made from sheepskin, and embroidered with colourful, traditional designs. Today they are worn by musicians playing for the tourists and drivers of horse-drawn vehicles plying for hire, but we all agreed that the garments around us were intended for use by those finding themselves sitting in soggy pants. Unfortunately, David discovered that all the items on display were far too small for him, but he quite unexpectedly declined to call for a larger pair - despite the repeated urgings of his companions, who were concerned for his comfort.

Perhaps we had a vision of him performing a Polish country dance before an appreciative audience uttering untranslatable cries, accompanied the while by the little band of musicians in the corner, all of whom were wearing white trousers. But sadly this was not to be and we were left to contemplate a lost opportunity, whilst, sitting opposite David, the writer of this report was secretly wondering how he would have performed if the waitress had been left handed.

Reported by John Wardill

Day 3, Friday 25th August - Morning

This was a walk through the Eocene in situ rocks which overlie, unconformably, the outermost, northernmost nappe structures of the Tatras. We reached viewpoints from which we could see the structures of this nappe, the Reglowa Nappe, and we saw several glacial features of interest.

Our bus journey of about 7 km. took us southwest from Zakopane, and then a short walk took us to the start of the forest track, where the change in slope suggested that the overlying flysch gave way to harder nummulitic limestone. We walked uphill, up the path beside the stream section, up a variable but steep bedding dip of 30^{o} or more. The limestone, in which we found nummulites of as much as 1 cm. in diameter, was underlain by a calcareous sandstone which was said to be dolomitic. The sequence coarsened downwards to a basal conglomerate which was stained by haematite, which was thought to have been derived from underlying veins. The clasts in the conglomerate were matrix supported, were not well rounded, and some were subangular. All were from local rocks of the Regle Series, i.e. they did not include exotica from the basement, though Eocene rocks elsewhere in the Tatras do include large blocks from other nappes.

Further uphill the soil became red, stained by the haematite veins in the underlying nappe, older than the folding and thrusting involved in the emplacement of the Regle nappe in the late Cretaceous. From a viewpoint on the crest of the hill we could look across the Dolina Mietusia, the Mietusia valley, southwards to the corrie at its head, with a large fold visible in the limestone. We were looking at Triassic, Jurassic and Lower Cretaceous limestones of the Czerwonych Wierchow nappe. Above them we could see the reddish colour of the grass which is characteristic of crystalline rocks, in this case the granitic cap of the nappe. The main corrie has several hanging subsidiaries above it, demonstrating three different levels of glaciation. The floor of the upper part of the valley was said to be full of very large blocks, which fell onto the surface of the occupying glacier from the cliff above in a rock avalanche in Pleistocene times. The valley outlet is to the west, i.e. it swung away to our right, disappearing behind a large crag of pale Jurassic limestone.

Our descent to the pass brought us to softer rocks, shales of varying kinds reflecting changes in sea level around the Triassic/Jurassic boundary, while the steeper crags within view were composed of pale Jurassic limestone. After a break we dropped down through the forest to the Malei Kaki valley, where glacial erosion was overprinted by valley incision, and large boulders reminded us of the power of rivers. Some were spectacularly water worn, with grooves and rounded shapes. The rocks were Triassic and included marlstones, but also a superb block of red basal conglomerate, (which we thought might be the same as the Post Office floor!). The later Triassic dolomites were said to be crinoidal and algal, which argues a continuing variation in marine conditions of deposition. Our path through the forest took us down to the foot of the valley.

Reported by Gilia Slocock

Przyslop Mietusi

Nedzowka
A 15 minute coach trip brought us to Nedzowka, 1 km east of Kiry, to the west of Zakopane, the start of the days walk.

After crossing a couple of fairly level fields, we started up a moderately steep path, which lead to the entrance to the Park, marked by an elegant wooden arch and keepers' hut.

Marek explained that the fields we had crossed were in the Eocene Podhole Basin sequence, here composed of conglomerates and sandstones, weathered to soils. Possibly there was a subsidance on the underlying surface leading to a variable thickness of cover - here the thickness was about 200-300 m. These were laid down in a Eocene sea which lay to the south of the present position and which was filled with flysh deposits after the main Cretaceous folding sequence of the Tatras.

The main rocks to be seen on entering the park, we were told, would be nummulitic and dolomitic limestones, calcarenites and conglomerates of the ChocNappe, Regle Sequence.

(E1) Stanikow Zleb
50 m from the entrance, in the stream bed, the youngest north limestone was found - a grey rock, rounded where weathered, showing the circular cross sections of Nummulites and 4 cm diameter strongly ribbed bivalves. This rock dipped at about 40^{o} to the north, and was overlaid by the Podhale series seen earlier in the fields.

A further 200 m up the track, the next member of the sequence was found - a grey coloured dolomitic conglomerate with clasts up to 10 cm, tightly packed with little cement and in places verging on a breccia, with angular fragments. Further on, the conglomerate became strongly red coloured, the result of staining from the underlying Cretaceous limestones, which carry haematite veins.

The path continued uphill for several km, arriving at a ridge after traversing some very attractive scenery in the wooded valleys.

(E2) Jaworzynka Mietusia
Looking north, with the Podhale Basin in the foreground, we could see the Outer Carpathians in the distance, which are composed of flysch materials, while the Podhale is filled with Eocene sandstones and shales. On the south side of the Outer Carpathians is the Klippen Belt, described as the relic of a major crush and thrust plane, composed now of isolated masses of limestone. Some Miocene andesitic volcanism is found there.

The Outer Carpathians has two main nappes with smaller folds in between.

Turning round to face south gave the members a tremendous view where we could see the Czerwone Wierchy range, although the peaks were in cloud. Marek explained the geology -the white cliffs to the west are Jurassic, bounded by thrusts, and resting on Cretaceous marls of the Krizna Nappe or the ChocNappe. Within the vertical limestone cliffs could be seen great folds of a nappe, this was the first time we that we were able to actually see these structures.

Hanging valleys were indicative of glacial action and the fact that there were several at different elevations indicated that there had been more than one glaciation. In the bottom of one valley, we could just see piles of massive boulders - these were limestone, and had been deposited by avalanche, either directly to their present position, or via a glacier.

As expected in limestone and dolomite mountains, a great many caves occur in the area, many of great length, often carrying streams.

The mountain face in front of us showed a sequence through the ChocNappe in the Wierch Series - this showed a sequence through the Triassic, Jurassic and Cretaceous limestones, although we had to take Marek’s word for this! The lower forested hills were in the Regle Series, Krizna Nappe, again with Triassic dolomites and limestones. The uppermost sequence in front of us was the Giewont Nappe, topped with granite and crystalline basement thrust on top of the pile from the east.

(E3) Przyslop Mietusi
A walk of about 1 km brought the party to a meadow, surrounded by mountains, another lovely place. This was Przyslop Mietusi, a pass through the mountains, floored in Triassic shales of the Krizna Nappe and to be our lunch stop, taken in rather draughty conditions, but welcome nevertheless.

Reported by David Ward

Day 3, Friday 25th August - Afternoon

After lunch, the party took the path towards Wielka Polana. 300 m down the path, the Triassic shales were found - dark red coloured, thinly bedded, with thin white limestones.

(E4) Wielka Polana Malolacka
Further down the path, the trees gave way to another meadow, this one with a very flat floor and Marek explained that this was the site of a Pleistocene lake, originally 65 m deep, subsequently filled with fine grained deposits and topped with coarser material.

To the sides of the valley were exposures of dolomite, showing crinoids and algal masses.

From the meadow, a view to the east showed the face of another mountain, Giewont, with a valley, the Wielka Polana, leading up to it. Exposed in the valley sides were white Triassic limestones overlain by granites and schists which had been thrust there.

The party now retraced their steps, and took the path towards Gronik. The path led steadily downhill through woods and both sides of the path were lined with 2 m boulders of dolomite and limestone, some with clints and grykes starting to develop, presumably before they were displaced to their current position. Marek suggested that they were here as a result of avalanches bringing them down from high on the valley sides.

(E5) Dolina Malej Laki
In situ thin dolomites in the valley walls were attributed to the Krizna Nappe. The path here consisted of many slabs of these rocks, beautifully polished by boots, showing, especially where the limestone was black, veins of white calcite and some structures which may have been worm borings.

A considerable discussion developed on the origin of limestones and dolomites - were dolomites ALWAYS replacements of limestones? DID animals preferentially use calcium rather than magnesium for shell building? As the calcium and magnesium ions are of different size, WHAT HAPPENS when magnesium replaces calcium in a carbonate? DOES magnesium replace calcium in calcite in the same way as it does in aragonite? Interesting debate on these topics occupied the members for the walk back to Gronik.

After leaving the Tatras National Park, a brief stop was made at the new Church of Our Lady of Fatimah in Zakopane, which had been consecrated by the Pope in 1997. This is a very modern style of building, with much use of the local granite and timber.

There were two objectives for our visit - the stone fabric of the church itself and the plinth supporting the Holy Father on the forecourt. Close examination of the plinth with hand lenses- possibly a matter of concern to the white felt trousered and jacketed keepers of the church - revealed that it was a labradorite, displaying beautiful large bluish plagioclase feldspars, which showed irridiscent patterns of reflected light.

The walls of the church outside had been left rough, with little to be observed, however inside the floor was laid with polished slabs of granite, and as well as the three typical minerals - quartz, feldspar and micas - there were also lovely zenoliths up to 15 cm across.

Our final stop for the day was the Tatras Museum, at the bottom of the main street. The museum contained sections on the geology, natural history and people of the Tatras, naturally most members headed for the geology section first, passing on to the other sections later.

The geological section was quite extensive and laid out on traditional lines of specimens in glass cases with a few models of the topography as well as a few large specimens of tourmalinised granite. Passage round the exhibits was rather slow, both because of their quality and hence the need to look carefully, but also because our leader Marek was in great demand as translator, and had to be shared between us.

All of the rock types typical of the Tatras were on display, and geologists visiting the area would benefit from an examination of them before entering the field.

With Marek's help, a glossary was assembled. The geological elements have been moved to the main Glossary but examples of other terms are given here illustrating the difficulties facing the party:

Polish	English
borsuk	badger
lis	fox
niedzwiedz	bear
widlydognoju	wooden fork

So, if you find you are being pursued by a niedzwiedz and you only have a widlydognoju, it's as well not to worry about the pronunciation!

The museum was followed, in true RGS style, with a visit to a teashop for refreshments - here, tea and apple cake for 10 people was 82 Zl - about £13.00

Reported by David Ward

Day 3, Friday 25th August - Evening

The evening meal in the hotel was reasonable, if not remarkable (was this the evening we got food poisoning?), and, in the usual style, the members trickled down to the bar afterwards. The bar was not a particularly stimulating place, presided over by a Polish lady with few words of English, brilliant carrot hair and the air of someone who wished themselves elsewhere.

However, a round for the 15 or so members was about £ 11, so we were able to tolerate the indifferent service. Several pints later, the indifferent bar and its keeper seemed less important, as discussion took place on the Tatras geology, scenery and plans for tomorrow.

About this time, a party of Poles drifted in from a conference in the hotel and became the second group in the bar and after a while asked us if they could make a noise - as they were investment advisors from Silesia, we were delighted to encourage them.

"Noise" turned out to be drinking songs, and after a couple we felt bound to applaud, this eventually turning into a response in the form of "10 Green Bottles", which earned us considerable applause from the Poles.

Carrots behind the bar, fearing the worst, tried to subdue the other group, but had left it far too late. More Polish singing was delivered, and we responded with " Old McDonald Had A Farm" and several similar ditties - this of course was thirsty work, and Carrots was now very busy.

The two teams by this time had conductors, and co-ordination of the individual's efforts was becoming difficult for them. This may have been exacerbated by the exchange of conductors, when each choir (as they saw themselves) was conducted by a conductor who had little idea of what was being sung.

Resolution of this minor problem took the form of the conductors standing on a table and jointly conducting the assembled throng and it was at this point that Carrots made her final, unsuccessful, attempt to control the situation, thereafter concentrating only on the Polish beer and Honey Vodkas challenge.

The climax came when the two choirs merged to form a ring and several Polish songs were interposed with The Oxford Boating Song, Auld Lang Syne and, magically, Jingle Bells, which our Polish colleagues knew word for word. A great evening for Entente Cordiale!

(This report is only one person's view of the proceedings - others may have seen the events in some different way, depending on memory, viewpoint and possibly intoxication)

Reported by David Ward

Day 4, Saturday 26th August - Morning

Bialy and Strazyska Valleys

The route walked was as Itinerary B (p18 of the handout) but in reverse. The first location visited was just beyond the entrance to the National Park, at the beginning of the steep-sided Bialy valley (Dolina Bialego) – see sketch map (Fig. 2) below, location A (approximately 1000 m above sea level). For some 50 m along the riverbed, thin shales alternated with thicker (up to about 20 cm) mid- to light-brown very fine-grained beds, dipping at 30° to the north. Marek described these beds as being composed entirely of ankerite. (Ankerite is a mineral, $Ca(MgFe)(CO_3)_2$. The rock occurs in a similar way to dolomite, having been formed by the action of Fe-bearing as well as Mg-bearing solutions passing through the original limestone). These beds showed well-developed jointing, where the ankerite had weathered to a much darker brown. No fossils were found.

Marek explained that the rocks seen at this location were of Oligocene age, locally known as the Zakopane Beds. These overlie the Eocene nummulites and basal conglomerates (which were seen on days 1 and 3) and were part of the lower beds of the Flysch series that comprised the thick filling of the Podhale Basin to the north.

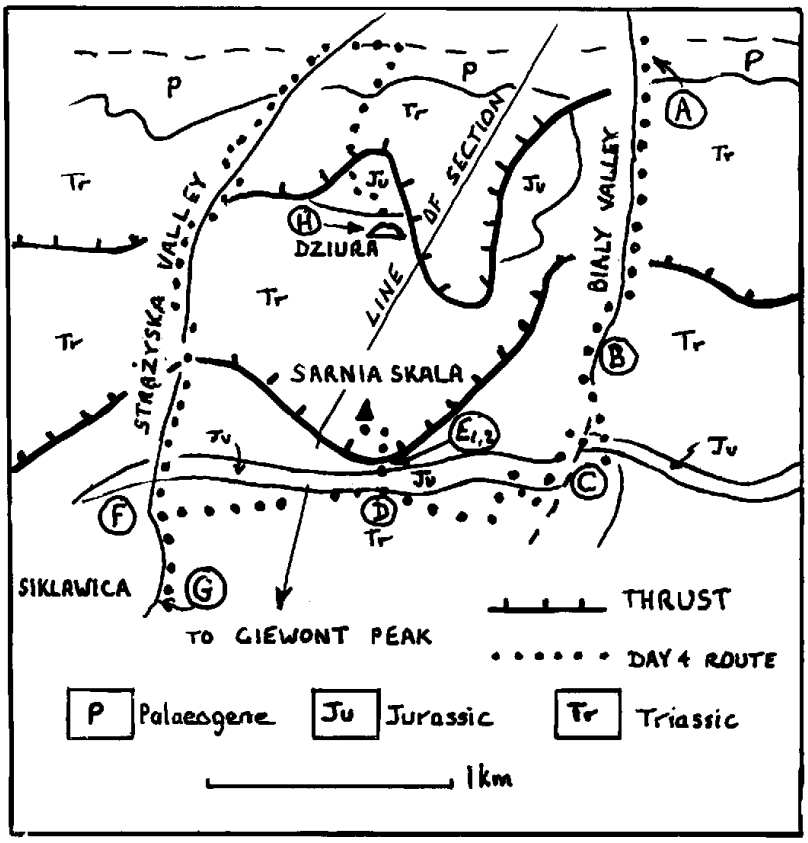


Fig. 2: Sketch map of Sarnia Skala

Proceeding south along the valley, no exposures of the basal Eocene rocks were seen, although geological mapping (see sketch section, Fig. 3) has shown that these were deposited unconformably upon the much older and highly deformed Mesozoic formations.

Continuing the ascent alongside the river, the valley narrowed to a gorge through a great thickness of Triassic dolomites of the Regle series. Where the dip could be identified, the often thick and largely structureless beds dipped steeply at about 70° to the north. Along the riverbed, many small waterfalls and potholes ('marmites') were seen, indicating rapid erosion. Is uplift of this massif still continuing?

The valley gorges were cut through the allochthonous Triassic dolomites of the Krizna Nappe complex. At location B, a well-developed brecciated dolomite was observed. This brecciation probably occurred during the intense post-Cretaceous folding and thrusting of this Nappe.

The route continued upwards, now in a generally southwest direction. Middle Triassic dolomites, reddish shales, pebbly sandstones and occasional thin conglomeratic bands dipping to the northwest were noted. At location C, a short section of very dark shales, mapped as Jurassic, were observed. This implied that a faulted junction (i.e. a thrust?) had been passed over, but was obscured along the route.

A short distance further south, more dolomites were seen, mapped as Upper Triassic. The route turned westwards, through a varied section of dolomites, reddish grits and sandstones, indicative of shallow

marine to continental depositional environments. At location D, (Czerwona Przelecz), the group enjoyed a welcome 'elevenses' halt. Here, Marek referred to his detailed geologic map, and discussed the general structure of the area and the nature of the Krizna Nappe thrust zone. This was said to consist of several subsidiary thrusts stacked one above the other, with a major thrust separating the Lower Nappe from the Upper Nappe.

From location D, the group climbed a short trail in a northerly direction towards Sarnia Skala (1377 m). A short distance up this trail, thinly bedded marls containing a few shelly fragments were found (mapped as Jurassic) at location E1. About 200 m further on at location E2, a succession of alternating soft brown to black shales and thinly bedded dolomitic limestones (Jurassic?) outcropped across the trail. Marek observed that the Lower Krizna Nappe thrust was mapped in this position (see sketch map). However, no signs of 'disturbance' could be found. *[The thrust was probably mapped from nearby evidence to occur at a point just above the soft sediments, but obscured by the terrain]*.

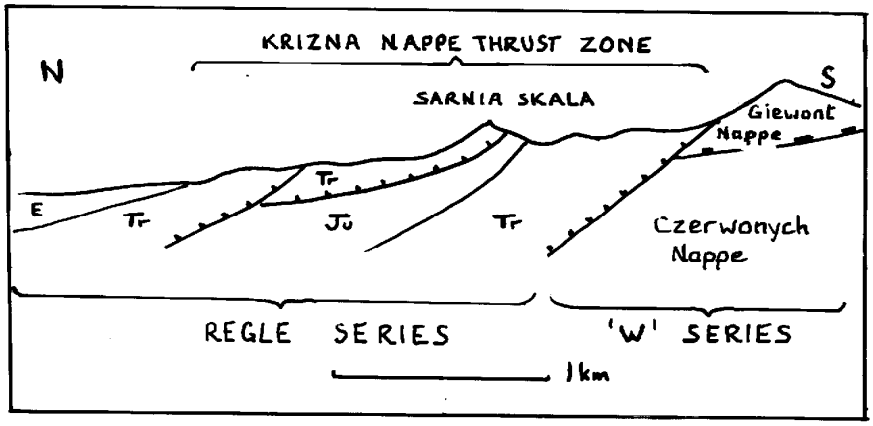


Fig. 3: Sketch map of Krizna Nappe thrust zone

A short but rough scramble took the group to the viewpoint of Sarnia Skala, with much photographic activity by group members. However rain clouds largely obscured the high Tatra Mountains to the south. The nearer peak of Giewont (1894 m), some 1.7 km to the south, could be seen. This peak was part of a separate thrust structure known as the Giewont Nappe. This is a thrust mass of allochthonous Wierchy Triassic and Jurassic units dipping steeply to the north and lying unconformably on a detached mass of crystalline basement. This 'crystalline tectonic island' overlies yet another major thrust structure - the Czerwonych Nappe.

After returning to location D, we continued along the trail westward and downwards on a steep, damp and slippery stony path to a picnic area at Polana Strazyska for lunch (location F). Then a short diversion south was taken to Siklawika waterfall (location G). The waterfall was about 22 m in height, falling over steeply dipping Middle Triassic dolomites, again part of the Regle Series of the Krizna Nappe. Here there was discussion about the nature of the broken and weathered surfaces of the hard dolomite. No firm conclusion was reached as to what mechanism caused the rock to 'break' into such irregular pieces, and what might be ascribed to 'jointing' and what to 'cleavage', if any. The surfaces were poorly defined, and there was great variation in direction of these surfaces where they could be measured 'in situ'. *[It is probably better to consider these surfaces as the product of 'stress fracturing' from different directions during the long period when these rocks were being moved from a far distance to the south of what is now the Tatra Mountains and then deformed within the Krizna Nappe structure in late Cretaceous times.]*

Reported by Gordon Hillier

(The locations given in the above report and in fig. 2 correspond to the locations in the Itinerary B in the following way: A - B9; B - B8; C - not marked on itinerary; D - B6; E - not marked on itinerary; F - B4; G-B5; H - not marked on itinerary.)

Sarnia Skala

This itinerary was taken in the reverse order from that indicated in Marek's handout.

(B9) Bialy Potok Stream
A gentle drizzle greeted us at the start of this trip, but cleared by midday, to give an overcast afternoon. Our first stop was a wooded valley with a stream about 5 m wide, and quite shallow - suited to wallowing in by visiting geologists. The stream had cut a channel in brown, thinly bedded shales, of Oligocene age, showing cross bedding indicative of west to east transport. A few thin tuff horizons separated the shales, and a ridge of ankerite created a 20 cm waterfall. The ankerite showed tapering black "needles" from the surface, unidentified, but possibly crack infillings.

A short walk up the path brought us to the mid Triassic dolomites which underlaid the shales. These were of the Regle Series, and gave rise to a topography where the land surface drops 200 m per km, resulting in fast streams and waterfalls. The uplift causing this slope was described as Recent. The dolomite is brecciated, with white veins of crystalline dolomite, much folded and faulted. There was considerable discussion regarding the determination of what was a bedding plane in such altered material, resolved by taking a view from a considerable distance, when features became clearer!

The stream bed changed direction by 90^{o} over short distances, and dips in the rocks also change radically, both indicative of major movement.

(B8) Bialy Valley
The path had, by this time, become quite steep, although still with a good surface and the party continued to climb steadily.

At a significant fork in the stream, black limestone was seen close to yellow dolomite, with considerable areas of shattering. The waterfalls were becoming more spectacular and the path took on a strong zig-zag course, in and out of the dolomites.

After a brief rest, where the path joined another at a "T" junction, the party moved 100 m onto a new rock type - a red Triassic mud, 0.3 m thick, on a white quartzitic sandstone. A further 100 m brought us to a patch of Jurassic shales, sufficiently close to the Triassic dolomite to let Marek convince us that we had crossed a major thrust plane! Yet another 100 m placed the party on thin grey limestones, also of Jurassic age.

(B6) Czerwona Przelecz
A few more zig-zags and we arrived at a clearing, the first sizeable open space since leaving the coach. Red shales and mudstones floored the clearing and were of Upper Triassic Giewont Nappe age and dipped $50\text{-}75^{o}$ to the north here, indicative of a major thrust, which separates the lower part of the nappes from upper, and which is more complex with more thrust planes. Marek explained that the red shales were typical of transitions from marine to near shore continental facies.

Views of the upper part of Giewont, the local dominant mountain, and Sarnia Skala, our objective, had now appeared through the trees, and another 100 m brought us to the final assent to the summit.

First, however, we crossed a thin limestone carrying distinct bivalves and corals.

(B7) Sarnia Skala
The track now took on a more severe gradient, and the surface deteriorated as we approached the summit of Sarnia Skala, a peak on the side of Giewont.

Leaving the trees, the track crossed red shales, then crumbled dolomite, then thin limestones, this marking the tectonic contact of the Wierch and Regle Nappes.

A scramble round a shoulder and up some loose rock brought us to the summit of Sarnia Skala, where we were rewarded with great views over Zakopane to the north and the lower part of Giewont to the

south. The mountain top itself consisted of a small flat plateau of dolomite, surrounded with fantastic upstanding masses of the same rock showing perpendicular bedding, striking east-west and with precipices on two sides - a place which repaid the effort of the climb.

The north face of Giewont was a sheer cliff of white dolomite and limestones showing distinct folded bedding - the contact between the Regle and Wierch Nappes, we were told, but this long distance geology was rather questioned!

While the views were splendid, the temperature was uncomfortably low for loitering, so the party shortly made its way back down to the clearing at Czerwona Przelecz, where we took the continuation of the path we had arrived on - now steadily travelling downhill on a rather bouldery surface.

(B4) Polana Strazyska
The path, as most do in the Tatras, brought us to a meadow, with stream and Tea Hut, where lunch was taken, in deteriorating conditions - gentle drizzle, enough to speed the eating. The meadow was in Jurassic shales of the Krizna Nappe. After this brief halt, the party took the path to the south, towards Siklawica.

Reported by David Ward

Day 4, Saturday 26th August - Afternoon

The group then descended northwards through the Strazyska Valley without stopping at further exposures. On return to the National Park entrance, there was time to spare to visit the nearby Dziura Valley where a cave of the same name was situated about ¾ km to the south up this valley. This cave was reached after passing yet again the near vertical carbonates of the Upper Krizna Nappe. (Location H on the sketch map - Fig. 2). There were no significant exposures along the trail.

The cave was reached by a flight of steps. The entrance was in a vertical face of limestone that appeared to be distorted and fractured, and it was hard to recognise any original sedimentary features such as bedding. An irregular patch of brecciated limestone was seen. It was not possible to establish whether this was tectonic in origin i.e. stress-related, or if it was a karst (sedimentary) feature - a fill of limestone debris in a solution cavity. A number of vertical faults could, with difficulty, be seen in this face. Those who entered the cave found it to be quite small and dry, only about 40 m by 20 m, and blocked at the far end by debris, which also covered the floor that sloped inwards. (Torches were at a premium, so it was difficult to see any interesting features of the interior that may have been present!). Marek stated that it was another example of the widespread karst features of this region. Originally it was part of an extensive underground drainage system, formed at one stage of the valley deepening process that occurred from the late Tertiary period onwards following uplift of the Tatra Mountains.

The cave was situated near a mapped junction of Upper Triassic dolomites and Lower Jurassic limestones of the Lower Krizna Nappe. It was also near a mapped position of the Upper Krizna thrust. In the nearby streambed, some of the group found limestone juxtaposed against dolomite. Adjacent to this was evidence of brecciation and considerable distortion of the rock in the banks of the stream. Limestone continued to be found for some distance downstream. This field evidence was indicative of tectonic movement and/or faulting, and thus appeared to support the mapped position of a fault zone – in this case, perhaps the basal thrust zone of the Upper Krizna Nappe?

The group returned to the Park entrance, where a local cheese was tasted and samples bought by some members.

Reported by Gordon Hillier

(B5) Siklawica Wodospad
A waterfall, not of huge volume, but very attractive, came over a dolomite ledge, down a bedding plane and fell about 23 m to the valley floor.

The surface of this plane shows two sets of joints at about 90^{o}, which is repeated in many exposures and fallen blocks here. Some discussion took place on the origin of the joints, and their subsequent (inferred) development to " clint and gryke" type structures seen elsewhere in the Tatras. A return northwards on the path we had arrived on, brought us back to Polana Strazyska, then on down the path to the next halt.

(B3) Trzy Kominy
The path had developed into a surfaced road, but with no traffic, running down a wide valley with craggy peaks and pillars on both sides, in places ornamented with what were thought to be Ravens by some, Capercaillie by others. Trees lined the valley bottom, and it was altogether a pleasant place.

Marek pointed out the dolomites, which here were of the Middle Triassic Krizna Nappe Series.

(B2) Polana Mlyniska
Still further down the valley, more exposures of dolomite were seen, these being also of the Krizna Nappe, as well as shales of both the Upper Triassic and Lower Jurassic.

(B1) Mouth of Strazyska Dolina
Back at “civilisation”, in the form of the local bus stop, Marek pointed out the Eocene Nummulitic Limestones of the Eocene Podhale Formation.

At this point, Marek wondered whether we would like to see a cave - an unnecessary question!

Dziura Cave
Another 700 m, along the edge of the National Park, then back in on the Dolina ku Dziurze, gently uphill, and we arrived at the Dziura Cave, having passed along the way yet another nappe sequence of nummulitic limestone, sandstones, Triassic dolomites and shales, with which we were becoming intimately acquainted.

The cave was eroded in Triassic Limestone, the under member of a sequence of Triassic dolomites, which here arch to the south.

The cave mouth is about 4 m high, 5 m wide which leads to a cavern 40 m deep, with a steeply sloping floor and arched roof. It appears to follow a fault which passes through the rock in the plane of the wall of the cave, and can be traced across the cave almost to the rear wall. While the cave was obviously formed by water action, it was not clear where the water entered, although there were several possible exits in the rear.

On leaving the cave, examination of the geological map carried by Marek showed that the area in front of the cave was in fact faulted, as well as consisting of both limestone and dolomite. A happy 15 minutes was spent dabbling in the stream, trying to sort out fault from sedimentary contact, limestone from dolomite and relating these to the map. We certainly tried, and maybe even succeeded!

The final stop of the day was at “Koliba”, a smoked cheese shop in a field, at the entrance to the Dolina, where some members, possibly with impaired senses of smell, made purchases.

Reported by David Ward

Day 5, Sunday 27th August - Morning

We started the day after breakfast with a coach journey to Kuznice (1014 m) at the western edge of the High Tatras (approx. 20 minutes), arriving in time to take the 09:30 cable car to Kasprowy Wierch (1950 m approx.). We were advised to wear warm clothing, as well as have waterproofs, as it could be very cold on the mountain top; when we boarded the car, the tops were shrouded in low cloud, and unfortunately, the view was hidden as we ascended. We changed to the second cable car at the midway station (Myslenickie Turnie, 1360 m), and then steeply up through the clouds to the summit station at Kasprowy Wierch. After disembarking at the top, the clouds started to part, giving us fantastic, if intermittent views both down the broad valley (Dolina Suchej Wody -"Valley of dry water") and south over the border into Slovakia. (Readers may be interested to know that the summit of Kasprowy Wierch is an "official" crossing point into Slovakia; the border at this point was marked by a piece of thin rope on marker posts, and "guarded" by a couple of Slovakian soldiers, waiting to check the passports of anyone who wanted to follow the path on the Slovakian side!)

After disembarking from the cable car, we walked slowly up the ridge towards the actual summit of Kasprowy Wierch. The summit is part of the Giewont nappe, and forms an island of the crystalline basement, bordered to the south east by overthrust sedimentary rocks. The morphology has been greatly influenced by glaciation, with the cable railway following a heavily glaciated valley up to Myslenickie Turnie, before following the ridge to Kasprowy Wierch. There are many hanging valleys, especially around the Suchej Woda, as this was the main route of the glacier to the lowlands in the north. The valley is a dry valley, as the underlying rocks of the Wiercha series are all porous limestones with an east-west strike. All water tends to find sink-holes, and flows to the west to reappear as Karst springs in the Dolina Bystrej to the west.

The crystalline rocks at the summit of Kasprowy Wierch form the largest crystalline cap in the region. There are three main lithologies: granitic rocks, forming the main part, but with small areas of white granites, formed by melting of sedimentary rock when the main mass was intruded, and zones of metamorphic rocks (gneisses, amphobolites, schists, etc.) formed in a "low pressure/low temperature event" (500-600^{o}; 4-7 kb pressure) by metamorphosis of lower Palaeozoic rocks. The majority of the granites are potassium-rich, with pink feldspar crystals, and are of non-magmatic origin, unlike the majority of granites in the Tatras, which are magmatic in origin. Pegmatites were also much in evidence, exhibiting large pink feldspar crystals. Some of the granite was fine-grained - "granito-gneiss", and together with the large-grained granites, was thought to represent the grain-size of the original source rocks such as sandstones, etc.

Walking slowly along the ridge (approx. 500 m) to the next summit of Beskyd (2012 m) took us over the zone of metamorphic rocks, typical of an amphiboliote facies. Several specimens of rock prompted much discussion of how the minerals exhibited could have been formed, for example a rock showing evidence of granite, gneiss and a pegmatite vein, and the gneiss being cut by a fine-grained granitic intrusion. (Despite the discussion, no firm conclusions were reached!) All in all, it took about an hour to walk less then 500 m!

The minor peak Beskid forms the boundary between the Western and the High Tatras, and from here, the view to the Northwest down the Suchej Woda showed the heavily glaciated sedimentary rocks of the [autochthonous] Cretaceous and Triassic Periods. These rocks underly the crystalline cap of Kasprowy Wierch, which was thrust over the rocks of the autochthonous series when the Giewond nappe was formed. Between the summit of Kasprowy Wierch and that of Beskid, the softer sedimentary rocks (red Upper Triassic shales) had been eroded at the Liliowe Pass, which forms a junction of a path leading up from the valley with the ridge path. In the area of the path, as well as the shales, there were some pinkish quartzitic sandstones of lower – mid Triassic age, which were said to contain ripple marks – suggesting that they had formed above the wave-base. The alignment of the ripple marks suggested that the origin of the sediment had been from the North. Some of the sandstones also contained feldspars, suggesting that the transport had been relatively short before deposition had occurred. The pink colour was thought to be due to quartz grains being coated with haematite.

Plate 2: View from Beskid

Plate 3: Descent into Dolina Suchej Wody ("Valley of Dry Water") from Kasprowy Vierch

Plate 4: Dolina Suchej Wody ("Valley of Dry Water") from Kasprowy Vierch

Plate 5: View from Peak of Kasprowy Vierch towards High Tatras

Several of the more energetic members ascended to near the top of Beskid to look for the contact of the Triassic over the (strongly weathered) crystalline basement rocks. The contact zone was eventually found, and showed up as a friable clay/shale containing many small fragments of mica. The overlying Triassic rocks consisted of an unconsolidated shale directly over the weathered granite, and as the shale contained significant quantities of the mica, it was deduced that the granite was already intensely weathered at the time of deposition of the Triassic shales.

After returning from Beskid back to the pass, the party started down the steep rocky path leading northwards from the pass into the valley. As we descended, we had a good view to the east over the heavily glaciated valley: in the far distance, the crystalline basement rocks of the High Tatras were visible. In the middle distance were the rocks of the autochthonous series (Triassic sandstones and shales; limestones and dolomites; Jurassic limestones) which were dipping at approx. 40^{o} to the north. As we descended to the floor of the valley, we saw the evidence of the glaciation in the form of a large moraine, and at one point, a sink hole where a stream disappeared into the moraine. The stream had been shown to reappear as a karst spring in the valley to the west – in fact, the predominant water flow was over the Tatra region from east to west, with several streams disappearing and reappearing in the next valley to the west. Shortly after leaving the sink-hole, we arrived at the mountain hut, where we had our lunch-break. (Because we had spent so much time on the ridge, the itinerary was cut short: if we had kept to our original plan, it would have been dark before we had returned to pick up the coach!)

Reported by Malcolm Iosson

Kasprowy Wierch

(C1) Kuznice-Kasprowy Cable Railway
Kuznice was a very short coach ride from the Panorama, and on arriving there, Marek gave us an introduction to the geological excitements planned for the day.

A couple of minutes later we were summoned (in front of many others who did not have the benefit of our Courier) for the cable car ride up to the first station, Myslenickle Turnie. On the way, Marek pointed out the cliff face on the east side, where there was exposed a section through the Giewont Nappe - attempts to photograph it were made, as were sketches. At Myslenickle we changed to a second car for the final assent to the summit, Kasprowy Wierch (1987 m), which was clear of the fog hanging round lower levels, and we emerged into a very bright, fresh, but cold (5^{o}C) morning.

The border between Poland and Slovakia runs along the ridge of this mountain, and beyond a string across the path, the Polish Border Guard stood - literally, in that there was no hut, guard post or shelter, the only barrier being the string. Apparently, in winter, the guard is expected to rub his hands together to stay warm - and this at 1987 m!

(C2) Kasprowy Wierch
The view from the mountain top was very exciting - deep valleys on all sides, with much bare rock, to our delight, trees filling the bottoms of the valleys, the odd little white cloud.

Kasprowy is capped with a grey granite, which shows some foliation, so should perhaps be called a granitogneiss. This is cut by pink potassium pegmatites, which are therefore younger than the granite. In places, feldspars up to 10 mm across were found, together with green feldspars much changed to chlorite, epidote, micas and clays. The pegmatite veins were generally from a few mm to 100 mm in thickness, and showed no cooling margins.

Progressing in an easterly direction along the ridge, and therefore downhill, we came to areas where banded amphibolites appeared, these being composed of dark hornblende and light plagioclase, this assembly being usually derived from basaltic rocks. The bands in the amphibolites were 1-3 cm thick and appear in contact with the granites.

Another 50 m east and the amphibolites showed biotites on the planes - indicative of a drop in pressure, or possibly a lithological gradation - Marek was not prepared to commit himself on this one!

Further east and the rocks changed again to schists, granites with pegmatites, quartz pods in golden micas within the amphiboles - clearly an area which had undergone considerable change.

The next find were patches of 5 mm rounded white feldspars in the amphibolites - indicative of decomposition of garnets following a reduction in pressure.

Thin haematite layers on joint faces in the granites occurred here, and seemed to be associated with the pegmatites, in that they often occurred where the rock had split along the peg vein, so that the haematite was between the peg and the granite.

This granite/schist sequence continued for 500 m, to a subsidiary peak on the ridge, called Beskid. This entire sequence is a block of basement which has been thrust up onto the younger sediments of the autochthonous Kominy Nappe.

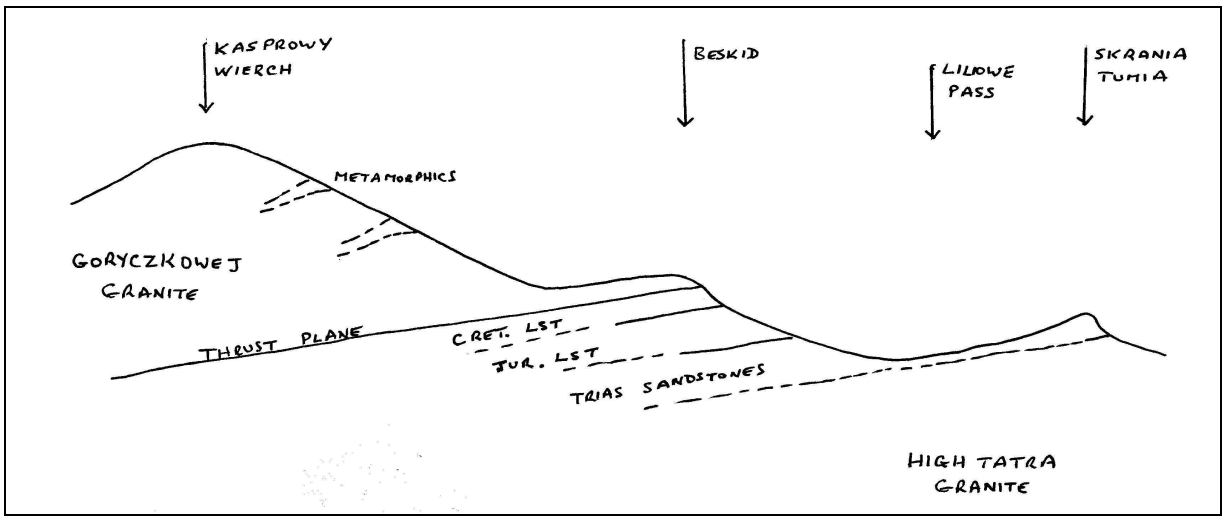


Fig. 4: Section along path from Kasprowy Wierch to Skrania Tumia (approx. 1.5 km)

(C3) Liliowe Pass
From Beskid, looking northeast, Marek was able to point out the sequence below us - first, the granite on which we stood - then the white limestones of the Cretaceous, below them the Jurassic Limestones, resting on the red Upper Triassic sandstones. These rested, conformably (autochthonously) on the crystalline basement. The entire sequence was only about 200 m thick, the result of erosion between each member. A rough track lead down the slope, crossing the above sequence and we were able to examine each member in turn.

Mounting the small peak in front of us, Skrania Tumia, enabled the members to see, on the southeast side, the base of the Triassic sitting, conformably, on the granite basement. The top of the basement had a weathered surface and a layer of pebbles, about 0.3 m thick separated it from the Triassic, a typical erosion unconformity.

(C4) Gasienicowa Valley
The party now retraced their steps to below Beskid, and took the downhill, northward path signposted to Swinica and Zawrat. This led into a wide valley, surrounded by the peaks of significant mountains and floored with moraines, screes, low vegetation, lakes and rocky outcrops - a truly magnificent place.

Marek explained that the exposures in this immediate vicinity were of Lower Triassic sandstones, cemented with silica, stained pink by haematite coats on the grains. It was possible to find ripple

marks, indicative of shallow marine conditions and land in this case was to the north, open sea to the south. The granite was seen to be 20 m away to the east.

A km or so down the path and the party stopped to look back (several stops had of course been made to take in the views (breathing deeply) on the way to this point). Marek pointed out the peak over which we had come and the exposure of the granite sitting unconformably on the white Cretaceous. The view to the east showed the granite, with above it the Triassic and Jurassic sitting in "autochthonous splendour" directly on it - this was the continuation of the contact seen at Liliowe Pass.

Entering the more shrubby area in the valley bottom, the party now came to Prezecz Karp, a place where a stream coming down the valley abruptly disappeared in a sink hole - this was explained by the fact we had moved onto permeable moraines, where the stream could pass into the rock.

A few hundred m brought the party to the hut, designated as our lunch stop.

Reported by David Ward

Day 5, Sunday 27th August -Afternoon

After lunch we set off up the eastern valley of Dolina Gasienicowa to its head beneath the towering height of Kozi Wierch at 2291 m. (C6). We were surrounded by granite of the Wierchy series. This valley has two northeast/southwest aligned tectonic faults and deep gullies have formed in the most fractured rocks with the best example on the left hand side. This granite is autochthonous and contains potassium feldspars, mica flakes, quartz, pegmatite, muscovite and biotite. It has a white core and red margins with mineral alignment near the margin and crystals 600-700 mm long. There was some discussion as to whether the pink colour of the feldspar was caused by haematite trapped between the interstices but no conclusion was reached. On the left hand side of the cirque was a series of ridges, running down the valley wall, of dark material possibly pyroclastic flow deposits.

The peaks of the High Tatras were not covered during the three glaciation periods so they remain sharp-pointed with many aretes. The morphology shows typical post-glacial features. Czarny Staw at 1620 m, aptly named the Black Lake, is steep-sided, 50 m deep, 650 m long, and lies in a large cirque approximately 30 m beneath a lip of rock and moraine. This is the lower of two rock basins. Behind the head wall a glacial valley leads off to the right from which a hanging valley with snow lying on its north face is visible on the left. This contains a tarn, one of the highest in the Tatras, Zmarzty Staw, named Frozen Lake because it is ice-covered most of the year.

From the tip of the cirque, looking north down the route to Murowaniec hut (C7) the valley opens out into a wide U-shape. The path down on the left hand side was initially very steep and there was a precipitous drop from the path into the valley. The rocks are a mixture of fine and coarse grey and pink granites, some showing foliation. Some tourmaline crystals were spotted. The steep side walls were scree covered in places and avalanche prone. We could see below us in the moraine-filled valley a tombstone to a famous Polish composer, Mieczyslaw Karlowicz, killed there, aged 29.

We could also see several regressions of moraine, both terminal and side deposits as well as eskers in the valley through which a stream meandered on the valley floor. This valley merges with the more westerly, wider and flatter one (described this morning) into a very large valley with a gentle sloping path down to the hut (C7). There was little exposure to be seen here but the hut stands on the lowest of the Wierchy series, the Lower Cretaceous limestones of the autochthonous Kominy Tylkowe series and shows karst features previously described.

At the hut the valley branches into two, Dolina Suchej Wody to the right and Dolina Olczyska, to the left, which we followed climbing up the side of Skupniow Uplaz on the left hand side of the valley through pastures over familiar limestones and dolomites. On the opposite side of the valley we could clearly see the brown Triassic sandstones (dipping north) of the Krizna nappe (the lowest of the Regle series, described in itinerary B). These lay unconformably but autochthonously on top of the granitoids of the High Tatras which showed parallel cracks and erosional surfaces before deposition of the Triassic sandstones. Further down the valley, cliffs of Middle Jurassic limestones showed as a white scar between the trees, indicating deposition in deeper water.

Our path continued upwards until we reached the Przelecz Miedzy Kopami Pass (C8). Behind, to our left, was the Giewont nappe with its near vertical Cretaceous and Jurassic limestones at the top of the Wierchy series, while in front we had a magnificent view of well-bedded Triassic limestones and dolomites of the Krizna nappe sticking up before us as a steep-sided white ridge with north dipping beds. Behind this, four lower hills of uneven shape were visible. Marek said these, too, were Regle series. Our Chairman was heard to remark that "they didn't look at all Reg'lar to him!".

Our path ran the length of the ridge on either side of which were steep-sided valleys of softer shales which had eroded to give V-shaped valleys. We had a beautiful view over Zakopane and the Pieniny Klippen belt with the Outer Carpathians in the distance. Great alluvial fans spread out across the valley from the enormous glacier travelling down Dolina Suchej Wody, which had developed beneath the mountains described today.

The path zigzagged down to Boczan (C9) through spruce forests over alternating layers of dolomites, sandstones and shales of the Upper Triassic period. In the valley below are two perpendicular faults, one of which can be spotted as a karst spring where water is forced upwards when limestone rocks rest against shales. Continuing downwards towards the cable-car station, the path became very slippery as several karst springs ran across the shales. We arrived at the station at 5:10 p.m., a distance of 9 km.

As it was our final day altogether, David took the opportunity to call the group together and thank Marek and Anya for making the tour such a success, Anya for making sure that all arrangements went without a hitch and Marek for his personal knowledge of the area which allowed us to understand the very complicated geology. He then proceeded to cut the cake (Chairman's privilege) ably assisted by Joyce (our inveterate fruit-cake maker) which was greatly appreciated by all as we stood and looked at the view over the valley. However, this idyllic setting suffered one minor drawback. We were standing in the daily parking spot for the many horses and carriages which brought tourists to the cable-car and a healthy farmyard smell assiduously assailed our nostrils; partaking of the scene in every sense of the word.

Our usual mad dash back to the hotel for dinner was followed by a pleasant time in the bar drinking coffee, beer and cherry vodka and relaxing after a truly fantastic day.

Reported by David & June England

(C7) Murowaniec Hut
Our, by now very standard, lunch was taken here, sitting in brilliant sunshine and enjoying the views, but only for a relatively short time!

A path to the southeast was taken, along with a great many other people, necessitating frequent stops in “lay-bys” while we were passed by travellers heading uphill at enormous speed, or downhill at a similar trot - all very perplexing for those from Reading, where a slightly slower pace added greatly to the enjoyment by allowing the scenery to be viewed.

One km up the path Marek pointed out the view to the northwest where we could see two lateral moraines stretching towards the northeast, with a drumlin field at the upper end. This was site of a glacier falling from the mountain to the east. The glacier passed over the low hills on that side of the valley, and then flowed down the adjoining one.

Outcrops of granite with pink pegmatites up to 20 cm wide, with feldspar crystals 5 cm across, appeared beside the path and were admired - blocks of the same material had been used to build the path, with great effect.

(C6) Czarny Staw
The object of this particular exercise was to reach a lake, Czarny Staw. (Interestingly, virtually every valley in the Tatras has a “ Czarny Staw”, making it unwise to navigate by lakes in this area.) This particular one was very well worth the effort of the walk - surrounded by peaks, long screes, and black reflective water, and admired by all. Marek pointed out the hanging valleys, indicative of glacial action, the north dipping joints in the granite and on the rear wall, a clear contact between the granite and the Triassic.

The main fractures here run northeast to southwest as they do in Morskie Oko. Over the ridge to the east is the 5 Lakes Valley, and over the next Ridge is Morskie Oko.

A debate arose over the red colour of the feldspars - as they were potassium feldspars, why were they red? Marek had seen thin sections showing very small haematite particles, others could remember glass sand analyses showing ppm levels of iron, but sufficient to colour glass, but it was agreed that neither could explain the colour - a subject for research on a winters evening!

The path back to the hut was eventually taken, to the regret of many, as all had enjoyed the scenery. At the hut, the path to the northwest was taken, towards Kopami Pass.

(C8) Przelecz Miedzy Kopami Pass and Skupniow Uplaz
The path from the hut led steadily uphill, giving great views back into the valley of Czarny Staw and we were glad of the need to take in the views to recover our collective breaths.

Crossing the Pass, we found the scenery in front of us very different from the earlier part of the day - here, we saw rounded, wooded hills and valleys full of trees and of course, we were all able to say "Regle" almost as fast as Marek, who went on to explain that the 5 rounded hills to the east were of Regle Nappe, while the hills to the west were of the Giewont Nappe. In the valley bottom, we were assured, were moraines containing blocks of the granite, carried down by glaciers from the mountains to the south, behind us.

The Giewont Nappe consisted of white limestones, nicely exposed in a sheer cliff face.

(C9) Boczan
Several km further downhill, on what was becoming a long walk, the path led to a stone surfaced track and progress slowed, because of the very jagged surface. Another viewpoint allowed Marek to point out dolomites and shales in the hillside to the east, these being of the Krizna Nappe. Finally, red shales appeared beside the track, and we knew we were at the bottom of the Krizna and just round the corner was the hamlet of Kuznice, at the bottom of the cable car we had taken that morning.

As this was the last time the party would assemble together, a gathering was held where the horses and carts were parked, which resulted in the Chairman standing in the muck - which some thought appropriate! Thanks were given to Marek for the splendid way he had led the trip and to Chris Fone for the excellent organisation. And, as always on RGS visits, fruit cake was served and the group photograph taken - all thought that the week had been excellent.

Reported by David Ward

Day 6, Monday 28th August

Visit To Wieliczka Salt Mines

Introduction

On our final day one party visited the Wieliczka salt mines and the second visited the Chocholowska Valley.

Wieliczka is located 15 km South-East of Krakow, about 100 km north of Zakopane. The two hour bus journey from Zakopane to Wieliczka gave us an opportunity to see a range of geological features; which were pointed out by Marek. A schematic outline of the geology we traversed is given in Fig. 2 in Marek's handout.

After leaving the Tatras we travelled north across the Podhale Basin filled with Palaeogene deposits, up to 2 km thick and locally much disturbed during the folding of the Carpathian orogen (see Fig 12 from Marek's booklet). The sequence comprises conglomerates and limestones at the base, accumulated in alluvial and near shore environments overlain by sandstones, shales and mudstones of the flysh series; these were deposited by turbidity currents in a deep sea environment. Locally there are thin tuff bands related to vulcanism in the inner part of the Carpathians to the south. These deposits formed a continuous cover but after the main uplift of the Tatra mountains in the Miocene were eroded and are now only found in depressions. A narrow belt of shattered limestones and dolomites occurs up against the southern edge of the Outer Carpathians, the Pieniny Klippen Belt. Marek pointed out a Jurassic limestone outcrop (a "klippen"), perhaps 30 m high, complete with a castle.

The Outer Carpathians consist of a series of successive nappes. These Mesozoic rocks have been thrust tens of km north. The rocks had not been metamorphosed, showing they had remained within 10 km of the surface.

To the north of the Outer Carpathians is the Miocene sequence of the Carpathian foredeep, in which lies the salt deposits. The northward thrusting of the Outer Carpathian Mesozoic (flysh) rocks over the Miocene deposits caused great disruption.

As is often the case in our geology trips, much of the above information has to be taken at face value from our leader and books. However, our tour of the salt mine gave us an opportunity to see for ourselves the great physical disturbances within the rocks.

Origin of Salt Deposit

The salt was deposited in the Miocene about 15M years ago. The salt deposit, which extends for 10 km along the northern edge of the Outer Carpathians, is 0.5-1.5 km wide and up to 400 m thick. Animal and plant fossils found in clay and other sedimentary intercalation within the salt testify to a warm climate, equivalent to that in the Mediterranean today. The middle 5 km has been mined, the western part has been used for brine extraction and the eastern is variable and unmined. In mid-Miocene times the basin became partially disconnected from the Tethys sea and there was sufficient evaporation for evaporites to form. The lack of magnesium salts is evidence that the basin was from time to time replenished with fresh sea water (the magnesium salts remain in solution).

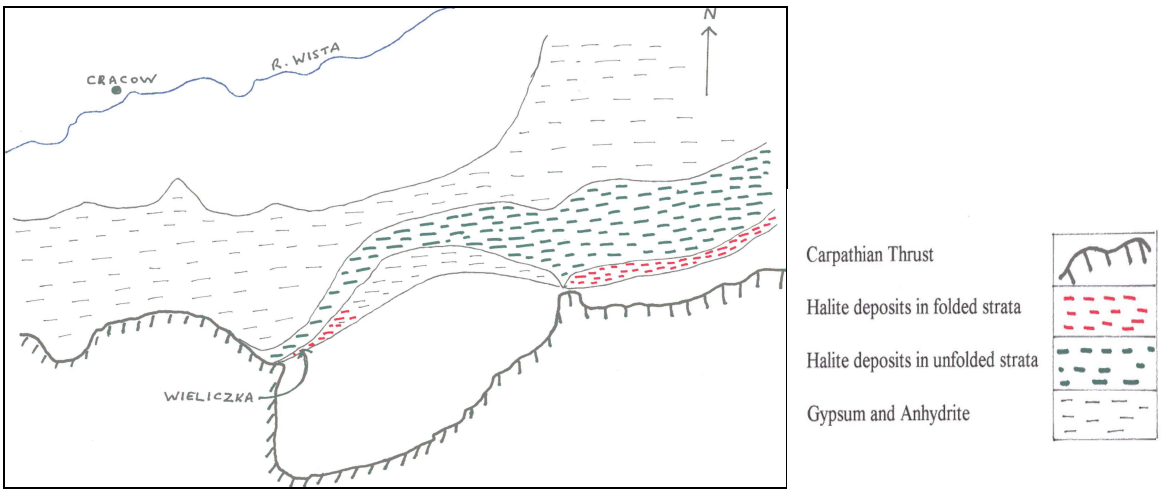


Fig. 5: Distribution of Miocene evaporite deposits near Krakow.

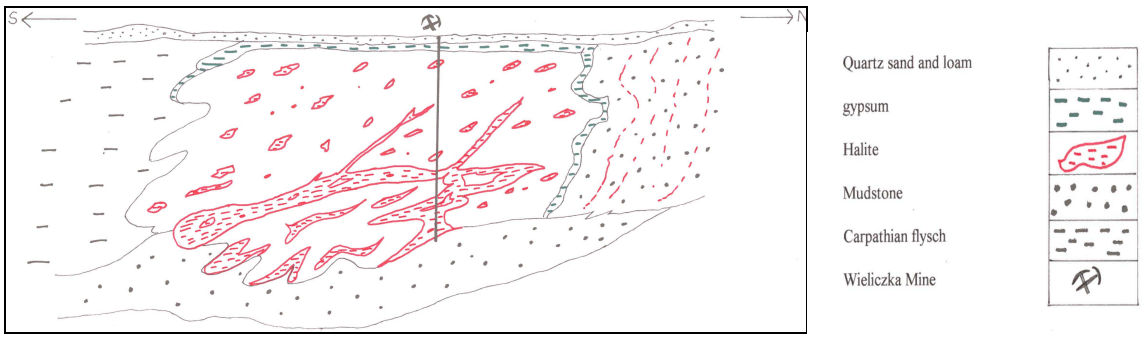


Fig. 6: Geological cross-section of Wieliczka Salt Mine.

Gypsum and anhydrite rocks accompany the salt deposits. The whole salt body is contained in an envelope of gypsum. This is of vital importance because it minimises the ingress of water into the mine. This envelope is thought to be a secondary deposit. Origin of gypsum envelope around the salt deposit (based on W.D. Nesse, 2000: *Introduction to Mineralogy*. Oxford University Press, page 402): When groundwater encounters a salt deposit, halite is dissolved. Continuous dissolution along the margins of the deposit allows a cap of less soluble components associated with halite to accumulate. The cap commonly consists of an upper/outer zone of calcite, transitioning inward to gypsum and then anhydrite. Often sulphur is found at the calcite/sulphate boundary in the cap. Sulphur forms due to oxidation of hydrogen sulphide (H_2S) produced by anaerobic bacteria from sulphides (e.g. gypsum) and hydrocarbons (often accompanying salt desposits). In Swoszowice there are sulphur deposits, believed to be formed by bacterial action on the gypsum, which were mined in the 16th and 19th centuries.

Visit to the Wieliczka Salt Mine

Wieliczka is not unlike many old mining towns in the UK-rather run down, old dirty buildings, railway yards and chimneys. However we arrived in bright sunshine and enjoyed our picnic lunch in the well landscaped gardens in front of the renovated mine museum building. This housed the ticket offices and naturally a gift shop.

The mine, one of the best known tourist centres in Poland for 200 years, currently welcomes more than 700,000 visitors each year. In 1978 UNESCO placed it on the First International List of World Culture and Natural Heritage. Visitor's literature is available in several languages. (Blaenavon mining town in South Wales was given the same status in November 2000).

The normal visitors tourist route in the mine consists of about 20 chambers, connected by about 2 km of tunnels. It is clean and well lit and contains numerous mining exhibits, splendid statues carved in

blocks of salt and even a church. There is also a specialist geology route through the mine where one can see a wide range of geological features. The route passes through about 6 km of tunnels and mine workings, often along corridors whose floor is covered in sticky mud, many flights of stairs and air control doors; these were to be a feature of our visit, being many in number and requiring a considerable push to open. We, of course, had chosen this tour.

After lunch we met our guide, Ms Jadwiga Stecka, the mine hydrogeologist and her two assistants who carried plans, hammers and various testing gear. We were given instructions in the use of breathing apparatus and issued with masks, helmet light, hard hat and blue coat, also an identification tag, so they count us down and, hopefully, up again. It was explained that pockets of methane gas were released into the workings during mining, and this was a serious danger before the mines were properly ventilated. We then descended the workers shaft, probably less salubrious than the tourist shaft, to a depth of 110 m. After a short walk along a timber lined tunnel we reached the first visible exposure of rock and Jadwiga explained the history and geology of the mine.

Salt has been produced in the area since the middle of the Neolithic period (around 3500BC) by evaporating brine springs. Rock salt was discovered in the 13th century and has been continuously mined for 700 years until the last mine was closed in 1997. Up to 200,000 tons of salt were produced per year by 700 miners. Now only 17,000 tons per year are produced from the mine drainage. 200,000 cu m of water are pumped out each year. Jadwiga showed us maps of the salt deposits and mine workings, plus stratigraphic columns. The salt deposits are located at depths ranging from 64 to 325 m. The 700 years of mining have left over 200 km of tunnels, over 2000 chambers, 26 surface shafts and 180 shafts connecting the underground levels. There are probably many others for which there are no records.

Plate 6: Fold structures in salt (1.5 m across picture)

The salt in the upper levels has been fragmented into blocks up to 30 m cubed (100,000 tons!). The salt was a glassy green colour with sedimentary laminations, often showing compression effects in the form of ripples. We observed some clay rich bands, thought to be seasonal inputs by rivers. We noted two adjacent blocks, several metres wide, with bedding almost at right angles to each other, although separated only by a meter wide band of silty gypsum referred to as “Zuma”. Conglomerates were also noted in other places. Our leader explained that often the adjacent blocks of salt appeared unrelated. One can only wonder at the enormous forces, which cause such turmoil within the deposits. There is still controversy as to whether they were produced while the rocks were being deposited or by

subsequent tectonic action. Did the deformation/ brecciation observed in the salt result from synsedimentary downslope movement of the deposits, or younger tectonic processes – thrusting of the Carpathian nappes over the Miocene of the Carpathian Foredeep – or both?.

We then passed through several of the massive, 30 m high chambers, where the most massive timber props, more than 1 m wide and 30 m high gave a cathedral like feel to the place. When the salt was mined, a layer of salt, ideally 1-1.5 m thick was left to support the walls, but huge amounts of timber propping were needed in the chambers and galleries. Piles of logs, several m wide and up to 30 m high, provided support in the middle of the chambers. Fortunately the timber has a long life in the mine, due to the preserving action of the salt.

At this point we entered the “tourist” part of the mine-carved and polished walls, wooden floors in places, larger than life statues carved in salt, shrines, monuments, a church and even a real brass band playing by a lake-and we turned down the tourist trip! Many of these chambers house museums dealing with the salt industry, local natural history and culture. There were markings on the wall where the salt had been mined by wedging blocks up to 2 x 10 x 0.5 m from the wall, which were then chipped into barrel shaped pieces “Balwan” for easy handling, while the chippings were put into barrels for transport. Cutting machines and use of gunpowder were introduced in the 1870s. For hundreds of years miners had to transport the salt themselves. Horses were first used in the mines in the 17th century.

We now left the “tourist” section and visited the large stables area established in the 17th century to house 100 horses. Amazingly, red "bricks" had been meticulously painted onto the stable walls and an ornamental entrance. The area is shortly to be included in the “tourist” route.

We then walked down a number of flights of stairs to a lower level where the rocks are more uniformly bedded. Although the salt beds are much thinner than the blocks at the higher levels, it is much higher quality, being 99.99% sodium chloride. A long paddle in a wet gallery brought us to a site where we could observe stratified salt which had undergone severe crumpling so that bands of lamination 0.5 m wide were beautifully folded into swirls, mini nappes and isoclinal folds, which ran along the ceiling and down the walls. (include a photograph of the folds). When one observes the folding on a km scale in the Tatras and then these here on a cm scale, one is reminded of the saying that every flea has small fleas on its back; i.e. every fold has a fold within it. A more recent discovery of high quality, “ice”, salt below a sandstone layer, which previously had been considered the bottom of the deposit, had brought much pleasure to the miners.

Our final stop was in the Sanatorium-yes Sanatorium. Over the door was “Jezioro Wessel” with crossed spades between the words. This was yet another chamber, this time with a wooden gallery built around it, a wooden floor, swimming pool, table tennis table, and what appeared to be hotel doors. Apparently people with respiratory diseases stay here for considerable periods. The theory being that electrostatic charges develop on the walls and attract particles, such as bacteria and viruses to the surfaces. Hence the air is clean and the patients recover their health.

Throughout our tour of the mine we saw many reminders that geology never stays still. Timber supports collapsing under the enormous pressures reminded us that nature was trying to fill the voids created by man. On the walls various types of salt crystals were being formed. The drainage waters continue to elute salts.

A walk to the base of the “tourist” shaft completed our visit and Jadwiga provided us with copies of the mine sections and the underground geology-a nice present to finish the visit.

When our group of 15 muddy, slightly weary, geologists emerged at the surface, dressed in blue coats, hard hats, battery lights and breathing apparatus we were confronted by some people wanting to take photographs as they clearly thought we were workers! The sun had also been replaced with dark clouds, which duly deluged the area. Some members of the party were seen bartering with a local café owner to borrow a garden table sun canopy to get them back to the coach. We thanked Marek for all his help in making the visit so informative and enjoyable.

The evening was spent in a local hostelry in Zakopane, where the local cuisine and a string band provided excellent entertainment and a fitting end to the visit. The 4 am wake-up call the next morning was not so good, but the travel arrangements went according to plan and we were back in Reading by mid-afternoon, well satisfied with a great visit.

Land Utilisation

Our journey between Zakopane and Krakow gave us an opportunity to observe the various types of land utilisation in Southern Poland and to speculate how this might change as the Region develops, particularly if Poland enters the European Union.

The Tatra mountains, to the south of Zakopane, appear now to be used mainly for recreation. Large areas have been set aside as a Nature Park. The small scale mining activities have long since been closed down. The remaining farmers appear to be increasingly dependent on tourism to supplement their income. For example, we saw numerous horse drawn carts being used to take tourists into the remoter parts of the park (see Day 2 of this visit report). At the edge of the park farmers were selling specialist produce, such as smoked cheeses, to tourists including our party.

The nature parks appear to be organised in a similar way to the American National Parks. Development within the park is strictly controlled, including severe restrictions on vehicular traffic. Hundreds of kilometres of paths have been laid down and are well signposted and maintained. It was noted that large numbers of Polish families, as well as more serious hikers, were walking many kilometres into the park, away from the car parks and bus stops carefully placed at the park entrances. It will be interesting to see how the cost of maintaining the parks will be met in the future, as labour costs increase. Currently there is only a nominal entrance charge to the parks.

There are some skiing areas within the park, but much of the newer development is on the slopes of hills just outside the park. Zakopane is now clearly dependent on tourism for much of its wealth. The area appears well placed to meet a growing demand for both summer and winter recreational activities.

There are many small scale farms in the region between Zakopane and Krakow. They reminded one member of our party of the small farm he was raised on in the north of England during the 1950s and early 60s. Crops grown include grass, cereals, maize, sunflowers, potatoes and some vegetables. Most fields are very small, often strips only about 10 m wide and no more than 150 m long. Single rows of cereal stooks ran along the fields. Only a few very small, about 2 m wide, combines were seen. Grass was being raked up by hand and hung on stick frames to dry. Cattle were tethered in ones and twos in the small fields. It was noted many of the people, both men and women, working in the field were relatively elderly. Clearly, this is a type of farming that would not survive in the more competitive environment of the European Union. Many of the younger people will leave the land for better-paid, less arduous, work in towns and cities. Those remaining will probably become part time farmers, supplementing their income from other sources, such as tourism or working in local factories. There was much evidence of development, including upgrading of the main road, factories and the inevitable new car show rooms. Reforming the land holdings into large commercially viable farms will be very difficult. Social welfare payments to support the ageing farm population will be major political issue. Some of the more remote areas will inevitably be depopulated. As with all changes, some people will see them as beneficial, while to others they will be a threat to traditional ways of life.

Plate 7: Farming Landscape

Reported by David Riley, Irene Davison and David Ward

Day 6, Monday 28th August

Chocholowska Valley Walk

Whilst the majority of group members visited the Wieliczka salt mine (fully described elsewhere), a smaller number of us preferred to spend our last day in a final scenic walk instead of the long time sitting in a coach (bearing in mind the sedentary nature of the journey back to the U.K. early next day).

So six of us, plus Pete, a British friend of Anya, were dropped at the entrance to the most westerly valley of the National Park – Dolina Chocholowska. This walk was non-guided and we had no geological briefing. It was less strenuous compared to previous days' sometimes steep and very rough paths. However it was the longest walk of all, about 16 km (10 miles) north to south and return, mainly on a flat, stony surface. Going at a slightly slower pace than on previous days, we were able to look at and identify (with expert aid from one of our group) the varied flora. Using the small-scale geological map included in the handout, plus the excellent 25,000 scale topographic map bought in Zakopane, we were able to pick out some geological and geomorphological features of interest, although the general sequence was generally similar to those seen on previous days. The accompanying sketch map (Fig. 5) shows our route and a slightly simplified version of the geology shown on the handout map.

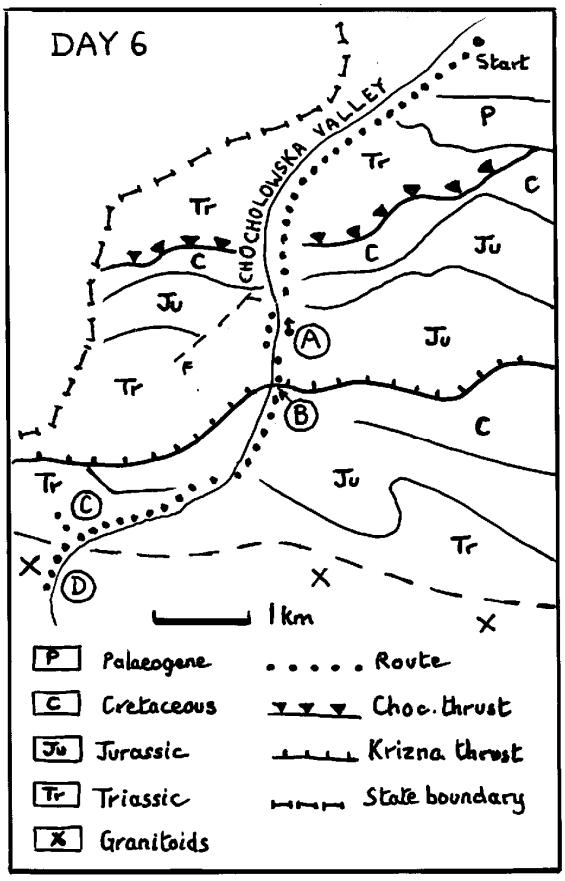


Fig. 7: Sketch map of Chocholowska Valley walk

The Park entrance was about 1 km north of the park boundary, which coincided with the mapped position of Palaeogene deposits. However here the valley was wide and flat, covered by post-glacial river flood plain and terrace deposits, with pastureland and cattle and sheep shelters. Without straying from the track, we were unable to identify any Palaeogene exposures that may have been visible along the riverbanks at a distance from the permitted route.

Walking south, the valley soon closed in, often with precipitous sides, as we passed through a series of steeply dipping dolomites and occasional limestones (the latter only recognised with the aid of an acid bottle). These rocks were mapped as allochthonous Triassic (Regle Series) carbonates of the Choc Nappe. This Nappe had not been encountered on previous days, and is mapped as being thrust over the Krizna Nappe - the sketch map shows the position of the basal thrust. Where bedding could be recognised, the rocks were often quite thickly bedded. As in previous days, much of the sequence was featureless and few sedimentary structures were observed nor any fossil evidence seen, due again to the intense structural deformation that these rocks had suffered.

Continuing south, we passed through a monotonous vertical sequence of allochthonous carbonates within the Krizna Nappe. About 3.5 kilometres from the start, a large karst spring issuing from a cave at ground level alongside the route was visited, called Chocholowskie Wywierzysko. See location A on sketch map (Fig. 5). The topographic map gives a flow rate of 500 l/s. Does this figure imply a constant flow rate through the year due to an underground flow restriction despite water table changes

at a much higher level, or is it an indication of the maximum flow rate? (*Note: On day 1, we saw another major karst spring named Lodowe Zrodlo, where the flow is given on the map as 600 l/s).*

A short distance further on, the near-vertical (?) rocks on the other side of the river appeared to be very disturbed and contorted. In particular, a partly protruding mass of dolomite (or limestone) appeared to be extremely well smoothed on the underside along a very low angle but gently curved surface which cut across all the other irregular sedimentary features – see photograph.

Plate 8: Trace of low angle thrust planes?

Other less distinct curved planes seemed to extend upwards at an angle to this unusual structure. On our side of the river, an irregular and nearly vertical layer of coarse brecciated dolomite was seen at ground level. This location, marked B on the sketch map (Fig. 5), coincided with the mapped position of the base of the Krizna Nappe. So it will be interesting to discover whether the low angle structure described was tectonic in origin. Also, to know if it provided evidence of a major thrust zone. *(The writer has no experience of mapping tectonic features that characterise highly deformed carbonate rocks!).*

From this point, the geological map showed that we were walking south through a near-vertical succession of autochthonous Cretaceous, Jurassic and Triassic carbonates and marls of the Wierchy Series. There seemed to be little superficial difference in the appearance of these rocks compared with the overthrust allochthonous sequences above, and we did not closely examine the exposures along the track.

After another 3 kilometres, and a short diversion to view a small chapel at Sw. Jana Chrzciciela, we reached the southern end of the recommended walk. The valley at this point was considerably wider, mainly due to glacial action as shown by the various meandering ridges and humps of moraine debris. These had in part been destroyed by subsequent river erosion and deposition of terrace deposits. The surrounding very steep sided valley walls again were surmounted by the now familiar but still very dramatic karst scenery consisting of sharply pointed rock pinnacles.

A tourist building at location C provided a resting place for our picnic lunch (inside, due to the extremely persistent wasps outside). As the map indicated that crystalline basement was exposed just a little further south alongside the river, four of us went in hopeful search as far as location D. However, only fluvial and glacial debris comprised of eroded fragments of the granitoid basement were found and we returned disappointed without any ‘in-situ’ specimens. After rejoining the others, we commenced the long walk back north to the pick-up point, where a minibus met us.

Reported by Gordon Hillier

The alternate venue was visited by 6 members of the party (plus Pete, Anya's boyfriend, who took care of the arrangements), who had opted out of the visit to the salt mines. We were transported by taxi/minibus to the boundary of the National Park, where we started walking after Pete had bought the entrance tickets.

The venue was the Chocholowska Valley (Chocholowska Dolina), which is approximately 4 km to the west of the Koscieliska valley visited on the previous Wednesday, and is very similar geologically. The valley is also very popular with the Poles, and is well served in the way of easy way-marked routes, with the benefit of a public transport system (of sorts) running up the lower part of the valley. The transport consisted of a tractor disguised as a steam engine, which pulled a couple of carriages - the only thing lacking (which would probably have been there if it were in England) was a "Thomas the Tank Engine" face on the front of the tractor! There were also opportunities for bike hire at the boundary of the National Park.

The beginning of the walk was a fairly broad open valley, following the metalled road south-west across the Eocene deposits at the base of the Tatras. There were no exposures, and most of the area formed pasture for cattle and sheep. After about 1 km, the valley started to narrow and, as the road approached the river, there were exposures of Triassic dolomite and/or limestone cliffs and crags visible to the west. (The Jurassic limestones seen at the entrance to the Koscieliska valley do not occur, as the Jurassic is missing at this location. The underlying structure is similar, however, in that the rocks form part of the Regle series, as seen in the Koscieliska valley.) Shortly after this, there were also exposures of craggy dolomites to the east, as the valley narrowed yet further. We continued heading south-west up the narrow valley for about 1500 m, before the valley veered to the south, and started to open out. At this point, exposure of shales and sandstones were visible in the stream bed and the banks of the stream, indicating that the reason for the "opening out" was that the softer rocks had been eroded more than the limestones and dolomites.

Following the metalled track for another km brought us to the end of the track, and a further closing in of the valley, with a change to limestone cliffs rather than dolomite. This was evidenced by the appearance of many small solution holes in the rocks at the base of the cliffs with a portion of the stream disappearing into them. The cliff near the track at this point carried a plaque commemorating the visit of the Pope (in his days as Cardinal Wojtela), as well as a memorial to a Leopold Komitowicza (however, not understanding the Polish, the reason for the memorial escaped us!). Just around the corner from this cliff, the path crossed a small stream which arose from a karst spring about

Plate 9: Thrust Zone

50 m from the track. As with other karst springs, the water originated in valleys to the east, and followed the east-west line of flow commented upon in other localities.

The track was followed for a further 500 m saw us still in the Triassic, with massive dolomite cliffs to the left and pillars/ crags to the right (west). The valley narrowed once more before opening out away from the river. Examination of the rocks in the river bed showed that there were thinly bedded shales and sandstones present, although the dolomite crags and pillars were still much in evidence on the western side of the valley. A probable thrust zone was identified (Plate 8), where the dip in the rock was very variable, and many of the strata seemed to be broken and distorted. At this point, there were sandstone boulders in the stream bed and massive limestone or dolomite cliffs above.

The track then started to ascend more steeply and to veer to the west, as the valley opened out into an area showing all the features of a glacial moraine. Assorted boulders, including crystalline rocks, limestones and dolomites were visible in the stream bed and the track. The underlying rocks in the area between the stream and the cliffs were covered with grassy vegetation, and were not visible. Rounded hills, typical of the nappes of the Regle series, were visible to the south of the track. A small chapel, apparently a point of pilgrimage for the local population, was located near the northern edge of the moraine. A paved track ran up to the chapel, and then continued as a grassy track to form part of the footpath network, leading over the hills to the north. We detoured up to the chapel, then followed a minor track to the local “mountain hut” for lunch/refreshments. A small sub-group of the party attempted to find the boundary between the Choc nappe and the overthrust (Giewont?) nappe of the Wierchy series. This boundary was indicated on the map as being just to the south of the mountain hut but there was no sign visible “on the ground” to the members of the party. As the track crossed an area covered by the glacial moraine, it was likely that the contact zone was hidden, and that one needed to leave the glacial moraine and examine the base of the cliffs in more detail. However, there was insufficient time to do this.

After lunch, we retraced our steps back along the main track, eventually returning to our starting point to be picked up by minibus at about 4 pm.

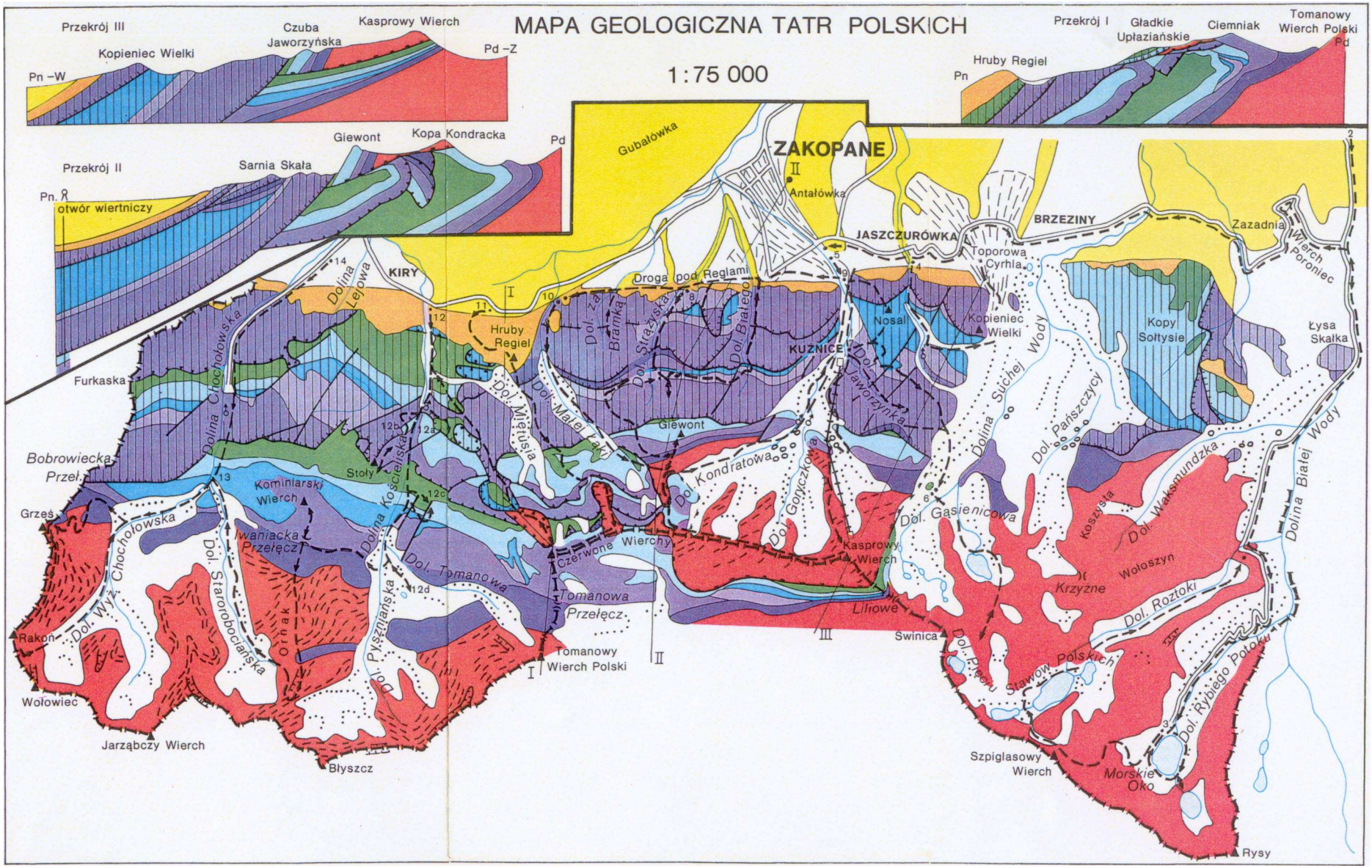
Reported by Malcolm Iosson

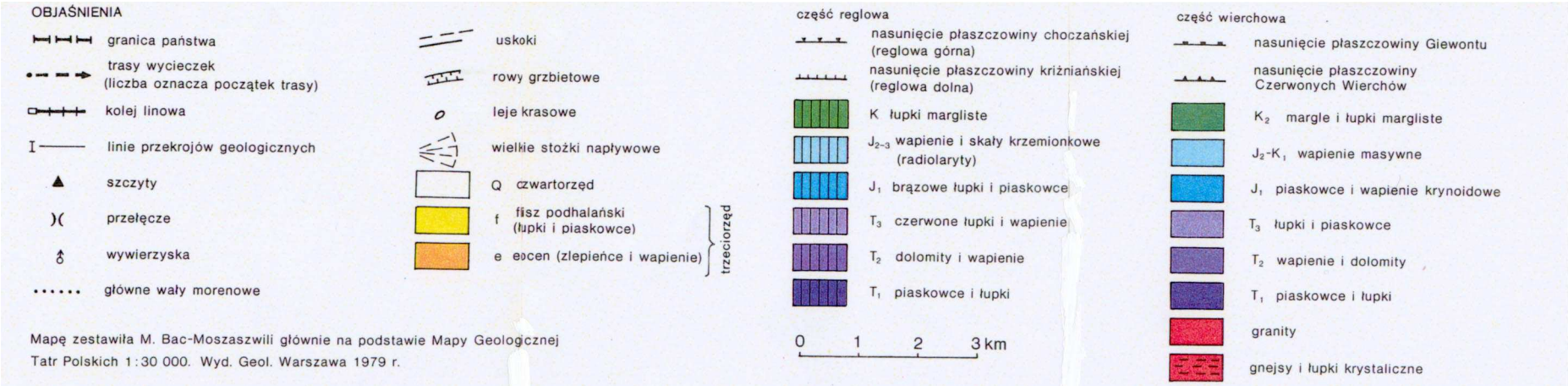
Evening

Later in the evening, the entire party were taken to a local hostelry, complete with stags and bear heads, antlers and stuffed unidentified animals where excellent food, drink and music, plus many discussions on the week passed the evening pleasantly.

Reported by David Ward

Geological Map of the Polish Tatras





EXPLANATIONS
The following entries correspond to the entries in the Geological key above

		Regle Series	Wierchy Series
state boundary	faults	Choc nappe thrust	Giewont nappe thrust
geological trips	crustal grabens	Krizna nappe thrust	Czerwone Wierchy nappe thrust
mountain railway	karst funnels	K - Cretaceous (marly shales)	K_2 - Upper Cretaceous (marls and marly shales)
cross sections	great alluvial fans	J_{2-3} - Middle and Upper Jurassic (Limestones and radiolarites)	J_2-K_1 - Middle Jurassic to Lower Cretaceous (massive limestones)
peaks	Q - Quaternary	J_1 - Lower Jurassic (brown shales and sandstones)	J_1 - Lower Jurassic (sandstones and crinoid limestones)
passes	f - Podhale flysh (shales and sandstones)	T_3 - Upper Triassic (red shales and limestones)	T_3 - Upper Triassic (shales and sandstones)
karst springs	e - Eocene (conglomerates and limestones)	T_2 - Middle Triassic (dolomites and limestones)	T_2 - Middle Triassic (limestones and dolomites)
main moraines		T_1 - Lower Triassic (sandstones and shales)	T_1 - Lower Triassic (sandstones and shales)
			granites
			gneisses and schists

Glossary

English	Polish (Phonetic pronunciation)
1	Yeden
2	Dvar
3	Tchee
4	Chterry
5	Pyench
6	Shair shch
7	Shedem
8	Awshem
9	Jev yench
10	Je shench
50	P yen je shont
100	Staw
1000	Tea shonts
(do not) Understand	(Nye) Raw zoo myem
Vegetarian dish please	Yar skair dan je prosher
Hallo	Jane Dough Brie
Goodbye	Daw ve Dzen Ya
Good evening	Dobry Vairchur
Please	Prosher
Yes	Tack
No	N ye
Thankyou	Jane ku Y air
Tea	Hairbaatah
Coffe	Kaa Vah
Milk	Mlayko
Sugar	Tsookair
Beer	Pea vo
Coke	Kola
Tonic	Tonnek
Orange Juice	Paw mar anchowy sock
Water	Voda
Cherrv Vodka	Veesh nuf ka
Clear Vodka	Chistah Vudka
Where is?	G dje yest?
How Much?	Eele Koshtwoye?
Sorry	Psher prah sham
Bus station	PKS
Train Station	PKP
Ticket	Bee let
Toilet	Toyaletta
Ladies	O Gents

Polish	English
kwarcytyczny	quartzite
margle	marl
piaskowce	sandstone
lupki	shale
wapienno	limestone
granit	granite
pegmatytowy	pegmatite
muskowit	muscovite
kwarc	quartz
granitognejs	granitogneiss
migmatyt	migmatite
lupec	schist
brekcja	breccia
korali	coral
jaskinia	cave
martwice	travertine
borsuk	badger
lis	fox
niedzwiedz	bear
widlydognoju	wooden fork