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# Geology and Structure of Steinegg Area, Lower Austria

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## Abstract

This paper pertains to the geology of the area around Steinegg in Lower Austria. The rocks of the region belong to a metamorphic complex, the grade of which is about amphibolite-granulite facies of regional metamorphism. The various observations and results of the structural analysis and petrographical investigations of the region in general, and on the rocks in particular are herein recorded.

## Auszug

Diese Arbeit beschäftigt sich mit der Geologie des Gebietes um Steinegg in Niederösterreich. Die Gesteine dieses Gebietes gehören einem metamorphen Komplex an, dessen Grad ungefähr Amphibolit-Granulit-Fazies einer regionalen Metamorphose ist. Die verschiedenen Beobachtungen und Ergebnisse der Strukturanalysen und der petrographischen Untersuchungen dieses Gebietes im allgemeinen und der Gesteine im besonderen werden hier aufgezeigt.

## Introduction

The area under investigation is around Steinegg (Lat. 48° 37' 30" and Long. 33° 13' 30"), a small town on the banks of the river Kamp in Lower Austria. The main link of transportation is the St. Leonhard—Fuglau road which passes through the area. The general geological setting of the area is that it lies on the Eastern flank of the Bohemian massif and forms a part of one of the three granulite bodies to the north of the river Danube in the Moldanubicum zone. This work in its geological and petrological aspects is carried out on the firmament of the earlier works of WALDMAN, 1951; EXNER, 1953 and SCHARBERT, 1964.

During this study, a detailed geological map of the region on a scale of 1 : 10.000 is prepared. To evaluate the structure, the data of the mesoscopic analysis are correlated with the microfabric diagrams constructed from the oriented specimens collected at various localities. The integration ocular is used in estimating the mineral composition of the rocks and a correlation is made of the different mineral assemblages with the facies of the regional

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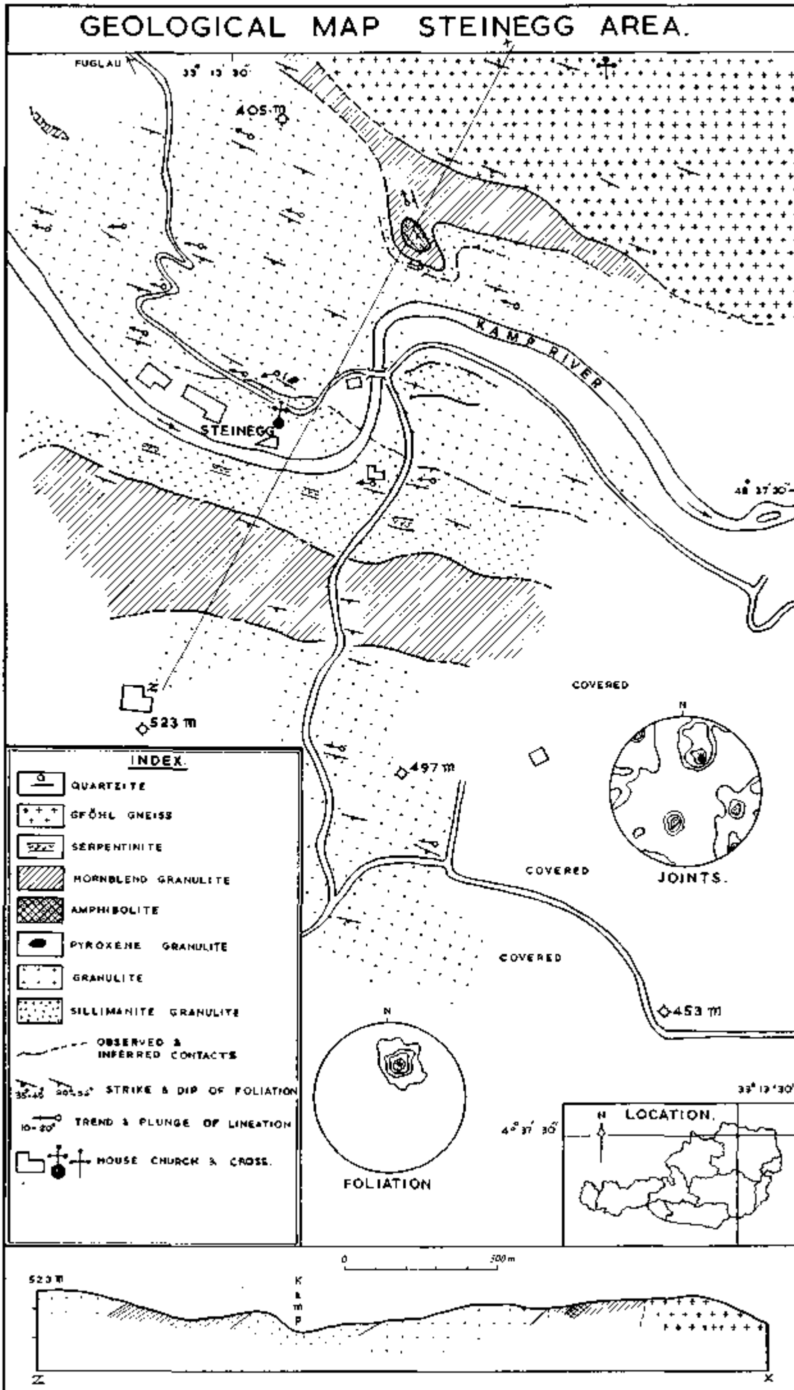

GEOLOGICAL MAP STEINEGG AREA.
FUGLAU
405 m
STEINEGG
KAMP RIVER
523 m
497 m
453 m
COVERED
COVERED
COVERED
JOINTS.
FOLIATION
LOCATION.
INDEX.
QUARTZITE
GFÖHL GNEISS
SERPENTINITE
HORNBLEND GRANULITE
AMPHIBOLITE
PYROXENE GRANULITE
GRANULITE
SILLIMANITE GRANULITE
OBSERVED & INFERRED CONTACTS
STRIKE & DIP OF FOLIATION
TREND & PLUNGE OF LINEATION
HOUSE CHURCH & CROSS.
500 m
Z
X

metamorphism. The Universal stage is used in making the confirmative determinations of the minerals.

## Acknowledgements

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## Field Relations

The three principal rock units of the area are granulites, amphibolitic rocks and Gföhler gneiss. These have been subdivided into seven distinct mineral assemblages on the presence, absence and dominance of certain minerals like biotite, chlorite, sphene, rutile, diopside and sillimanite. These mineral assemblages are recorded in the accompanying table. The enclosed geological map shows the geographical distribution and the geological setting of the different rock units.

The granulites are essentially medium grained quartzo-feldspathic rocks with garnet, biotite and sillimanite. Marked orientation of the constituent minerals, in particular of platy quartz, mica flakes and sillimanite needles result in a strong lineation in these rocks. Prominent development of s-planes and gneissosity is generally observed in the upper reaches and is not so profound in depth. Banding of these rocks due to the localisation of dark minerals with minor foldings are noted at some places (W. H.). The contacts of these rocks with other rock units are tectonic in nature. Gradational contacts are observed at some places.

The amphibolitic rocks are equigranular, medium grained and dark colored. They are in general banded and present a layered appearance. Their contacts with the granulites are gradational at some places but they have sharp contacts with the Gföhler gneiss. Extensive migmatisation is noted in the contact of Gföhler gneiss. Localisation of garnets is also noted.

The Gföhler gneisses are medium grained equigranular quartzo-feldspathic rocks with a distinct metamorphic impress. The minor constituents are generally mica and garnet which are evenly distributed throughout the rock. They have a well developed gneissosity. The contact zone with the granulites is not traceable but the trend of the rocks coincide with the trend of the granulites. The gneissosity is obliterated at the contact but is developed to a good degree at some distance away from the contact.

Pyroxene granulite outcrop, a small lens shaped body within the sillimanite granulite with sharp contacts is located near the Church. The rock is even grained, dark coloured and appears fresh.

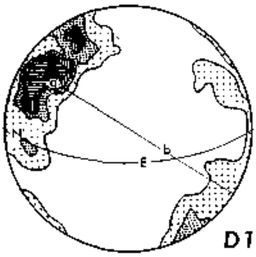
The serpentinites occur in a narrow zone to the south of the river Kamp. This zone may be representing one of the former shear zones of the region. The quartzites and the pegmatites are generally fillings in the widened joint planes and there is no regular oriented pattern of their occurrence.

## Structure

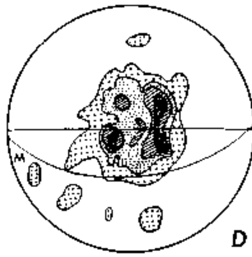
The fabric diagram of 100 foliations showed that the general strike of the region is 110° and that the formations have a southerly dip of 40°. A change in the strike direction to N 30° W is recorded in the northeastern part of the area but it is presumed to be essentially local in nature and does not have a bearing on the regional structure. The foliation appears to be due to the compressive forces acting at right angles to the plane of the foliation (HARKER, 1932). The mean value of 30 lineations is plotted on the s-plane and it is 290°/15°. The lineation is parallel to the axes of the minor folds, particularly observed in the granulites (near W. H.). The lineation is regarded as intersection of two former active s-planes. The fabric diagram of the differently oriented joint planes (poles are plotted) show two maxima whose positions in space are 20°/50° and 200°/50°. They are interpreted as strike (parallel to the mesoscopic b) and cross (a—c) joints respectively. These joint systems seem to have originated during the last stages of deformation (CLOOS, 1937). Limited occurrences of mica segregations and alkali feldspar crystals are found in the s-planes.

To carry out the micro fabric analysis, the area is divided into three domains: I. Granulites, II. Sillimanite granulites and III. Amphibolites. A number of oriented specimens are collected in these domains and are shown on the geological map as A, B, C etc. The preferred orientation of the tectonite minerals — quartz (optic axes) (Figs. 1, 2 and 3), mica (poles of cleavages) (Figs. 4 and 8), sillimanite (c axes) (Fig. 7) and hornblende (interpolated b and c axes) (Figs. 5 and 6) are measured on the Universal stage. The plottings are made on the lower hemisphere. Some of these diagrams (8 figures) are presented here.

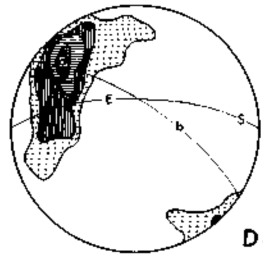
The oriented diagrams of the quartz optic axes show a sharply defined girdle around the b axis. The b axis is the mesoscopic lineation. The symmetry of these diagrams is near orthorhombic symmetry observed in some cases and may be attributed to the pre-existing anisotropy of the parent rock. The mica subfabric diagrams have an axial symmetry and the axes of the diagram coincide with the axes of the fabric. The undulose extinction of the quartz grains and the lengthwise extension of the mica flakes along the s-planes which are noted at a number of places may be regarded as evidences of post-crystalline deformation and mimetic crystallisation respectively.



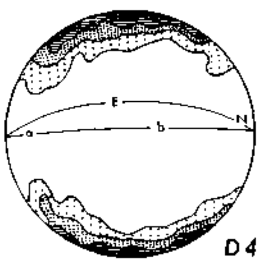
D 1



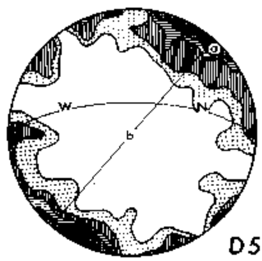
D 2



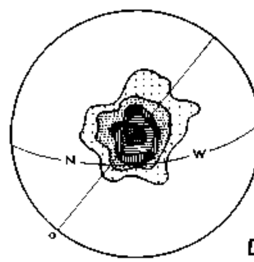
D 3



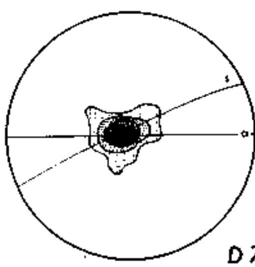
D 4



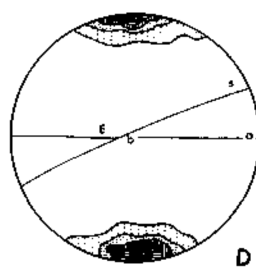
D 5



D 6



D 7



D 8

D. 1. Domain I. Quartz. Optic axes of 300 grains. A = Contours at 9, 7, 5, 3 and 1% per 1% area.

D. 2. Domain I. Quartz. Optic axes of 270 grains. C = Contours at 8, 7, 5, 3 and 1% per 1% area.

D. 3. Domain I. Quartz. Optic axes of 250 grains. D = Contours at 8, 6, 4, 2 and 1% per 1% area.

D. 4. Domain I. Biotite. Poles of 200 (001) cleavages. F = Contours at 12, 9, 6, 3 and 0% per 1% area.

D. 5. Domain II. Hornblende. B axes of 150 grains. G = Contours at 8, 6, 4, 2 and 0% per 1% area.

D. 6. Domain II. Hornblende. C axes of 150 grains. G = Contours at 20, 16, 10, 8, 4 and 0% per 1% area.

D. 7. Domain III. Sillimanite. C axes of 70 grains. H = Contours at 40, 30, 20, 10 and 0% per 1% area.

D. 8. Domain III. Biotite. Poles of 200 (001) cleavages. H = Contours at 25, 20, 15 10, 5 and 1% per 1% area.

The plot of the c axes of the sillimanite with the maximum coinciding with the mesoscopic b shows that the grains tend to orient themselves in the s-plane. The well developed maxima of the (001) cleavages of hornblende coinciding with the constructed lineation but showing no tendency to spread in the s-plane may be attributed to the syntectonic crystallisation of the mineral. The microfabric data in general coincide with the mesoscopic observations.

## Petrography

The granulites have granoblastic texture tending to be gneissic, the amphibolites and the pyroxene granulites have equigranular medium grained textures and the Gföhler gneiss has well developed gneissosity. This gneissosity is regarded as an impress of metamorphism.

Granulites: Quartz exhibits two contrasting shapes and sizes — platy and granular. The platy grains have minute cracks developed at right angles to the direction of elongation. All the grains show brushy extinction indicating that they are subjected to stress. The large grains contain minute inclusions of rutile and plagioclase feldspar. It is also found to occur as poikilitics in the large alkali-feldspar grains. Alkali feldspar present in these rocks has dusty appearance and is generally altered to sericite and kaolin. Plagioclase feldspar ranges in composition from An 27 to An 30. Lamellar twinning as per the simple albite law is the most common. Myrmekitic intergrowths are also observed. Biotite has strong pleochroism and has perfect (001) parting and is generally not altered. Pleochroic haloes are also observed in them. Almandite represents the garnet group in these rocks. The mineral attains considerable percentages in the assemblages 2 and 3. The crystals are euhedral, well developed and are traversed by a number of cracks. Rutile present in these rocks varies in shape from acicular to granular. Sillimanite is present in the assemblage 3, and has the characteristic needle shape. Some instances of this mineral localising in zones along with magnetite is also noted. A few grains of ortho-pyroxenes generally enclosed by garnets are found to be distributed sparsely in these rocks. The composition as determined from the optical data is between enstatite and hypersthene. The formation of muscovite and chlorite from alkali feldspar and biotite in the otherwise stable assemblages of 1 and 2 is also noted.

Amphibolitic rocks: The mineral assemblages of these rocks show only minor variations. The quartz and feldspar are in minor amounts except in the assemblage 5. They are fresh and granular in shape. The plagioclase feldspar with An 42% $\pm$ 3% is present in good amounts and the alteration products are sericite and kaolin. Garnets are almandite in composition. They are traversed by a number of cracks and magnetite is localised in these cracks. The principal mineral of these rocks is hornblende and the interpolated composition of the mineral from the optical data is that it is magnesium rich. The diopside present in these rocks has little amount of Fe. The chlorite present is largely an alteration product. The interpolated composition is towards Mg end. It occurs generally as a pseudomorph of garnet, biotite and hornblende. Relics of hornblende in the chlorite are also observed.

Gföhler gneiss: The mineral composition of these rock resembles to a great extent the composition of a granite. The alkali feldspar dominates and the microcline present shows the characteristic polysynthetic twinning resulting in the gridiron structure. Two types of perthitic intergrowths are commonly observed — bleb and string perthites. The presence of sphene and rutile in the same sections of the rocks is an interesting observation. The garnets are very evenly distributed throughout the rocks and are minute in size.

The formation of chlorite from hornblende, biotite and garnet, and muscovite from alkali feldspar are regarded as an indication of retrograde metamorphism or they could in all probability be representing adjustment to the changes in the conditions of metamorphism during the stabilisation stages. However, the large amount of chlorite present in the amphibolitic rocks (hornblende granulite) favours the setting up of the conditions of retrograde metamorphism.

The granulites which are generally regarded as poor in mica, have in certain cases 9% of biotite. This enrichment in biotite can well be explained thus — biotite with good amounts of Ti can exist in the granulite facies, the necessary Ti for this purpose being taken from the formation of rutile from sphene (after Ramberg). The presence of sillimanite in good amounts may be taken as indicative of the high Al content of the original material (SCHARBERT).

Modal analysis of rock types around Steinegg.

| Minerals | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Quartz | 49.00 | 46.00 | 50.00 | 2.50 | 2.00 | 37.00 | 30.00 |
| Alkali feldspar | 27.00 | 29.00 | 29.00 | 1.50 | 2.00 | 20.00 | 45.00 |
| Plagioclase feldspar | 10.00 | 7.00 | 7.00 | 30.00 | 20.00 | 13.50 | 1.00 |
| Garnet | 2.00 | 8.00 | 6.00 | 8.00 | 18.00 | 12.00 | 2.00 |
| Biotite | 9.00 | 7.00 | 4.00 | — | 6.00 | 8.00 | 8.00 |
| Rutile | 1.00 | 1.25 | 1.25 | — | — | — | — |
| Iron ore | 0.75 | 0.50 | 0.75 | 0.50 | 2.50 | 1.50 | 1.00 |
| Apatite | 0.75 | 0.50 | 0.50 | — | — | — | 1.50 |
| Hypersthene | 0.25 | — | — | — | — | 3.00 | — |
| Sillimanite | — | — | 1.25 | — | — | — | — |
| Hornblende | — | — | — | 54.00 | 35.00 | — | — |
| Diopside | — | — | — | 1.50 | 12.00 | 5.00 | — |
| Sphene | — | — | — | 2.00 | 2.50 | — | — |

1. Granulites rich in mica and poor in garnets (+ rutile).
2. Granulites with mica and garnet (+ rutile).

3. Granulites with mica, garnet and sillimanite (+ rutile).
4. Amphibolite (+ sphene) — sensu stricto.
5. Hornblende granulites (+ sphene) — amphibolite with diopside.
6. Pyroxene granulites — two pyroxene garnet rocks.
7. Gföhler gneiss — granitic gneiss.

## Conclusions

1. The foliation (110°/40° S) is due to a stress system acting in the directions of NNE-SSW.

2. The growth of alkali feldspar crystals and segregation of mica are limited to the plane of foliation.

3. The joint systems have originated during the last stages of formation.

4. The grade of metamorphism of the rocks is equated to the almandite amphibolite-granulite facies on the mineralogical composition.

5. The original sediments appear to be Al rich.

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