W Gasthof Fürberg besteht das hügelige Wiesengelände aus Sandsteinen (Gosau?).

Die Kirchsteinkalkzone SW Himmelspforte sind nicht weit gegen E verfolgbar, hier liegen Hierlatzkalke und Plattenkalke vor.

Die Plattenkalke E Sommerau (B. PLÖCHINGER) sind Kirchsteinkalke.

Die Kirchsteinkalke sind am Südrand des Münichsees weit verbreitet.

Bericht 1986 über geologische Aufnahmen im Quartär auf Blatt 65 Mondsee*)

Von DIRK VAN HUSEN (auswärtiger Mitarbeiter)

Neben ausgedehnten Revisionsarbeiten wurden nur die Spuren der Lokalvergletscherung um die Eisenauer Alm und das Gebiet westlich der Vöckla kartiert.

Um die Eisenauer Alm ist eine Abfolge von Moränen erhalten, die von den Eiszungen aus den Karen des Suissen- und Mittersees abgelagert wurden. Den höchsten Eisstand zeigt der mächtige N–S streichende Wall östlich Weinkogel (Weg von der Alm auf den Schafberg) an, der die westliche Begrenzung des Eisstromes markiert. Zu dieser Zeit waren die Lokalgletscher mit dem Eisstromnetz des Traungletschers verbunden, aus dem nur die Ackerschneid und der Hügel nördlich Buchberghütten als Nunataker herausragten. Dieser trägt eine ca. 15 m mächtige Kappe aus Konglomeraten, die aus mäßig gerundeten Komponenten bestehen, von denen einige bereits Verwitterungserscheinungen zeigen. Es dürfte sich dabei um einen Eisstaukörper aus der Abschmelzphase der Rißeiszeit handeln.

Einen bereits wesentlich kleineren Eisstrom markiert die mächtige Moräne, auf der die Hütten der Eisenauer Alm stehen. Er zeigt gemeinsam mit den Wällen auf dem Rücken westlich des Grenzgrabens einen Gletscherrand an, als beide Eisströme noch vereinigt, aber bereits wesentlich stärker zum Ackergraben hin orientiert waren.

Aus den ersten Abschmelzphasen dürften dann noch die deutlichen Wälle südlich des Weges Eisenauer Alm, Oberacker Alm (Kote 1003 m) sein, als beide Zungen bereits getrennt waren. Dieser Zeit sind auch die Wälle im Grenzgraben zuzuordnen. Die letzten Spuren der Eiszunge aus dem Suissensee Kar sind die Wälle, die das kleine Zungenbecken südlich der Jagdhütte umschließen.

Im Bereich des Vöcklatales wurde der Rißgletscher in der Zellerseefurche in drei Lappen geteilt. Der erste überströmte den Sattel beim Hochmoos, der zweite die breite Mulde bei Haslau nördlich des Lackenberges, und der dritte drang nördlich des Kogler Berges bis gegen Langholz – Obermühlham vor. Dieser hinterließ einen breiten Wall, der von Hochfelder über Mazlröth – Hochfeld bis Unterreith zu verfolgen ist und mit einer Sanderschüttung ins Vöcklatal verbunden ist. Ihm vorgelagert sind noch Reste von Moränenwällen bei Obermühlham und nördlich der Bahn bei Mazlröth, die einem etwas größeren Stand angehören dürften, ohne aber mit einer erkennbaren Sanderschüttung verknüpft zu sein. Beide Wallgruppen tragen eine ca. 1–2 m mächtige Verwitterungsschicht ohne Karbonate, die dunkelbraun gefärbt ist und diese Ablagerungen deutlich von den jüngeren Niederterrassen und den wesentlich stärker verwitterten Moränen bei Reitzing und Pölzleiten abgrenzbar macht.

Die Eiszunge bei Haslau schüttete die weit geschwungene Moräne Radlhof – Golau auf, wodurch der Haltgraben zu seinem eigentümlichen Verlauf gezwungen wurde. Die Fortsetzung dieses Walles stellen die Wälle bei Breitenau – Vormoos dar. Äquivalente zu dieser Moräne sind die Wälle bei Oberholz – Jagdhub, die sich nach einer kurzen Unterbrechung noch nach Süden in einer deutlichen Staukante fortsetzen. Diese Wälle führen neben den Flyschgeschieben 20–30 % kalkalpines Material, das oft stark korrodiert ist (die Mächtigkeit der Verwitterungsschwarte konnte nicht beobachtet werden).

Mit diesen Wällen ist der steile Übergangskegel nördlich Mühlbauern Säge und Angern verknüpft, der nach anfänglich steilem Gefälle und unruhiger Oberfläche in die flachere, glatte Hochterrasse Schlag–Schwendt übergeht.

Die kleinste der drei Eiszungen entwickelte sich über dem Sattel beim Hochmoos. Sie reichte bis ca. 400 m südlich der Vormoos Mühle und hinterließ den deutlichen Wall bei Ebnat und äquivalente Sedimente östlich der Vöckla. An diese schließt eine Hochterrasse an, die bis über die Vormooser Mühle zu verfolgen ist. Durch die Erosion der Vöckla ist in dem breiten solifluidal überformten Moränenwall eine ausgedehnte Massenbewegung entstanden, die wahrscheinlich noch nicht zur Ruhe gekommen ist.

Blatt 67 Grünau im Almtal

Bericht 1986 über geologische Aufnahmen in den Nördlichen Kalkalpen auf Blatt 67 Grünau im Almtal

Report 1986 on Geological Mapping in the Northern Calcareous Alps on Map Sheet 67 Grünau im Almtal

Von OLE GRAVERSEN, KIM ZINCK JØRGENSEN, CHRISTIAN KRÜGER & JENS SØLLING (auswärtige Mitarbeiter)

In 1985 a mapping program was established in the Northern Calcareous Alps in the Grünau area by Institut for almen Geologi (Institute of General Geology), University of Copenhagen, involving a group of undergraduate students (* = Diplomkartierungen). Two mapping areas are situated south of the Cretaceous Flysch Zone:

1) Hauergraben – Zwieseleck (J. SØLLING*)
2) Kasberg (C. KRÜGER*)

while two areas ESE and NE of Grünau cover the Grünau Halbfenster (Flysch) and the adjoining part of the Northern Calcareous Alps to the south and north:

3) Geißstein – Schindlbach – Brenntbach (K. Z. JØRGERSEN*)
4) Tissenbach – Hochsalm (O. GRAVERSEN).

For the areas 1, 2 and 3 the mapping program was completed in the summer 1986.

The early mapping of the area was published in the map sheet Kirchdorf (1 : 75.000) by GEYER & ABEL (1913). Later more detailed studies covering the areas now under investigation are published by GASCHE (1938), KIRCHMAYER (1956, 1957), PREY (1950, 1953) and WEBER (1960).

The following account of the geology is based on field observations made in 1985 and 1986 and names are given according to correlations with the current nomenclature of published sections and maps in the Northern Calcareous Alps (ZANKL, 1971; PLÖCHINGER, 1980).

The following main bed rock units have been established in the area (listed in descending order):

Quaternary
Flysch
Oberalmer Schichten/Schrambachschichten
Plattenkalk
Hauptdolomit
Wettersteinkalk
Wettersteindolomit
Reiflinger Kalk
Gutensteiner Kalk

Furthermore minor outcrops of Gosau sandstein, Tressensteinkalk and Helvetikum, only occurring within a single area, are described in the presentation of each area.

Gutensteiner Kalk

Gutensteiner Kalk is a dark, mostly bituminous, wellbedded limestone alternating with subordinate marl bands. The lithology varies from a bituminous mudstone, which is the most frequent facies, over paler wackestones and packestones to a grainstone composed entirely of echinoderm fragments. Most of the limestone beds have developed a network of stylolites.

In the Gutensteiner Kalk occur several 10–40 m thick intervals characterized by different bedding types. The transitions between these intervals are normally gradual over a few meters, but abrupt changes occur. The bedding types vary from thin (1–3 cm) laminated limestone alternating with mm-thin marl bands, to thicker bedded (5–20 cm) massive limestone alternating with marlbeds of c. the same thickness. In places the marl is missing and the beds are then defined by dissolution and non-deposition surfaces. The bedding may further vary from fine bedded nodular dark limestone with small druses, and flint and dolomite concretions alternating with thin marl bands, to more massive (1–3 cm) nodular limestone. The rock is at certain horizons very fossiliferous with reference to bodyfossils, particularly echinoderms and brachiopodes, as well as tracefossils e. g. *Thalassinoides*.

The Gutensteiner Kalk reaches a maximum thickness of c. 400 m, but this unit is cut by several thrusts, so the true stratigraphical thickness is expected to be much less.

Reiflinger Kalk

The lithology of the Reiflinger Kalk is largely similar to the upper part of the Gutensteiner Kalk. It is a nodular, dark, partly bituminous limestone with chert nodules in the lower part.

From a mapping point of view the boundary between Gutensteiner and Reiflinger Kalk is defined as the first occurrence of large chert nodules. A stratigraphical more correct boundary should presumably have been defined lower in the Gutensteiner Kalk sequence.

The chert rich layers locally alternate with marly crinoid and brachiopod limestone. This facies is followed by fine bedded, nodular limestone having varying darker and paler bedding and lacking chert nodules. 20–30 m above the first chert nodules, greenish, marly laminae between beds have been observed.

Wettersteinkalk

This rock unit varies from an unfossiliferous micritic limestone over an algae-bearing packestone to a coral grainstone. Since different facies occur in each area, a more detailed description will be given by each in the individual areal descriptions.

Wettersteindolomit

This unit is entirely uniform and consists of a massive, white to pale grey dolomite having a characteristic sugary appearance. Locally dark impurities (clay?) occur in small fractures. The unit has no bedding except for the lowermost 5–6 m on the boundary to the Reiflinger Kalk.

Hauptdolomit

A major part of the mapped area is covered by a thick dolomite unit. A total thickness of at least 600 m has been observed at some places. Because of thrusting and locally intense mesoscale folding within the unit, the stratigraphic thickness is likely to be less. The colour of the rocks is mainly pale brown to grey, but darker beds also occur. The dolomite rocks are often well bedded with individual beds ranging from c. 10 cm to 2 m in thickness. Stylolites occur both within single beds and along bedding boundaries. In some places individual beds may show lateral outwedging. Sedimentary structures within the beds are mostly lacking, probably caused by the dolomitization of the unit. At some outcrops well preserved sedimentary structures are observed. Sometimes the bedding types seem to alter in a cyclic manner. Each cycle starts with a 10–30 cm thick, erosive, greenish conglomeratic bed with intraclasts and shell fragments. The conglomeratic bed is often succeeded by a 1–4 m thick sequence of pale to dark grey vuggy dolomudstones containing shell fragments. Thereafter follows a 1–3 m thick sequence of algal laminated birds-eye dolomite. Sometimes small erosive channels containing intraclasts fillings cut the lamination. The colour ist mainly pale grey to white, but dark grey (organic rich?) laminae occur. A 1–3 cm thick greenish clay horizon terminates each cycle. We propose that this cyclic behaviour of bedding types could represent a dolomitic version of Lofer cycles (FISHER, 1964). In many outcrops only two of the above mentioned bedding types are present, namely the massive dolomudstone and the algal laminated birds-eye dolomite.

At the upper levels of the dolomite unit intercalations of pale grey limestone beds and limestone nodules in the dolomite tend to become frequent.

Rocks of this unit may show intense fracturing and any bedding is impossible to recognize.

In agreement with earlier mapping in this area the dolomite unit is correlated with the Hauptdolomit.

Plattenkalk

The Plattenkalk unit consists of pale greyish brown to nearly white limestone beds alternating with dolomite beds. The latter vary from massive speckled beds to finely irregular laminated beds. As in the upper part of the Hauptdolomit thin irregular layers of clay randomly

occur in the sequence. They are believed to terminate Lofer cycles being soil horizons. The transition from almost pure dolomite to nearly pure limestone within the Plattenkalk is gradual. The boundary to the Hauptdolomit has arbitrarily been chosen where the occurrence of laterally persistent limestone beds constitute more than c. 50 percent of the rock (in a vertical scale).

Fossils are abundant, especially Megalodonts in varying sizes are commonly observed.

In general the Plattenkalk outcrops in synclines on the ridges. However, in some areas the Plattenkalk is emplaced along steep thrustfaults.

Flysch

An association of clastic sediments has been observed in the north eastern part of the mapped area. The unit consists of rapidly changing lithologies of mainly pale grey marls and sandstones with minor layers of shales and clays. The sandstones are often lime and mica bearing; the weathering colours are typically in grey to brown and reddish brown shades.

During the mapping the flysch association has been treated as a single mapping unit. This flysch unit is of Cretaceous age and outlines the Grünau Halbfenster.

Oberalmer Schichten / Schrambachschichten

The unit consists of brecciated massive pale grey to greenish grey and reddish brown micritic limestones. Thin sections of the rocks contain large numbers of Calpionellids. One species has been identified as a *Calpionella alpina*. In agreement with the earlier mapping in this area, and on basis of the observed Calpionellids, these limestones are correlated with the Oberalmer Schichten/Schrambachschichten of upper Jurassic to lower Cretaceous age. Rocks belonging to this unit have been observed in a single road exposure on the Falkenmauer ridge in the north eastern part of the mapped area.

Quaternary

In the Quaternary cover the following deposits have been distinguished: Alluvium, moraine, gehängeschutt, hangbreckzie, bergsturz and landslide.

Alluvium

Deposits of this unit cover the floor of the main valleys in the area, the Almtal and the valleys of Grünaubach and Schindlbach. The alluvium is often bordered by river terraces. The deposits are mainly coarse grained fluvial gravels with clasts almost entirely derived from the local limestone units.

Moraine

Occurrences of moraines are mostly restricted to gentle slopes leading down to the valleys. The moraines are mostly coarse grained with only a little content of fine clastic material. Like the alluvium, the moraine contains mostly limestone clasts.

Gehängeschutt

Deposits of this unit are observed on the slopes of the hills and in minor gullies in the whole area. The deposits are composed of coarse grained gravels, individual clasts are very angular. The lithologies of these clasts correspond very closely to the lithologies of nearby underlying bedrock in almost all cases. The fractured Hauptdolomit rocks are easily weathered out, the gehängeschutt deposits are therefore very frequent in areas of this bedrock unit. The gravels contain very little fine grained matrix. Because of the similarities in lithology it can be difficult to distinguish between deposits of this unit and the moraines. It is assumed that boundaries between the two units can be transitional.

Hangbrekzie

The hangbrekzie is distinguished from the gehängeschutt by the calcite cementation of the hangbrekzie. The occurrence of the hangbrekzie is similar to the gehängschutt. Transitional deposit types to gehängeschutt have been observed at several places.

Bergsturz

Deposits of this unit have been observed beneath steep slopes. Individual rock fragments are often very large (m size). These deposits also show transitional deposit types to the gehängeschutt unit.

Landslide

Landslides have been recorded only from areas where rocks of the flysch unit are present in the bedrock.

Structural relationships

Fracturing and minor faulting and thrusting of limestone- and dolomite rocks are important components of the deformation pattern. Brittle deformation tends to be more frequent in dolomite rocks than in limestone rocks, probably due to a greater competence of the dolomits. This is clearly demonstrated at fault/thrust controlled boundaries between e. g. the Hauptdolomit and the Gutensteiner/Reifinger Kalk units. Close to these boundaries intense cataclasis of the rocks of the Hauptdolomit is seen, whereas the primary beddingplanes of rocks of the Gutensteiner/Reiflinger Kalk units are preserved intact. In some places minor thrusting without cataclasis is seen within the Hauptdolomit unit, but only in connection with thin clay beds acting as décollement planes.

Complete dolomitization is often observed in rocks bordering thrust/fault planes within pure limestone units. It may be assumed that cataclasis along shearzones favours permeation of Mg-rich brines, thus giving rise to a late dolomitization of the limestone rocks.

The general orientation of folds of the mesoscopic scale is given by a roughly east-west trend of foldaxes, plunges are gently towards both east and west, generally less than 15°. Mostly the folds are of the flexural slip type. Wavelengths vary from decimeter size to tens of metres, much depending on the local average thickness. E. g. finely bedded rocks of the Gutensteiner Kalk unit often show intense small scale folding (dm size), whereas the smallest fold wavelengths seen in Hauptdolomit rocks are about 2 to 5 m.

Interference with a more weakly pronounced north-south trend of foldaxes is seen in some places. In still other places no obvious trend of axes is seen at all. The folds are often asymmetrical showing northern vergence, which is in agreement with a general northerly direction of tectonic transport.

Hauergraben – Zwieseleck

(SØLLING)

The area is located west of Almtal, south of Hauergraben – Lainaubach and north of Kleiner Karbach – Gasslkogel. The stratigraphic units recognized in this area are the Gutensteiner Kalk (tmg), the Reiflinger Kalk (tmr), the Wettersteinkalk (twk), the Hauptdolomit (td) and the Plattenkalk (tdk). Furthermore the Jurassic

Tressensteinkalk (itr) and the Cretaceous Gosau Sandstein (krs) outcrop to the west.

Topographically the area is dominated by east–west striking ridges and valleys although this pattern is less obvious to the west where the Wasserkogel – Schnellerplan ridge strikes north–south.

The Hauptdolomit represents more than fifty percent of the bedrock within the mapped area. Primary sedimentary structures, including lamination and birds eye structures, are only locally preserved, and the Hauptdolomit appears mostly massive with a pale yellowish colour, though it might be white and sugary. The latter ist ovserved in the Vorderer Rinnbach Valley, where bedding is completely lacking. In Vorderer Rinnbach Valley and further south the stratigraphically highest part of the Hauptdolomit is present. This is recognized by intercalations of limestone beds and marly layers which increase in number upwards until the Plattenkalk takes over. North of Vorderer Rinnbach pure dolomite makes up the Hauptdolomit, probably representing a lower stratigraphic level.

To the north the lowermost stratigraphic units, the Gutensteiner Kalk, the Reiflinger Kalk and the Wettersteinkalk have been thrusted on top of the Hauptdolomit at Zwillingskogel. The Gutensteiner Kalk and the Reiflinger Kalk have been mapped as one unit owing to the poor quality of outcropping. Lowermost in the sequence the rock is dark, commonly bituminous and with thin well defined bedding.

The Reiflinger Kalk is recognized in the upper part of the sequence by nodules of chert and dolomite in a dark limestone becoming paler upwards.

Near Grünau a variant of the Reiflinger Kalk, the Raminger Kalk, has been observed. It is characterized by bands of chert in a pale dolomitic limestone, but as it is only observed once, it has been included in the lower part of the Wettersteinkalk exposed at Wiesleithen.

The combined sequence of Gutensteiner Kalk and Reiflinger Kalk reaches a total of 550 metres in thickness to the east of Zwillingskogel but tectonics are likely to be responsible for some repetition within the sequence.

Ammonites (*Balatonites* c. f. *balatonicus* MOJS.) have been reported (E. GASCHE, 1938 in A. TOLLMANN, 1976, p. 79) in Hauergraben to the north dating the lower part of the sequence, the Gutensteiner Kalk, to Middle Anisian.

The Wettersteinkalk makes up the top of Zwillingskogel and can be traced along the ridge to Hochkogel in the west. It is mostly a massive pale rock but poorly defined bedding occurs. Crinoids have been observed north of Gsolberg but mostly the limestone is unfossiliferous.

To the south the Plattenkalk outcrops as synclines on top of the Mangstlberg – Kiesenberg and Zwieseleck – Gasslkogel ridges. A stratigraphic sequence of more than 500 meters of Plattenkalk is measured at Tennalm with no sign of repetition. The limestone is well bedded with a greyish colour and contains numerous fossils including small megalodonts. A slightly different limestone, rich in giant megalodonts, is present in the bottom of the Vorderer Rinnbach Valley. Omission surfaces are here revealed by a red or green colouring. This unit is bounded by faults to the north and south and dips gently (7–8°) to the east. The southern syncline at Schnellerplan outcrops with an axis dipping of 20–30° to the west, while the northern syncline at Mangstlberg is subhorizontal to gently eastdipping.

To the west of Wasserkogel a major fault parallel to the Traunsee cross cuts the area and much younger rock units are exposed to the west.

To the north, just west of Hochkogel, Hauptdolomit is in contact with Cretaceous Gosdau Sandstein. Though poorly exposed it is readily recognized being an arenaceous dark bluish limestone weathering out reddish. It can be traced to the mapsheet to the west covering the Traunsee area. To the south this Cretaceous unit is bounded by a pale massive limestone. It is brecciated eliminating any former bedding. On the map sheet to the west covering the Traunsee area the Gosau is bounded to the south by the Jurassic Tressensteinkalk indicating that this is also the case here.

Structural description

The area is dissected by faults/thrustfaults dividing the area into four tectonic units.

At Zwillingkogel the most prominent structural feature, a major thrustfault has brought Lower Triassic rock units on top of Middle Triassic Hauptdolomit. The thrustfault runs along the Zwillingskogel – Hochkogel ridge and has a dipping of c. 60° to the north. Going west the thrustfault cuts up through the stratigraphic sequence, Gutensteiner Kalk, Reiflinger Kalk and Wettersteinkalk only leaving Wettersteinkalk at Wandlkogel and Hochkogel. The thrustplane flattens northward and describes a gentle syncline.

The underlying tectonic unit is made up of Hauptdolomit and Plattenkalk. It is further cross cut by minor faults. They are steeply southdipping and have a general east – west strike. This pattern is disturbed to the west close to the second major fault striking north – south. Here the minor faults are deflected to the south. Within the Vorderer Rinnbach Valley secondary dolomitization along faults causes bedding to be only locally preserved. Between the faults the rocks are mostly gently folded except to the north where a fault brings the bedding in an almost upright position.

West of the second major fault running from Hochkogel to Gasslkogel the third tectonic unit is exposed. Faults within this unit are deflected to the north close to the major fault.

To the east Hauptdolomit rests, discordantly, in a steep angle on Wettersteinkalk and reveals the third major fault. This fault can be traced across the Almtal and connected with a fault formerly named the Teichl-(Schwereck)Störung. To the northwest it disappears below the thrustfault at Zwillingskogel.

Tectonic summary

A major thrustfault at Zwillingskogel brings lower Triassic rocks on top of middle Triassic Hauptdolomit. The thrustfault cuts off the Teichl-Störung to the east and a north–south striking fault to the west. This dates the thrustfault as the tectonically youngest feature. The fault to the west deflects minor faults east and west of the fault bringing post Triassic rocks in contact with Triassic rocks.

Kasberg

(KRÜGER)

To the west the Kasberg area is limited by Almtal and towards the south by Straneggbach over Ringhütte to Steyrling, which together with the border of the map de-

limits the area to the east. The northern boundary against the Geißstein – Schindlbach – Brenntbach area is drawn along the Hochstein high over the north side of the Kasberg-plateau to Wasenbach. Six mapping units have been recognized in this area: Plattenkalk (tdk), Hauptdolomit (td), Wettersteindolomit (twd), Wettersteinkalk (twk), Reilfinger Kalk (tmr) and Gutensteiner Kalk (tmg).

Tectonics has caused a somewhat inverted stratigraphical succession though a normal sedimentological succession is present within each tectonic unit. Upper Triassic Hauptdolomit and Plattenkalk is overlain by Middle Triassic Gutensteiner Kalk – Reiflinger Kalk – Wettersteindolomit and Wettersteinkalk.

The Hauptdolomit occurs along the west side of Kasberg from Wasenbach in the north to the western end of Meisenberg in the south. In this area the Hauptdolomit has a thickness of up to c. 500–550 m, which is not necessarily the true stratigraphic thickness owing to thrusting.

On the Kasbergalmstraße, from 699–950 m a. s., the Hauptdolomit is uniform and contains few or no sedimentological structures.

Above 950 m, greenish marly layers begin to occur between the dolomite beds. A little further upward a dolomitic version of Lofer cycles is developed. This cyclicity continues for c. 50 m, and varies in degree of development. From 1020 m, darker dolomite with limestone intercalations occurs, and locally still containing greenish-layers.

At 1070 m black, bituminous marly dolomite, the so-called Seefelder facies, occurs in isolated (5–10 m) lenses, and a major lens of Gutensteiner Kalk is present.

In the uppermost part of the Hauptdolomit the bedding planes are diffuse and the number of limestone beds increases. A pure limestone that could be called Plattenkalk is not developed. The only area where Plattenkalk has been observed as a bedded, pale limestone is in the NE part of Wallibach between 1150–1200 m.

The Gutensteiner Kalk/Reiflinger Kalk beds are the most widely distributed rock units in the area. They occur on the Kasberg plateau above c. 1200 m and continuing over Schwalbenbauer to Jausenkogel in the north-east and along the southern part of Kasberg from the crest of Meisenberg over Rabenstein to Zösenbach in the east. The best exposures are seen on the Kasbergalmstraße above 1130 m. From 1130 m to c. 1350 m the rock is well bedded with distinct, thin (1–20 cm) parallel beds. Apart form a single gastropod in the lowermost part no fossils have been observed. At 1360 m the first crinoid layers start to occur and a little above the beds become nodular and irregular.

This facies continues to 1440 m where the crinoid beds reappear but in a more thickly bedded version. Above these beds follows nodular, highly bioturbated limestone (presumably "Wurstl-Kalk"). These beds grade up – with minor Brachiopodcoquina intercalations – into paler, nodular, poorly fossiliferous limestone containing slump structures. The sequence is terminated partly by a bank like thick bedded (0,5–2 m), pale limestone, and partly by a chert rich, nodular limestone. This determines the Gutensteiner Kalk/Reiflinger Kalk boundary.

The chert rich layers alternate with marly, well bedded, fossiliferous layers containing 2–3 species of crinoids and at least 6–7 species of brachiopods (one has been determined to be a *Tetractinella trigonella*, SCHLOTH). Furthermore a single, well preserved conodont has been found and identified as *Gondolella foliata inclinata* (KOVACS), giving a late Ladinian to early Carnian age (KOVACS, 1983).

At Benn Nock and north to the boundary to the Hauptdolomit, the Gutensteiner Kalk and Reiflinger Kalk is dolomitic. The rocks are still slightly bituminous with primary lamination and bedding.

The boundary between Reiflinger Kalk and Wettersteindolomit is either a sharp contact or a gradual transition from bedded, nodular Gutensteiner Kalk/Reiflinger Kalk to well bedded, reddish and greenish mottled, sugary dolomite which within 5–6 m, becomes a massive sugary white dolomite.

Wettersteindolomit occurs in the eastern and southeastern part of the area i. e. in the south from Hundskogel, Brunnkogel over Zösenbach to Hochkogel and with a northern limit in the Katzengraben. No bedding has been observed and apart from some minor bodies of Wettersteinkalk above the Wettersteindolomit on Hochkogel. No upper boundary has been mapped, so the thickness is impossible to obtain, but on Hundskogel there is at least 500 m of dolomite.

On the Hochkogel ridge at least two separate Wettersteinkalk units occur, of which the contacts with the underlying dolomite are irrgular. It seems that much of the dolomitization has occurred along faults cutting into the limestone.

The Wettersteinkalk on the Hochkogel peak consists mostly of oncolites, crinoid and coral fragments, sphinctozoans etc. with a matrix of micrite, while the western unit is composed entirely of corals in or very close to life position. The matrix here is partly micrite an partly sparite.

Along the north side of Straneggbach at Seeleiten Wettersteinkalk is developed as a monotonous, pale limestone with no or very faint irregular bedding. The rock is poor in fossils except at one location where the rock was found to be a grainstone composed entirely of crinoid fragments.

At. G. Ödsee, further to the south, the limestone (found only as loose blocks) is composed of orientated intraclasts resembling a turbiditic flow. Generallly the boundary to Wettersteindolomit is somewhat arbitrary since the transition Wettersteinkalk/Wettersteindolomit is gradual over 20 m and because minor dolomitized bodies occur within the limestone.

Structural description

A general south-east dip of the bedding in the area implies that the lower tectonic units outcrop to the west while the highest units occur to the east.

The most striking structural feature of the area is the thrust that brings the Middle Triassic Gutensteiner Kalk/Reiflinger Kalk and Wettersteindolomit to overlie the Upper Triassic Hauptdolomit.

The thrust itself can be followed along the west side of Kasberg. It rises from Straneggbach where it either runs parallel to the Hauptdolomit bedding or cuts the bedding at a very low angle. The thrust plane (outlined by the Hauptdolomite – Gutensteiner Kalk boundary) flattens over Wallibach and dips gently northward creating a flat anticlinal structure having a fold axis orientated c. 100°/10–20°. Along Kasberg the thrustzone seemingly runs parallel to the bedding unit – over Wasenbach – it apparently cuts up through the

Hauptdolomit, creating a relative steeply southward dipping slope.

The thrust plane should more correctly be considered as a broad irregular zone which on the Kasbergalmstraße starts at c. 1070 m with higly disturbed Hauptdolomit bedding followed by an inclined Gutensteiner Kalk lens (across c. 15–20 m).

Above this, a disturbed Hauptdolomit sequence occurs, which is somewhat different from the underlying Hauptdolomit having a pronouncedly higher content of pale limestone beds. Since the sedimentological succession has not been observed as being complete it is likely that the upper parts of the Hauptdolomit have been tectonically displaced. At 1130 m the transition from Hauptdolomit to Gutensteiner Kalk is very sharp, containing only a thin (few cm) crushed zone.

Within the Hauptdolomit itself there are signs of minor thrusts/movements, e. g. Wallibach 720 m, where the bedding is highly folded in an otherwise undisturbed sequence. A further mapping of these zones has not been possible.

The hanging wall rock units consist of a stratigraphically correct succession of Gutensteiner, Reiflinger Kalk, Wettersteindolomit and -kalk. The lowermost 80–90 m of Gutensteiner Kalk is intensely folded and cut by several minor thrusts. This implies that the thrust zone has affected c. 150–200 m of Hauptdolomit and Gutensteiner Kalk rocks.

Within the Gutensteiner Kalk, folds and crushed zones indicate thrusting. This is the case along the southern margin of the Kasberg plateau, where the bedding is highly disturbed. Crushed zones have been observed between the Kasberg peak and Schwalbenmauer, and further southward along Rabenstein. These disturbed zones all occur in the upper part of Gutensteiner Kalk/Reiflinger Kalk which, together with differences in Reiflinger Kalk levels, indicate one or maybe several minor thrust planes within the upper part of Gutensteiner Kalk.

The great thickness of the Gutensteiner Kalk, especially, could partly be explained by a stacking of low angle thrust lenses internally within Gutensteiner Kalk. Alternating thicknesses going from west to east could be explained by irregularities in the bounding thrustplane.

The boundary between Gutensteiner Kalk/Reiflinger Kalk and Wettersteindolomit is somewhat dubious, although the rocks lie stratigraphically correct.

Two features favour the explanation that Wettersteindolomit has been tectonically displaced upon Gutensteiner Kalk/Reiflinger Kalk in this area.

The first observation is that Wettersteindolomit is cutting the chert nodule (Gutensteiner Kalk/Reiflinger Kalk boundary) horizon on the north and west sides of Langscheidalm where the dolomite is in direct contact with Gutensteiner Kalk.

The second feature is that, according to observations during this fieldwork and the 1913-map of GEYER, Wettersteindolomit rests directly on Hauptdolomit west of Almtal opposite Stranneggbach. This implies that a major thrust directly underlies Wettersteindolomit. It is most likely that this feature may continue east of Almtal, and it is reasonable to assume that the Wettersteindolomit here likewise has been tectonically placed upon the Gutensteiner Kalk/Reiflinger Kalk.

The thrust, underlying Wettersteindolomit west of Almtal, is the one that cuts Gutensteiner Kalk/Reiflinger Kalk and further has minor later thrusts carrying lenses of Gutensteiner Kalk/Reiflinger Kalk into Wettersteinkalk.

The lens of Gutensteiner Kalk/Reiflinger Kalk in Wettersteindolomit in Zösenbach (600 m) and Langscheidalm (700–800 m) is surrounded by three thrusts. One on either side which have to join and cut through the Wettersteindolomit from Zösenbach over Hochkogel down to Katzengraben. The Gutensteiner Kalk/Reiflinger Kalk lens is cut by a third thrust at a high angle in Zösenbach by the unit that covers Brunnkogel – Hundskogel.

Tectonic summary

Summarizing this interpretation, the area consists of three major tectonic units: The lowermost Hauptdolomit/Plattenkalk unit separated by a thrust to the Gutensteiner Kalk/Reiflinger Kalk unit, that in its turn is separated by another thrust carrying the Wettersteindolomit/-kalk unit as the uppermost unit. All three units are cut internally by minor thrusts. This is best visualized within the Wettersteindolomit unit where obvious different lithologies are involved.

Geißstein – Schindlbach – Brenntbach
(JØRGENSEN)

The area is located south of Grünaubach – Stoßbach – Schwarzenbach, east of Almtal and north of the Wasenbach – Hochstein line. The mapping units in the area are the Gutensteiner Kalk (tmg), Reiflinger Kalk (tmr), Wettersteinkalk (twk), Hauptdolomit (td), Plattenkalk (tdk), Oberalmer Schichten/Schrambachschichten (io/kn), Cretaceous flysch (fy), Helvetikum? (he) and Quaternary. The distribution of the pre-Quaternary rock units in the area are governed by a number of south dipping thrust faults striking c. WNW–ESE, separating the area into four major tectonic units.

The northernmost main unit (the lowest structural level) is bordered to the south by a major southdipping (45° subvertical) thrustplane striking ESE from Langau to Jhtt. Keferreuth. Towards the western part of the area a continuation is expected of this thrust fault situated along Grünaubach (this assumption is based upon field data obtained by O. GRAVERSEN). The main unit can be subdivided into three minor thrust sheets, all southdipping. A succession of Wettersteinkalk – Hauptdolomit – Oberalmer Schichten/Schrambachschichten is overthrusted by a Hauptdolomit unit (maybe Wettersteinkalk at the base?) along the Falkenmauer ridge. Both thrust sheets are again overthrusted by a Wettersteinkalk unit along Stoßbach – Schwarzenbach. Rocks of the Wettersteinkalk unit from the lower thrust sheet are mostly poorly bedded pale grey limestones, but wellbedded sections are observed at several localities. Here algal laminated beds seem to alter with massive grainstone beds in a rhythmic manner. Erosive channels with algal laminated intraclast fillings are also observed in these sections. The massive grainstone beds contain large numbers of Dasycladacean algas. Some horizons consist entirely of Dasycladacean alga fragments. On basis of the erosive channels it is assumed that the rock unit is lying in an upright stratigraphic position (this assumption is supported by evidence from thin sections).

The following Hauptdolomit unit consists of fairly wellbedded massive pale to brownish grey dolomite rocks. Folding and intense fracturing are often seen in

this unit. Towards the boundary to the underlying Wettersteinkalk unit the dolomite rocks show shearing and cataclasis. The Oberalmer Schichten/Schrambachschichten unit have only been recorded from the westernmost part of the Falkenmauer ridge. The rocks are exposed in a few hundred meters broad zone in the thrust zone that separates the two Hauptdolomit units. The following Hauptdolomit unit above the thrustplane is composed of fractured pale grey poorly bedded dolomitic rocks. Rocks of this unit are only exposed in the north easternmost part of the mapped area.

Above the thrust plane of the Stoßbach – Schwarzenbach thrust fault follows a succession of poorly bedded pale grey to grey limestone rocks that are correlated with the Wettersteinkalk unit. Weathered rocks of this unit often show a characteristic spotted surface pattern. Thin sections of the rocks reveal what could be interpreted as completely recrystallized Dasycladacean algas. The rock unit becomes wider in the easternmost part of the area.

South of the previously described Wettersteinkalk unit follows the second major tectonic unit; to the south bordered by a steep (70° subvertical) dipping thrust fault extending in a east southeasterly direction from Obere Höll to Wasserböden. This thrust fault is also known as the Teichl (Schwereck) Fault (A. TOLLMANN, 1976). The main unit can be subdivided into several minor steeply dipping thrust sheets (laterally not very persistent) composed of rocks of the Gutensteiner Kalk unit, the Reiflinger Kalk unit, the Hauptdolomit unit, the flysch unit and possibly the Helvetic unit. The main unit wedges out towards ESE. The structural relationships within this unit are likely to be more complicated than it appears from the geological map. Bedrock units are not well exposed and it is difficult at individual exposures in the field to distinguish rocks of the Gutensteiner Kalk unit and the Reiflinger Kalk unit.

Rocks of the second unit are partly overthrusted by rocks of the Gutensteiner/Reiflinger Kalk units belonging to the fourth main unit (the Kasberg sheet). These overthrusted rocks are lying as klippen in a zone extending from Zwillingskogel along Zuckerhut, Dachskopf and Kieshütte to Geißstein. The rocks of the klippen zone do not seem to differ lithologically from the rocks of Gutensteiner/Reiflinger Kalk units of the second main unit, so only the structure makes a differentiation of the rocks of the two tectonic units possible. The lithologies are almost similar to the ones described from Kasberg Almstraße. Although in the western part of the klippen zone rocks of the Gutensteiner Kalk unit tend to become more thick bedded and less bituminous. This could mark a transitional facies to the Annaberger Kalk unit (A. TOLLMANN, 1966). Unidentified brachiopods and crinoids have been observed in the Gutensteiner Kalk unit at a few localities in the klippen zone. Due to intense weathering and erosion, the flysch sequences of the second main unit are very badly exposed and structural and stratigraphiic observations are scarce.

The fine grained clastic rocks within the flysch unit favour the landslidings observed at many places in the flysch areas. Measurements of beddingplanes mostly show very random orientations, thus indicating a "floating" behaviour of the flysch rocks. Tectonic lenses of metamorphic rocks (garnet mica schists) (Helvetikum?) outcrop at two localities near Dachskopf within the flysch zone, indicating a profound thrusting within this second main unit.

South of the Teichl (Schwereck) Fault follows the third major tectonic unit, bordered to the south by a flatlying thrust (SSE dipping in the easternmost parts of the area), known as the Kasberg thrust (A. TOLLMANN, 1976), extending from Wasenbach along Schwalbenmauer, Turmmauer to Steyrling on the neighbouring mapsheet. The unit consists of rocks of the Hauptdolomit and Plattenkalk units. The Plattenkalk unit outlines the internal structures of the whole main unit, the Plattenkalk unit being in stratigraphic contact to the Hauptdolomit unit. Strata are relatively flatlying in a stratigraphic upright position. Mesoscale folding, faulting and thrusting of the rocks are frequent, particularly close to the Teichl (Schwereck) Fault. A major south dipping thrust fault has been discovered in the north western part of the main unit where it runs parallel with the Teichl (Schwereck) Fault. A repetition of the Plattenkalk unit in this area outlines the thrust fault. A 200–300 m broad east–west striking zone of almost white brecciated dolomite rocks have been observed at Farrenauhütte. The zone seems to be steeply south dipping and cuts of the Plattenkalk unit to the north. I believe that the zone is a fault zone and that late dolomitization took place in the rocks of this zone. The Plattenkalk unit wedges out towards the eastern part of the area, and east of Jausenkogel the unit is cut off by the Kasberg thrust. In general the observed thickness of the unit is less than 80 m, but at Hochberg the thickness is c. 200 m. This difference in thickness could be explained by facies variations, but internal thrusting and folding in rocks of the Hochberg area indicate that tectonics are responsible for most of the increase of thickness. Fossils are rare in rocks of the Hauptdolomit unit, unidentified shellfragments have been observed at a few localities. Fossiliferous beds are numerous in Plattenkalk beds from where foraminiferas, gastropods and bivalves have been identified.

The southernmost part of the mapped area is occupied by the fourth major tectonic unit (the highest structural level), consisting of rocks of the Gutensteiner/Reiflinger Kalk units overthrusted on rocks of the third main unit. Intense mesoscale folding and thrusting have occurred in rocks close to the thrust plane (the Kasberg thrust). In the northeastern part of the thrust sheet (south of Farrenauhütte) deformation is accompanied by a major dolomitization of the limestone rocks. Structural and petrographic observations within rocks of the klippen zone (previously described from the second main unit) support the assumption that these rocks structurally belong to this thrust sheet (the fourth main unit).

Tectonic summary

More than ten individual thrust sheets can be classed with four major tectonic units (unit 1 to 4).

The lowest structural level is represented by the northernmost tectonic unit (unit 1), composed of steep south dipping Wettersteinkalk and Hauptdolomit units. To the south along the Grünaubach – Geißstein line, unit 1 is overthrusted by steep SSE-dipping rock units of flysch, Helvetikum and Gutensteiner/Reiflinger Kalk (unit 2, the Grünau Halbfenster). The most profound thrusting of the whole area is seen in this unit. Along the steep SSE-dipping Teichl (Schwereck) Fault, unit 2 is overthrusted by unit 3, composed of flatlying

Hauptdolomit and Plattenkalk rock units. In the southernmost part of the area along the subhorizontal Kasberg thrust, rock units of Gutensteiner- and Reiflinger Kalk (unit 4, the Kasberg sheet) are overthrusted on unit 3. Klippen derived form unit 4 are now resting on top of parts of unit 1 and unit 2, in a zone extending from Zuckerhut to Geißstein.

Distribution of rock units in the whole area reveals the presence of a complicated imbricate SSE-dipping thrust system, with indications of a duplex-like thrust system.

Tissenbach – Hochsalm
(GRAVERSEN)

The geology of the northeastern borderzone of the Kalkalpen in the Grünau area reflects the structural position north of the Grünau Halbfenster. The bedrock is mainly made up of the Hauptdolomit unit and a number of limestone units that outline the structure. The mapping is, however, complicated by the discontinuous character of the outwedging mapping units that make it difficult to establish a general stratigraphy.

The structure of the area is outlined by a NW–SE strike with layers dipping 40–60° to the southwest. The general variation also includes southdipping and steeply westward dipping strata, and in a few areas northdipping strata are seen in connection with major thrusting. Minor thrusting is a general feature especially in the Hauptdolomit, while mesoscale folds are only very seldom observed. The major thrust levels are marked by crushing and shearing and the main outline must be the result of a number if disintegrated thrust sheets. The correlation and identification of the stratigraphic position of the individual limestone units have not yet been satisfactorily established.

A white compact limestone outcropping above the Hauptdolomit has been established as a continuous marker unit in the southwestern part of the area, where it has been followed from Janslkogel passing Windhagkogel to Gangjodl north of Grünauberg to the WNW. Above the white limestone unit, east of Gangjodl, there follows a layered grey limestone containing brecciatied dolomite nodules. In the northern part of Grünauberg, in an overlying thrust unit, a shaly marlstone followed by a homogeneous grey limestone occurs above the nodulous limestone. On this basis it may then be tentatively suggested that the white compact limestone above the Hauptdolomit and the nodule containing limestone may be included in the Plattenkalk and the Gutensteiner Kalk respectively, while the shaly marlstone and the overlying limestone may possibly reach into the uppermost Triassic an lower Jurassic.

Although the mapping is incomplete, it is evident that a complicated imbricate thrust pattern must follow to the north indicated by successive Hauptdolomit/limestone sequences often separated by intensive thrusting. At the northernmost margin of the Kalkalpen, north of Hutkogel, the thrusting is underlined by sheets of flysch being thrusted up into the tectonic succession from below.

Reconnaissance in the eastern part of the mapped area has revealed a single outcrop area of the white dolomite on Loskogel resting on the Hauptdolomit or possibly flysch as a tectonic klippe bordering the Grünau halbfenster. Intensive imbricate thrusting can also be demonstrated east of Engeleck where the flysch, containing blocks of the white dolomite, is outcropping in the 1000–1100 m level compared to the general 500–600 m level of the Grünau Halbfenster to the west.

Blatt 69 Großraming

Bericht 1986 über geologische Aufnahmen in den Kalkalpen auf Blatt 69 Großraming

Von RAINER BRAUNSTINGL (auswärtiger Mitarbeiter)

Das Kartierungsgebiet umfaßte einen etwa 5 km breiten Streifen am Westrand des Kartenblattes. Von der Mollner Linie im N (Roßberg – In den Mösern) reicht das Aufnahmsgebiet bis knapp an das Sengsengebirge im Süden heran. Es wird zur Gänze zur hochbajuvarischen Reichraminger Decke gezählt.

Der hier etwa 1000 m mächtige Hauptdolomit dominiert das Kartenbild. Gegen seine Hangendgrenze treten aus dem generell massig ausgebildeten, kleinstükkig verwitternden Hauptdolomit zunehmend 1 bis 3 m dicke Bänke hervor. Dazwischen schalten sich etwas geringmächtigere Kalkbänke ein, die gegen das Hangende immer dünnbankiger werden und die Dolomitbänke allmählich in den Hintergrund drängen. Dieses Einsetzen des Dachsteinkalkes ist an folgenden Forststraßen aufgeschlossen: Großer Buchberg, Eiseneck (W der Krummen Steyrling), sowie Lindeck, Schneeberg und E Scheiblingau (E der Kr. Steyrling). Die Mächtigkeit des Dachsteinkalks schwankt zwischen 20 m im N (Lindeck) und 50 m im S (Buchberg). Darüber folgen meist Kössener Schichten, die nur selten aufgeschlossen sind, sowie eine Jurakalkentwicklung, deren massige, rote, selten hellbraun Krinoidenspatkalke im S eine Mächtigkeit von 200 m übersteigen. In den nördlichen Juramulden (Lindeck, Großer Buchberg) erreichen sie maximal 50 m Mächtigkeit, wobei allerdings keine stratigraphische Überlagerung gefunden wurde.

Im Vergleich zur Geologischen Spezialkarte 1 : 75.000, Blatt Weyer, konzentrieren sich die Neuerkenntnisse auf 3 Gebiete:

- Mollner Linie (In den Mösern),
- Kleiner Buchberg – Jaidhaus (Krumme Steyrling) und
- Raum Klausgraben – Vorderreuter Stein.

Der Streifen S der Mollner Linie, die „Breitenauschuppe", ist wesentlich komplizierter gebaut, als bisher angenommen; Reiflinger Kalke in verschiedenen Ausbildungen (massig oder gebankt, mit und ohne Hornsteinknollen), Lunzer Schichten, Opponitzer Schichten (Rauhwacken, braune Kalke) und Hauptdolomit sind eng miteinander verschuppt (z.B. beim Gehöft Schraml, Maroldenalm und Rosenegger Alm). Die Gesteine sind vielfach auch intern stark gestört, brekziiert und gefaltet. Schöne Falten im Reiflinger Kalk findet man an der Forststraße im Schneegraben, W Kote 815.

Im S schließt steil südfallender Hauptdolomit an. Der Kleine Buchberg (Blattrand W Jaidhaus) besteht nicht aus Hauptdolomit, wie bisher angenommen, sondern hier taucht unter dem Dolomit eine Antiklinale mit Reiflinger Kalk und Opponitzer Schichten empor. Die Achse