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Recent Geological Investigations in Southern Tyrol — Alto Adige, Eastern Alps

Carried out by members of the University of Padua

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With 1 figure

Schlüsselwörter

Alto Adige (Südtirol)
Meran-Mules Complex
Schneeberg Complex
Tauernfenster
Greiner Schiefer
Calcschists with Ophiolites
Brixner Quarzphyllit

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Foreword

The present paper summarizes the results of geological investigations in Southern Tyrol-Alto Adige, carried out during the last years by members of the "National Research Council — Studies Center", University of Padua, Italy. The report reviews also recent publications and articles which are presently under press.

Observations and hypotheses of previous authors were partly confirmed by new and detailed evidence. On the other hand, the present studies led to divergent opinions on several subjects, as can be expected in a complicated area where numerous scientists have been working during the last century, and where various and often contrasting ideas have been developed. Some, even fundamental, problems are still unsolved, awaiting future research.

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The results of the recent studies are presented in the newly published geological map sheets "Merano-Meran" and "Bressanone-Brixen" of the Geological Map of Italy 1 : 100.000, and in the respective "Explanatory Notes".

The region in question was mapped at a scale of 1 : 25.000 by a group of geologists from the Geological Survey and from the University of Padua, working under direction of Gb. DAL PIAZ, A. BIANCHI and B. ZANETTIN.

The report area covers sectors of three main structural units of the Eastern Alps: Austrides, Pennine Zone and Southern Alps.

Austrides

The surveyed area comprises sectors of the "Ötztal-Nappe", a structural element of the Austrides.

Stratigraphic Sequence

B. SANDER established the following lithologic and stratigraphical sequence:

Bottom

1. The Meran-Mules banded paragneisses
2. The Hochkreuz (Laas) micaschists
3. The Schneeberg Complex

Top

Meran-Mules paragneisses and Hochkreuz (Laas) micaschists compose the Meran-Mules Complex. In the north of the Schneeberg belt, the Stubai-"Altkristallin" (an extensive, pre-Mesozoic metamorphic rock unit) is covered by Permo-Triassic sedimentary rocks, the so-called "Tribulaun Unit".

West of the Passeier valley, GREGNANIN & PICCIRILLO (1969) recognized alternations of quartzites and amphibolites between the Meran-Mules paragneisses and the overlying Hochkreuz-Alta Croce (Laas) schists which are possibly indicative of a stratigraphic unconformity.

A similar phenomenon was observed in the eastern sector, north of Mühlwald-Selva dei Molini, in the Speckboden area, where exposures of the Hochkreuz (Laas) micaschists were previously not known to exist (BAGGIO, DALLAPORTA, ZIRPOLI, 1970).

The Hochkreuz (Laas) micaschists are overlain by conglomeratic schists, followed by carbonate quartzites and psephitic schists. These rocks represent the lowest part of the Schneeberg Complex which, in agreement with SANDER, and for reasons to be discussed below, are considered to be of post-Hercynian age.

The above rock unit has been subdivided by E. JUSTIN-VISENTIN & B. ZANETTIN ("Explanatory Notes", Map Sheet Meran-Merano) into two parts: the lower one, called "Gspell-Casabella Series", is composed of a multitude of rocks: quartzites, conglomeratic schists, amphibolites, calcareous schists, giant-sized garnet bearing schists and marbles. The upper part is called "Saltnuss-Salto Series" and consists of monotonous, locally carbonatic, garnet bearing phyllites and micaschists.

The marbles, associated with some amphibolites and few black quartzites which directly overlie the Hochkreuz micaschists (Ratschings Tal, Hochkreuz Spitze, Pfelders Tal) have also to be attributed to the Gspell-Casabella Series. Therefore, the term "Laas Series" (SANDER), widely used by many other geologists working in this area, should not be employed any more because the rocks in question belong to two different units: the micaschists to the Meran-Mules Complex, the marbles to the Schneeberg Complex. To avoid further complications, the term "Hochkreuz micashists" is proposed for the originally pelitic rocks.

The transgression of the Permo-Triassic sequence upon the Stubai paragneisses is marked by a thick layer of conglomeratic schists which form the lowest part of the Tribulaun Complex.

According to ZIRPOLI (1969), an homogenous granodioritic body was emplaced into the Austridic schists in the surroundings of Eidech Spitze (Monte Alto, Pfunderer Tal). The granodioritic intrusion took place after the main phases of the Alpine orogenesis and has therefore considered to be contemporaneous with the granitic-tonalitic intrusions of Rieserferner and Rensen Spitze.

Numerous, slightly metamorphosed dykes originate from the Eidech Spitze granodiorite, cutting through the old crystalline paragneisses as well as through the Mesozoic calc schists.

Structures

It is clearly evident that the metamorphic rocks throughout the report area were strongly folded along axes trending from east-west to northeast-southwest in the western sector. This resulted in a system of isoclinal folds, overturned to the south. Fan-like structures were observed in the eastern sector. Since the folding had also affected the Permo-Triassic sequence, it is certain that the dominant folding phases are of Alpine (Cretaceous-Tertiary) age.

The strongest compression was observed in the region between the Insubric Line and the margins of the Schneeberg Complex. Towards north, the amount of Alpine deformation decreases and pre-Alpine structures have been preserved at places ("Schlingenbau", SCHMIDEGG, 1964).

In the Meran-Mules Complex, formed by paragneisses and Hochkreuz-Alta Croce micaschists, GREGNANIN & PICCIRILLO (1969) detected older, north-northwest trending fold axes.

Also in the Schneeberg Complex, minor folds of meso-to microscopic dimensions were found. Their axial directions do not always correspond with the directions of the major folds (ADAMI, JUSTIN-VISENTIN & ZANETTIN, 1964; JUSTIN-VISENTIN & ZANETTIN, 1965).

Metamorphic and microstructural history

In order to study the petrogenesis of the Austridic schists, numerous microstructural analyses were made.

The Meran-Mules Complex

The banded paragneisses and the overlying Hochkreuz micaschists of the Meran-Mules Complex were studied by GREGNANIN & PICCIRILLO (1969) who recognized the same metamorphic stages in both rock units.

A succession of three main deformations, accompanied and followed by crystallizations, are evident. A fourth petrogenetic phase is of post-crystalline character. Particularly important is the second deformation which caused the present schistosity and micro- to mesoscopical folding (the axial directions vary between north-south and N 40° W). This deformation was followed by an intense static crystallization (Cr_3) of porphyroblastic biotite and garnet; staurolite and kyanite (plus sillimanite); metablastic plagioclase and quartz.

At places, this static blastesis was very intense, resulting in the formation of highly crystallized schists (JUSTIN-VISENTIN & ZANETTIN, 1965; GREGNANIN & PICCIRILLO, 1969 a, b). The latter rocks are particularly abundant in the area Moos-Kolben Spitze-Stulles-St. Leonhard-Jaufen Paß).

A final, more or less retrograde metamorphic phase is everywhere evident which caused a paragenesis of minerals indicative of low temperature: quartz, albite, muscovite, biotite and chlorite. The same petrogenetic history was identified by SASSI (Explanatory Notes, Map Sheet Meran-Merano) in the amphibolites which occur as conformable layers within the paragneisses and micaschists of map sheet Meran-Merano, and by GREGNANIN, JUSTIN-VISENTIN & SASSI (1968, 1969) and GREGNANIN & SASSI (1969) in granitoid gneisses.

Sillimanite-bearing gneiss was recognized by LORENZONI & ZANETTIN-LORENZONI (1965/66) in the Schenna-Rio Masul area, along the northern boundary of the Iffinger granodiorite massif, and in the zone Meran-Vellau-Vernuer.

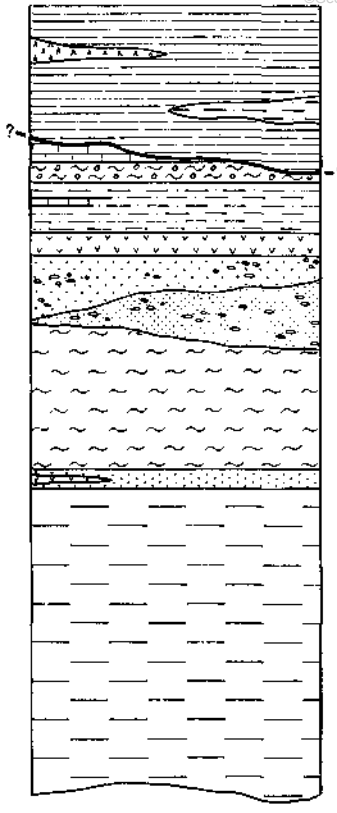
The same authors (1969) conducted micro-structural analyses of the various rock types forming the complexes of Montemarlengo and Giogo S. Vigilio.

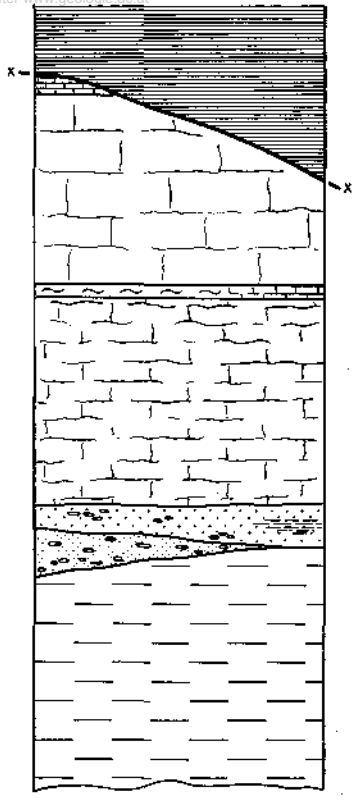
In micaschists of the crystalline basement, several phases of metamorphism are recognizable, whereas in the conglomeratic series and in the overlying quartzites and carbonate rocks only one, very weak metamorphic phase was seen. This led the authors to believe that the weakly metamorphosed rocks are of post-Hercynian age.

GREGNANIN & SASSI (1966) found very conspicuous paragneisses in the upper Ridnaun valley and in the upper Pflersch valley: the rocks consist of thin successions of alternating light- and dark-coloured layers and patches and are disharmonically folded. The mesoscopic appearance is similar to that of arteritic migmatites. However, the absence of potassium feldspars and other petrogenetic features led the authors to exclude an origin by anatexis or magmatic injection. A genesis by metamorphic differentiation is assumed.

The Schneeberg Complex

Microstructural analyses by ZANETTIN & JUSTIN-VISENTIN (1971) revealed several metamorphic stages. It has to be stressed that the most important phase in this case is a postkinematic stage (Cr_3) which occurred under conditions





Schneeberg Complex
Saltnuss series
Phyllitic micaschists
Amphibolites
Carbonate-bearing micaschists
Gspell series
Marbles
Micaschists with large garnets
Carbonate-bearing micaschists
Amphibolites
Quartzites and metamorphic conglomerates (with carbonates)

Oetztal and Stubai old crystalline basement
Hoch Ducrt metamorphic conglomerate (without carbonates)
Hohe Kreuz Spitze micaschists
Quartzites and amphibolites
Meran-Mauls gneisses

? ? Thrust plane

Steinach nappe
Steinach phyllites

Tribulaun - Telfer Weissen Complex
Marbles and calcareous phyllites
"Hauptdolomit"
Phyllites and yellow dolomites
Wetterstein dolomite
Pflersch metamorphic conglomerate and quartzite (with carbonates)

Stubai old crystalline basement
Gürtl metamorphic conglomerate (without carbonates)
Stubai gneisses

X X Overthrust plane

Fig. 1.

corresponding to the kyanite-almandine-subfacies. Similar results were achieved by SCOLARI (1970) on "amphibolites" of the upper Passeier valley. SCOLARI's studies deal particularly with the genetic problem, employing several chemical and modal analyses. At presence, the author tends to believe that the Passeier "amphibolites" probably derive from tuffs and pelites.

The Tribulaun Telfer Weissen Complex

The metamorphism of the Permo-Triassic rocks overlying the Stubai Paragneisses is substantially similar to that of the other units (see graph). One has to remember that the Permo-Triassic strata have generally a lower grade of metamorphism. However, staurolite and hornblende occur locally in the basal conglomerate. The grade of metamorphism is therefore somewhat variable, depending on the intensity of deformation (ZANETTIN & JUSTIN-VISENTIN, 1971).

Comparisons

Of the three main structural units mentioned above, one is certainly of pre-Hercynian age (Meran-Mules), another is definitely Permo-Mesozoic (Tribulaun) whilst the stratigraphic position of the Schneeberg Complex is still being discussed.

Comparing the results of microstructural studies it becomes evident that the metamorphic history of the rocks of Schneeberg Complex could be correlated with the pre-Mesozoic basement (Altkristallin) as well as with that of the post-Hercynian complexes. ZANETTIN & JUSTIN-VISENTIN (1971) think it more likely that the Schneeberg Complex is comparable with the Permo-Triassic unit because of the close lithological and stratigraphical analogies between the basal parts of both complexes (conglomerates, carbonate-free quartzites, conglomerates and carbonate-bearing quartzites, "Garbenschiefer", marble horizons with quartz grains and lenses).

This analogy leads the author to consider the possibility that the postkinematic phase of crystallization (Cr_3) in the Meran-Mules schists is of Alpine (Cretaceous-Tertiary) age. It might therefore correspond to SANDERS "Tauernkristallisation".

As it is well known, an Alpine age of the Schneeberg Complex has already been assumed by SANDER. FRIZ & ZANETTIN-LORENZONI came to similar conclusions. According to these authors, the Jaufen Tal syncline has to be attributed to the Schneeberg Complex and does not represent the calcschist formation of the Pennine Zone.

Petrogenesis

Many occurrences of granitoid gneisses are to be observed within the rocks of the Austridic Complex. They form generally concordant lenticular bodies and stratiform layers.

The most conspicuous mass is a migmatic gneiss complex which crops out in the north of Parcines in the Texel Group. Its central part consists of granitic biotite gneiss and felspathized paragneisses. The northwestern margin of this zone is cut by the tunnel of the Vernagt-Naturns hydroelectric plant which runs for 14 km. in paragneisses of the Meran-Mules Complex and its associated granitoid gneisses (GATTO, LORENZONI, SASSI, ZIRPOLI & B. ZANETTIN, 1964).

Because of chemical analogies between the granitoid gneisses and their country rocks (the paragneisses), LORENZONI & B. ZANETTIN (1964) assumed that the genesis of the granitic rocks might be substantially connected with structural modifications, i. e. through a process of isochemical granitization.

Based on this working hypothesis, LORENZONI & ZULIAN (1968) subsequently analyzed the biotites of the paragneisses, of the granitoid gneisses, and the biotites of the „Augen"-gneiss which is commonly found between the two former lithotypes, representing probably a transitional stage between the former. The authors discovered some systematic variations in the composition of the biotites.

The migmatic gneiss complex of Parcines was studied by GREGNANIN & SASSI (1969): field- and laboratory data show that this rock was formed by injection of granitic magma of anatectic origin which, in the upper parts, caused the feldspathization of the country rocks.

The numerous, stratiform intercalations of leucocratic rocks in the Meran-Mules and Stubai (Breonie) paragneisses have been thouroughly investigated by GREGNANIN, JUSTIN-VISENTIN & SASSI (1968, 1969). Petrographic criterions permitted the authors to distinguish four distinct groups:

1. Granitic orthogneiss (called Tumulo gneisses by the above authors), considered to be a metamorphic product of old, synkinematic injections of leucocratic melts;

2. Leucocratic paragneisses, with potassium felspar and/or chessboard albite "augen"; these rocks are interpreted to be products of metasomatic feldspathization of previously quartz-rich paragneisses.

3. Leucocratic paragneiss, with progressive albite blastesis; also of metasomatic origin;

4. Quartz-albite fels, considered to be the final product of sodic metasomatism.

A field of pegmatites in the Ratschings Tal (Val Racines) was studied by SASSI (1968): The numerous pegmatite bodies which intersect the marbles (or the paragneisses in their immediate neighbourhood) are of variable mineralogical composition. The rocks exhibit an irregular distribution of potassium feldspar. The composition of the light-coloured mica is controlled by the nature of the country rocks. The pegmatites are explained as resulting from a metamorphic mobilization which took place after the tectonic events leading to the dense folding of marbles, amphibolites, paragneisses and micaschists.

Pennine Zone (Pennides)

Three main structural units are exposed in the Tauern window. From bottom to top follow:

a) Groß-Venediger (Gran Veneziano)

b) Greiner

c) Calc schists with ophiolites.

No new specific geological-petrographical investigations of the Tux- Groß-Venediger-Complex were carried out by the "Centro di Studio". The geological field evidence, however, showed a multitude of geologic features, much more complex than was recognized before.

It should be pointed out that the recently performed age determinations confirmed the chronological unity of the Tux and the Groß Venediger (Gran Veneziano) Complexes.

In the Greiner Complex („Untere Schieferhülle"), BAGGIO & DE VECCHI (1965) recognized a succession of metamorphics. In its lower part, detrital features indicative of transgressional deposits are still preserved. The upper part of the section consists of marbles and dolomite-marbles which indicate an ingression. The deposition of the sequence began in Upper Carboniferous times, ending in the Middle-to Upper Triassic epoch.

In the Mesozoic calc schist-ophiolite complex, BAGGIO (1969) distinguished two subdivisions, separated by a horizon of "greenstones" (pietre verdi). The lower sector consists of grey-bluish marbles and of typical calc schists, whereas the upper sector comprises predominantly metamorphosed pelitic rocks. Amphibolites and serpentinites form the intermediate horizon of greenstones. They are usually associated with marbles, dolomite marbles and dolomites as well as with metamorphosed cherts.

An effusive origin of the greenstones has been recognized by DE VECCHI & PICCIRILLO (1968). The highest grade of metamorphism corresponds to the staurolite-almandine subfacies.

BAGGIO & DE VECCHI (1970) ascertained that the schists of the Senges Tal (Val di Senges), until recently attributed to the Greiner Complex, actually belong to the calc schist formation.

Southern Alps

Geological problems in the Southern Alps have mainly been studied by SASSI & ZIRPOLI. Their results are briefly the following:

1. Complete absence of the Hundskopf limestone; the South Alpine phyllites are free of marble intercalations. Small lenses of carbonate rocks are associated with the Klausen - Gufidaun (Chiusa) amphibolite.

2. Many paragneisses are in fact porphyroids or derive from tuffs and other acid volcanics. The occurrence of similar rocks in other exposures of the metamorphic basement of the Southern Alps, i. e. Comelico — unteres Villnöss Tal —

Agordo Cereda area — western Valsugana, led Sassi &Zirpoli to assume the existence of a pre-hercynian rhyolite plateau. The meta-volcanic rocks can be employed for stratigraphic correlation (Sassi & Zirpoli, 1968).

3. The phyllites and paragneisses have stratigraphic contacts.

4. Gregnanin & Sassi (1967) detected chloritoid in phyllites of the Sarntaler Alpen; this is the first recorded find of this mineral in this part of the South Alpine basement complex. Slightly metamorphosed sandstones within the Brixen phyllites were described by Sassi (1968). The sandstones probably separate two stratigraphically well distinguishable units: one of pre-Hercynian — the other of Hercynian age. The phyllites and the graphite - bearing quartzites of Afers and of Villnöss Tal belong to the latter.

5. According to Sassi & Zirpoli (1965, 1968), the grade of metamorphism increases from east to west (from Comelico to the Sarntaler Alpen), and from south to north (from Recoaro to Brixen).

6. Preliminary data on the chemical composition of the white micas (phengitic varietes are scarce) seem to indicate a metamorphism characterized by low pressure.

7. Scolari & Zirpoli (1970) studied the thermal contact zone of the Brixen granite, where phyllites underwent intense structural and mineralogical transformations (formation of hornblende hornfels; migmatites). Particularly interesting is the variable composition of biotites and garnets: rising temperature led to an increase of the TiO_2-content of the micas; in garnet, it produced an increasing almandine content at the expense of spessartine.

Regarding the age of the granite massifs of Brixen—Iffinger—Kreuz Spitze, recent determinations conducted by the Nuclear Laboratory of Pisa gave an age of 273 ± 6 m. y., i. e. late Hercynian. On the contrary, biotites of the northern marginal zones with oriented textures were found to have only an age of 32 m. y.

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