

B. Foreland of the Alps

1. Lithostratigraphy, Palaeopedology and Geomorphology

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With 2 figures

1. Introduction

The northern Alpine foreland, as far as it belongs to the drainage systems of the Danube and the Lake Constance-Rhine Rivers and within the political boundaries of the Federal Republic of Germany will be dealt with in this short summary. The latest papers concerning Quaternary research in the West German Alpine foreland can be found in the first ten references of the bibliography. In addition, these reports can be drawn on for references to older literature. The attempt of RICHMOND (1970) to compare the quaternary stratigraphy of the Alps with the Rocky Mountains will be also gone into.

As is well known, PENCK (1901—1909), who, together with BRÜCKNER, discovered the four glaciations of the Alps, named them after the foreland rivers Würm, Riss, Mindel and Günz. Everyone also has cognizance of the didactical principle, whereby the alphabetical sequence was applied to rivers which were not too small and at the same time allochthonous to the foreland. It is a fact that PENCK & BRÜCKNER, with their stratigraphical principle of tetraglacialism, were able to connect *loci typici*, which are still useful, for the glacial series of one of the four ice ages in the area of its like-named river.

The present common names for those ice ages divided by true interglaciations have been internationally accepted through the use of the PENCK-BRÜCKNER names for the last (Würm) and the three preceding ones. The stratigraphical expansion by EBERL (1930) for the "Danube Ice Age" and by SCHAEFER for the "Biber Cold Age", which were accomplished by the same method as those above, have found wide acceptance.

The following problems for modern Quaternary research grow in this connection, that is, the relationship of the ice ages and the dividing warm ages:

1) Since the expansion of the four ice age pattern will probable be made worldwide, as also in the northern Alpine foreland itself (for example MÜHLBERGER in Switzerland even before PENCK & BRÜCKNER), the naming of the independent Alpine foreland glaciations can be accomplished through various methods:

a) Through geological-stratigraphical methods — with or without reference to the PENCK-BRÜCKNER names.

b) Through geomorphological methods with more or less emphasis placed on the PENCK-BRÜCKNER names. The question whether the German Alpine foreland can be taken as a whole for the *locus typicus* of the entire Quaternary stratigraphy can only then be answered in the positive when it can be proved that the Alpine foreland in fact exhibits a complete stratigraphical table through the comparison of numerous stratigraphical specimens with those in other well investigated glaciated areas. This question can not be dealt with here. Instead the following problem is set forth:

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The best occurrences of Glacial Series in the Alpine foreland or the remainder thereof for the above named Ice Ages should first be mentioned for those interested but strange to this area. Only the lithographical and pedostratigraphical, along with the geomorphological, work methods will be drawn on. The enclosed map is meant to ease the search by the visitor for those places named in the text. It is also necessary to mention a further problem of the Alpine foreland Quaternary research. It was confirmed early that the mostly hypsometrical confusedly packed meltwater deposits in the form of stepped gravel terraces especially in the area between the Bavarian tertiary hill country and the Riss valley point to more than four ice ages. PENCK resorted to the solution that tectonic activity caused the highest deposited Günz gravel to be at various heights. EBERL (1928—1930), KNAUER (1929), GRAUL (1943) and others proved that tectonic activity in this sense had not transpired, so that more than four ice ages must be present. The middle and young Pleistocene series also appears to be divided into several independent gravel fields. EBERL and all those following have attempted to solve this phenomenon in that Würm, Riss, etc. would be divided into several stadials, even as far as ice eras, that is, in the sense of a "Riss Ice Age Group", etc. The stratigraphical quality of the cold age deposits, whether they are proof of an independent glacial, a larger climate fluctuation (stadial) or a small fluctuation (phase) or not, can to some extent be insured through various work methods. The axiom should be: so long as a climate fluctuation of inferior degree is assumed, so long can no exact evidence for a larger fluctuation be proved. The research history of the Quaternary of the Alpine foreland is only accurate when it is confirmed that the research in general has followed this axiom. Also, polyglacialism, as represented by EERL, is in no way a "fantastic product of an autodidactical outsider", but instead it is a very actual theory, in that, worldwide, tetraglacialism with an estimated maximum duration during his time of 600,000 years must be replaced by a polyglacialism with a duration of approximately three times as long. As previously mentioned, therein lies the problem of the stratigraphical labelling of the glacial series and/or their remains. SCHAEFER insists that the older name-giving Würm to Günz rivers are not connected with the geological-stratigraphical sequence of the ice ages which are completely divided by interglacial deposits, but instead by the physionomical, mostly geomorphological characteristics of the four glacial series of PENCK, which he at that time established. These are briefly repeated as follows:

1) Lower terraces: without loess and not cut up, in topographical connection with young moraine, completely fresh — Würm.

2) Higher terraces with mostly a loess or clay cover, already with dells. The related moraine already "washed out" — Riss.

3) Mindel - Lower debris cover, partly without tertiary slope terrain already, cut up, deeply weathered (geological organs). Moraine still heavily washed out. Where covered by younger deposits, in places intensive fossil soil preserved (large interglacial).

4) Günz — Upper debris cover, almost nowhere in valleys deposited, but form the highest, often wide levels instead, heavily cut through with small creeks and with clay, deep geological organs. As a result of later tectonic activity lies at various heights.

The discussion, whether the future stratigraphical naming of glacial series or their remains (mostly the gravel fields in the northern foreland) should result from geological or from geomorphological aspects, is still in progress. It has been completely proven that, in the entire foreland west of the line Ingolstadt—Augsburg and east of the line Schärding am Inn — Burghausen, that is, also in northern Austria, there are many fields where the fourth last ice age does not form the highest debris cover, but instead still older, surely cold age debris, is deposited. Therefore, these ice and/or cold ages are expanded by the names "Donau" (Danube) for the fifth last and "Biber" for the sixth last glaciation

based on the geological methods of PENCK & BRÜCKNER. This is not the only reason for the usual labelling of the cold and/or ice age deposits. The following must also be mentioned:

1) The division of the Pleistocene simultaneous in ice ages (e.g. the last — Würm) and in ice age groups (e.g. the ice age groups of the deposited upper terraces in the valleys by SCHAEFER) obliterates a clear subdivision of the Pleistocene which must be constructed on qualitative equivalent strata division. The geomorphological state of debris fields, as well as the moraine surface, are not alone dependent on age. The degree of cutting as well as removal plus the intensity of weathering and the loss of loess or clay can strongly differentiate the physiognomy of surfaces of the same age, and all the more so the older the surfaces are.

Further to be pointed out is the stratigraphical importance of various qualitative and quantitative gravel compositions of the Pleistocene deposits in the foreland. Obviously the meltwater streams of the Alpine valley glaciers had the greatest quantitative importance. These spread out after emergence into the foreland in spite of the less resistant material of the glacial eroded terminal basin with its Tertiary strata. They passed over the lower flat floored valleys (Muldentäler) of the autochthonous foreland rivers and covered them with imbedded and selected Alpine glacial meltwater facies, made up of



Fig. 1. Quoted local names in this paper.

river gravel which stemmed from periglacial wandering gravel-clay cover. The river gravel is to be always separated distinctly from the gravel-clay cover. More interesting is the facies change along the Danube valley, where here also the Alpine material always lie on the eastern deposits (Black Forest, Schwäbische Alb) of the one and same cold or ice age. As the latest investigations confirm (SINN, SCHEUENPFLUG, LÖSCHER) the palaeogeography of the foreland river system if of greatest importance for the Pleistocene stratigraphy, especially where palaeopedological methods leave us at a loss due to the lack of fossil soil.

These investigations were brought forth during the foreland field trip of the last conference of the DEUQUA (Stuttgart-Hohenheim 1972). Even though the occurrence of fossil soils on the surface of the recumbent facies which always shows the rubble of the

nearby drainage system, is in no way proved (in the meaning of ŠIBRAVA 1970), remains of meadow marl with determinable konchyliies have been found in the debris of the higher terrace (Dillingen—Höchstädt an der Donau), in Mindel debris (Riedlingen/Danube), in the even older Bucher debris east of the Iller and in the "Donau" age material of the Staudenplatte. Since 1914, with the exception of Riedlingen (GRAUL & BRUNNACKER 1962), these konchyliies have been considered to be from a cool humid or warm humid climate. This phenomenon can only be mentioned here; its final answer remains to be found. It is to be warned against extensive stratigraphical conclusions as long as the palaeobiologists haven't determined the degree and durations of resistance of the river meadow konchyliies in the northern Alpine foreland during the advance of the ice. This can, in my opinion, have continued in a river meadow ectopy far into a cold age, so that a direct and absolute statement can not be made about the temperature in the long advance of Alpine glaciers and therefore also not about the Pleistocene stratigraphy based on this intermediately deposited meadow clay.

The most important occurrences of alternating rubble facies during a cold or ice age can be found in the following valleys:

- 1) The upper Danube valley as far as it falls under the influence of the Rhine glacier meltwaters on the far side of the Danube-Rhine watershed.
- 2) The foreland rivers of the Danube as far as they spring or sprang in the foreland (foreland autochthonous valleys) and were reached by the terminal basins and their meltwaters.
- 3) Stone carried by moraine or meltwaters of the central Alps which was transported over the transfluence passes in the areas of the Lech, Loisach and Isar foreland glaciers. The basic site shows also here another composition, namely, that of the Limestone Alps with its lack of crystalline material plus Tertiary material of the foreland as opposed to the later meltwater deposited crystalline rubble. In general, the moraine of the maximum positions show the highest percentage of central Alpine material.

2. The Glacial Series of the Last Ice Age

Locus typicus for the Glacial Series of the Last Ice Age is still the profile from Lake of Starnberg (a basin scraped out by ice) to the young moraine of Leutstetten with the breaching of the Würm River and the in north adjoined main upper terrace which extends past Gauting into the Munich plain. Also this Glacial Series of the Last Ice Age can be nicely observed on the northern end of the old Iller glacier in the Memminger dry valley as well as near Winterstettenstadt on the most northerly site of the Last Ice Age Rhine glacier and also through other foreland glaciers. Frequently the main low terrace is considerably cleared away, in a funnel-shape, from the outermost moraine mound down valley (TROLL's "tumpet building" through the readvance and final retrogression of the glacier front). Deeper levels are carved into the vast fluvioglacial debris (the advance debris) of the Würm Ice Age in this cleared out area, the so called partial fields (Teilfelder), which, however, join at the level of the main low terrace down valley, so that, as a rule, further down valley they are not subdivided. Still further down, the narrow valley alluvial fans, which are deposited into one another through heavy Late Glacial carving, are to be differentiated from the partial fields, as are the Alpine rivers which empty into the Danube valley and possess very wide alluvial fans, however of the Holocene age. In this way, deciduous tree trunks, which were dredged from a depth of 4—5 meters in the Iller alluvial fan near Ulm on the Danube, were therefore first described (GRAUL & GROSCHOPF 1951). Through the ever increasing gravel excavation from the Danube valley floor during the last twenty years, such large numbers of oak, beech and other trees with a length up to 12 meters and a diameter up to almost 2 meters have

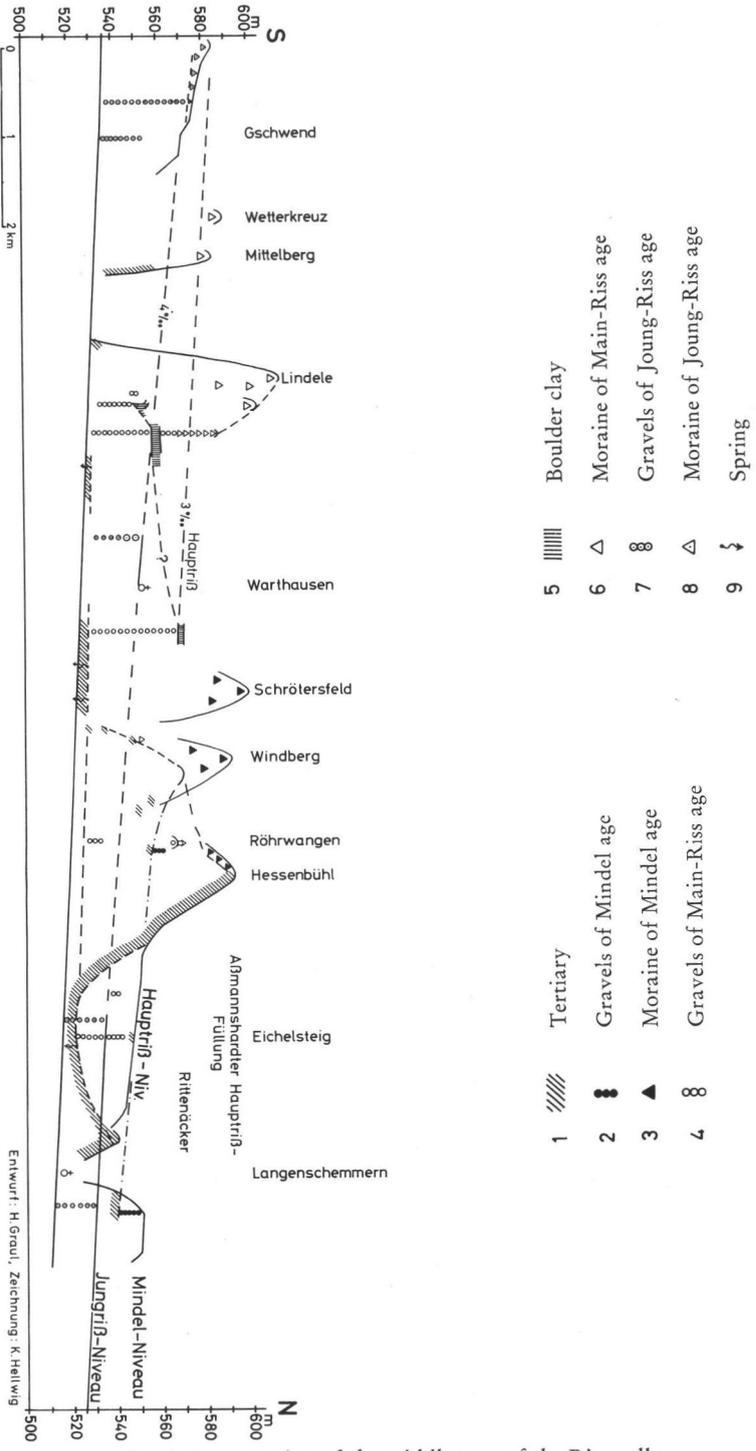


Fig. 2. Cross section of the middle part of the Riss valley

been extracted so that a dendrochronological examination has promised rewarding results (see BECKER). It has been proved through these discoveries that the entire Danube valley between Messkirch and Lech and in the lower valley sections of the Riss, Iller and Lech valley has no remains of the lower terrace main level, but instead that the last glacial debris, except for a few meters depth, has been cleared away and replaced by holocene debris of various ages. Meanwhile the same condition has been proved near Linz (KOHL) and in the Tullner Field on the Danube (in Piffel) over large areas. This is not only an interesting contribution to the Holocene development of many of our fluvial alluvial fans, but also it leads, lithostratigraphical and geomorphological for the quaternary in the northern strip bordering of the Danube, to the following questions:

1) What relationship in this respect is there to the pre-Würm age fluvio-glacial debris in the Danube valley? It is possible that this debris has experienced a partial clearing away during a warm age and then a recovering?

2) Can cold age and warm age Danube accumulation within a debris deposit be exactly differentiated by sedimentology?

3) Can the surface of this debris be exactly correlated with the surface of the fluvio-glacial debris accumulation in the area of the foreland moraine (as has been the usual method in the past)?

4) As an essentially younger soil formation exists on the youngest alluvial fans and valley meadow plains, isn't it to be expected that another soil on the upper terraces in the Danube area—under the loess—another fossil soil exists as that in the southern foreland?

As is well known, the question already exists for the Last Ice Age whether there was a climate fluctuation and what qualities did it have. In general one speaks of cold fluctuations at the end of an actual forest warm age until the final disafforestation. The cold age sets in with these fluctuations, whereby a recognizable warming determined by pollenanalytical or pedological methods occurred, although it is expressed as a warm fluctuation or interstadiale. Proof of such warming ages are present, but the question up to the present is not completely answered, that is, if there were warming periods which resulted in foresting, forest soil development and world wide raising of the ocean level to the approximate post glacial extent. (as KIMBALL & ZEUNER 1946 tried to prove for the upper Rhine valley). Both here and in the Aare valley it was proved (GRAUL 1962) that the three traceable lower terraces levels below Basel completely belonged to the upper Würm/young Würm/uppermost loess (Above Stillfried B). The decade long debate over the stratigraphical placement of the "Göttweiger" weathered horizon should be mentioned in connection with the above. One should not disregard the fact that the recumbent part of the ice age valley debris can be older than the complete stage of the maximum Würm glaciation, especially in the main terminal basins of the Alpine rim (e.g. the so called Laufener debris in the Salzach area) and also further up valley. Also to be considered is that peat can be preserved between this recumbent material and the push debris which lies above. However, these peats can only be spoken of as interstadial formations and not as those with interglacial character. Reference is made to the biostratigraphical and periglacial section.

3. The Glacial Series of the Second Last Glaciation

The interglacial between the last (Würm) and the second last glaciation (Riss) can be truly only pedologically proved through the parabrown soil under the Last Ice Age loess. Soil remains under the Last Ice Age earth flow, beyond the loess area and under the young moraine and lake clay in the ice rim basins, have the same stratigraphical importance. These are extremely rare — the best known are from Hörmating (Inn glacier),

Kreuzpullach (Isar glacier), Federsee-Basin and the Wurzachter Basin (Rhine glacier). Each site furnishes proof that the soil remains *must* be from the last warm age. This is readily shown in the entire northern strip of the Alpine foreland, that is, in the Danube valley and its surrounding area where the young loess-covered gravel fields of the Second Last Ice Age in 8 to 14 meter levels above the valley floor as upper terraces are preserved. These gravel fields can be followed relatively with ease up valley to the terminal moraine:

- a) in the Riss valley,
- b) in the Danube valley near Zweifalten-Datthausen,
- c) from Hitzenhofener Field near Memmingen to the terminal moraine of Legau and

at other sites. Two upper terraces exist in the foreland of the Rhine glacier whereby the higher of the two can be followed to the outermost old moraine (see figure 2) and the lower to the moraine lying further within the basin (Rissegg). Here we are dealing with the complex of the young Riss stadials. Complete proof of an interglacial between the young Riss complex and the main Riss series has not yet been furnished. The stratigraphy immediately preceding the Würm age has become problematic though the latest pollen-analytical examinations in the area between the Riss and the further inward lying Würm moraine. (see Section — FRENZEL). The locus typicus of PENCK for Riss in the Riss valley from Biberach northwards can be retained, where-by in very large observation sites a phase fluctuation with two moraine deposits can be confirmed. Recognizable is a 42 meter deep fluvioglacial deposit whose base runs to the tertiary 3 meters above the present valley floor below Biberach. This is late upper glacial, as it could be only deposited with the overflow of the meltwaters of the Rhine glacier over the Rhine/Danube watershed in the northern foreland. Above this is a 4 to 6 meter thick till (Geschiebemergel) strip near Lindele, Biberach, that can be followed northward to Warthausen. This is probably the ground moraine of the furthest stand of the ice which had lain in the Riss-Lobus near Röhrwangen-Oberhöfen. A further glacial complex of a readvance stand lies above this till (Lindele terminal moraine). See figure 2 in the Biberach Guide. The glacial series (Schwaben-Erding) which lies on the east of the Munich plain and which was described and placed in the Riss Ice Age by PENCK, has been questioned by BRUNNACKER (1964). KOENIG (1972) has the opinion that the stratigraphical solution at this site doesn't seem to have been found. The state of research in this area can be perused in his paper.

Also the glacial series of the Second Last Glaciation further eastward are by far not confirmed so perfectly as the locus typicus in the Riss valley. Most of all the magnificent observation sites are missing.

The above mentioned question is difficult to answer, that is, if the Riss Ice Age meltwater deposits in the Danube area were partially cleared away again and covered by warm age debris similarly as in the post glacial. Imbedded wood lying above the ground water level is completely weathered and this weathering, which took place during the interglacial and post glacial when no loess cover was present on the higher lying lower terrace, makes it difficult to detect a different debris facies. The present loess cover is 2 to 3 times that of the post glacial. In addition almost all debris areas of the Danube valley show a definite debris facies with a strong local character which isn't absolutely warm age, but possibly late upper glacial.

4. The Glacial Series of the Third Last Glaciation

Although there are very few locations — and these of secondary importance — in the separate moraines and in the area of the terminal moraine where a discussion "Würm or Riss" can be thought of, the question concerning the stratigraphical classification of the PENCK "Mindel Ice Age" is in no way settled. There are two essential conceptions for the German foreland.

1) The one side persists in a concept, based on the geomorphological terminology of PENCK, with the distinction of lower and upper terraces and a debris cover as forms. These three geomorphological terms corresponded to the Young, Middle and Old Diluvium. (Whereby SCHAEFER attaches great importance to the preserving of the term „Diluvium“). That means further that the debris cover, that is, the uncovered Riedel debris therefore is and should remain Mindel and Günz Ages. Should several glacial series deposits be determined between the fields of the lower terrace and the debris cover, then we must speak of several Riss ice ages (WEIDENBACH since 1936 and followers in Upper Schwaben) or the PENCK scheme must be utilized through additional names (e.g. BECK in Switzerland 1932 with “Kander“ and “Glütsch“ Ice Ages which he however gave up in 1937 and SCHAEFER since 1965 with “Paar“ instead of the earlier “Riss I“ or “Old Riss“ Ice Age.)

2) The other side persists in a concept based on the geological-stratigraphical terminology of PENCK with the naming of the last ice age as Würm, the second last as Riss, the third last as Mindel and the fourth last as Günz. The author has subscribed to this conception for the past 12 years. The following determinations were decisive for him as well as many other authors.

a) The international nomenclature of the ice ages after PENCK should not be overthrown through further refinement of the stratigraphy in relative small areas (local effect).

b) In glaciation areas with a large scale physiography, for example in North America, there are not many total deglaciations to be found, that is, true interglacial with deciduous foresting and corresponding soil development and with simultaneous raising of the ocean level to approximately the present height, so that we can not make do with the terms Würm to Günz for the last four great glaciations.

c) Moreover, more than four foreland glaciations can not be determined in the Rhine glacier foreland nor in any other foreland glacier, much less in North Germany, that is, there are presently only definite moraines for four glaciations. Their stratigraphical independence are proven most positively by the vast fossil weather horizon or “Schieferkohlen“ — both through deciduous pollen. All other “evidence“, such as the strata discordance in moraine areas or the various base heights of the fluvio-glacial debris fields can be explained mostly by local morphogenetic phenomena within the one and the same glaciation. That means that categorically justified suspicion exists only when, in the event the weather horizon or Schieferkohle is missing, the following facts are to be observed:

1) Instead of weathering, polished and scarred conglomerate surfaces are under the till (e.g., SCHAEDEL 1961 near Binsstock in the Riedlinger Basin and SINN 1972 near Hinterschmalholz (10 km SSE Ottobeuren). This is proof of the formation of an interglacial conglomerate and glacial polishing.

2) Depositing of pleistocene conglomerate rubble or drift material in the beds of a glacial series points to a preceding glaciations in the foreland (e.g., the conglomerate boulders in the Riss advance debris outside Biberach — see GRAUL 1952).

3) A perfect debris cover complex which shows a minimum age of the mostly fluvio-glacial substrata in the recumbent material based on the fossil weather level (e.g., the cover strata in the bricks works of Offingen in the Mindel valley which proves “at least the third last glaciation“ for the age of the recumbent debris — LEGER 1970, 1972).

4) The only geomorphological proof for a form of a true interglacial in the area we are dealing with is a general height difference of at least 5 meters in the heaped up base through the entire Danube valley, height differences over short stretches can originate from local causes, such as a severe shortening of the river bed, etc. It is well known that

the convergence of the various debris accumulations of the Pleistocene is so large at the junction of the Alpine discharge into the Danube valley and their enlargements (Donauried, Donaumoos, Dungau among others) that misunderstanding and confusing are very common through the back and forth oscillation of the subsequently cleared out soils of the Danube valley during the joining of the debris remains. That is why distinct deeper debris bases are necessary in order to classify accumulations of two different ice ages.

When one considers the correlation of the Rocky Mountain glaciation phenomena with those of the Alps (RICHMOND 1970) the following should be briefly mentioned:

The Pinedale/Bull Lake soil on the upper Bull Lake moraine has a date of approximately 70,000 years from the present based on the Ryolith overflow in the recumbent material of this moraine.

Our development in the Last Interglacial or the Second Last Glaciation must be older. All quoted datings of the Schieferkohlen — with a great uncertainty of this method — only furnished an age of at least this time period.

It is therefore completely hypothetical to parallel the upper Bull Lake glaciation dated at 70,000 years with our main Riss (*locus typicus* — Biberach). Based on this we have only one interglacial — the Riss/Würm with Zeifen Schieferkohle as the *locus typicus* in the German foreland. Therefore, through such a correlation (RICHMOND 1970) one can not successfully place the lower Bull Lake glaciation (130,000—70,000 year ago) in the same age as a Riss I (WEIDENBACH 1936—1940 or BOURDIER 1962) or Old Riss (GRAUL 1952) or Paar glaciation (see SCHAEFER since 1965). Following PENCK'S geological-stratigraphical naming, RICHMOND could have also paralleled the lower Bull Lake moraine with Mindel. But he was thwarted by the young absolute age and the discrepancy in the Illinois (see his figure 6). Therefore, the correlation of Quaternary stratigraphy of the Rocky Mountains with the Alps is still open.

In conclusion is to be mentioned that we have young Riss formations in the German foreland (GRAUL 1952, 1962; EICHLER 1970) but no interglacial can be proven between them and the main Riss. The young Riss formations are, therefore, considered to be late stadials of the Riss glaciation. The young Riss formations do not lie so unfavourably, that a fossil weathering couldn't have been preserved between them. But up to the present none have been found.

As we don't know the absolute age of the Riss or Mindel in the Alpine area, we must pursue a relative stratigraphical dating. All the deposits and/or glacial series of the foreland, which up to now have been designated as Old Riss based on the example of GRAUL (1952), can be unconditionally compared with those deposits designated as Mindel by the ice age researchers in Salzburg (WEINBERGER) and in upper Austria (KOHL). The same prevails for the gravels and moraines in Mindelheim County, which SCHAEFER assigns to a Paar ice age. They are still well preserved through the entire Mindel valley: in the lowest section near Offingen, then Tannhausen—Kirchheim—Spoeck—St. Katharina and St. Georg near Mindelheim and then past the completely preserved debris cover (there can be positively no thought of a type of "upper terrace" from Mindelheim on) between Auerbach valley in the west and Westernach valley in the east passed Köngetried to the outermost terminal moraine of the Iller glacier in the Holzer Forest. This terminal moraine contact is considered proven by SCHAEFER (1965), as well as by SINN (1972). The deposits at the Mindel valley junction with the Danube valley were proved to be from the third last ice age by LÖSCHER (1972) based on the series of fluvio-glacial gravel fields and LEGER (1970) based on the cover stratum in the Offingen brick works. It is, therefore, more than suggested that these facts for the so called Mindel Ice Age from PENCK be accepted and these occurrences in the Mindel valley be considered *loci typici* for Mindel. The name should consequently also be retained.

A succession of four ice age deposit series in the area of the Isar foreland glacier, each divided by an intensive weathering, has been made known, lithographical and pedological, by KRAUS (1966). The glacial deposits of the third last ice age have also been designated by KRAUS as Mindel. The deeper level of this moraine, which has an older moraine under it, gives interesting hints of the morphogenetics of the Munich plain. However, this area can not be taken as *locus typicus*. Only detached sections of the glacial series of the Mindel Ice Age are preserved here, as well as in other areas.

5. The Glacial Series of the Fourth Last Glaciation

The foreland glaciation of the Fourth Last Ice Age is also at other sites other than south of Munich proven by moraine, which must be older than the series of the Third Last Glaciation (Mindel) based on lithostratigraphical and pedostratigraphical grounds. Complete glacial series, as far as I know, have not been observed. Other than in the Salzach foreland glacier (EICHLER and SINN), these preceding oldest moraines lie buried under younger old moraine of the further northward reaching glaciation. Thus, older moraines with an intense weathering under above lying Mindel moraine is known of: e.g., near Hof Riedwangen/Rottum in the eastern Rhine glacier foreland. Further northward, these moraines also cover further fluvio-glacial debris, which must be likewise considered as part of the glacial series of the fourth last glaciation due to their height on the tertiary and by the remains of a fossil surface weathering.

Examples can be found near Hattenburg and zum Stein in the area of the northern Rhine glacier (GRAUL 1968) or near Binsenstock, Riedlingen with polished and scarred conglomerate surfaces (SCHÄDEL 1961). The last occurrences lie in the Danube drainage system, but possess typical Rhine glacier debris composition, so that it could have only been transported over the European watershed into the Danube area by ice. The structure of this formation through deep weathering in the Iller glacier foreland must be also kept separate from the younger old moraines (described by SINN 1972 near Hinterschmalholz). A *locus typicus* for the Günz Ice Age cannot be spoken of, in that the glacial series is, in all cases, only partially preserved. However, the debris of the fourth last glaciation is abundantly present in the upper section of both Günz valleys, so that no serious reason exists for changing the names.

6. Pre-Günz Ice Age Deposits with Ice Age Character

Peculiarly, there is pre-Günz ice age gravel deposits only east of the Salzach, that is, in Austria or west of the Lech. These deposits must be spoken of as cold age and even as fluvio-glacial formations due to their overall structure, that is, distant material with evidence of syngenetical large grain permafrost soil. Similar moraine, which EBERL (1930) described, could not be hitherto confirmed. Nevertheless, there exist no reason for not speaking of those higher debris plains as at least Danube cold age. The conviction is universal, however, that there was foreland glaciation during that time. The name is not strictly bound to a *locus typicus* by EBERL, apart from the fact this old debris in the Zusam plain between the Mindel and the Lech valleys is broken off at a steep bank of the Danube valley. However, the name finds support later through the fact that the Zusam plain without doubt contains debris with a typical Danube facies (Alb limestone, Black Forest crystalline material and red sandstone) at the base of the accumulation. (SCHEUENPFLUG 1970 and LÖSCHER 1973). This debris must be also considered to be from a cold age because of its large colorful distant material facies, for it differs basically from the selected Pliocene Danube debris, which remains north of the present Danube course.

The division of the Danube age gravel plains from those of the Günz Age, which was first carried out by EBERL, has been again placed in question by SINN's antithesis 1972, in which he has constructed the longitudinal profile of the S—N running meltwater deposits in Bavarian-Schwaben in the sense of PENCK, and also in which he has not accepted EBERL's cleared area structure in the longitudinal furrow of Memmingen-Türkheim. However, the large weathered horizon west of the Iller on the highest debris cover with its lack of crystalline material, has been proved to be not only under Mindel deposits, but also under Günz deposits. (Near Hattenburg on both sides of the valley — GRAUL 1968, and the high ground north of Biberach — EICHLER 1970).

7. The Oldest Large Grain Sediment of Cold Climate Origin

SCHAEFER gave a hysometrical even higher group of debris the new name of "Biber" cold age within his coldest "Diluvium", which was supposed to be pre-Pleistocene. Correct is, that the debris both in the Stufenberg (578 meters), which rises approximately 80 meters above the Zusam plain and in the highest "Schotterriedel" watershed in the Aindlingen terrace steps between Leck and Ingolstädter Donaumoos must be older than Danube age and cold age. There is also a tertiary gravel debris in a high lying summit (Kastlberg) east of the Paar, which can be pedologically well separated. ABELE & STEPHAN (1953) have compared this debris with that of the Staufenberg and the upper debris of Aindling.

Conclusion: The lithostratigraphical and pedostratigraphical methods, together with those of geomorphology, have furnished an important contribution to the ice age research in the relative small area which has been dealt with. However, an overintensive use of these methods will without doubt lead to confusion. The local character of some phenomena (e.g. debris-terrace sequence) can lead researchers to misinterpretation through the belief in the overall importance of the work area. They are then to be pitied when universal stratigraphical conclusions are drawn based on local peculiarities. As absolute dating can not be counting on for a long time, relative dating must be expanded in every way. That is why we especially welcome the examination of the uncovered peat in the old moraine areas (see the contribution by FRENZEL) and the search for fossil peat horizons which have been systematically begun. As is well known, evidence thereof is especially the porous deposits of the pleistocene, the fluvio-glacial debris and the gravel moraine under the true soil horizon with varied diagenetic changes by the activity of the water loss, which we can sum up as deep weathering. FEZER (1968) undertook a successful attempt to project the intensity of these occurrences after the elimination of climate variance and petrovariance during the duration of the influence, which he succeeded in doing in the area we are here dealing with. The application of these methods for a stratigraphical division is most certain, of course, in a petrographical uniform area. Relative dating of relict as well as fossil soils has also been attempted palaeopedologically, whereby especially the methodical endeavours of METZGER (1968) in the Heidelberg Geomorphology Laboratory is to be mentioned. As these methods also prove not only four divisions of the ice ages, but, in addition, that pre-Günz relict soils on pre-Günz gravel fields exist, the diagram should, in conclusion, illustrate: the pre-Günz age deposits show a substantial intensivity of the weathering in opposition to the younger formations, which can only be understood as a accumulation of the weathering process through a still longer period of its influence on the surface. Moreover, this accumulation effectiveness of the weathering on the surface can be ascertained also with older fossil soils.

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