Zeitschrift: Schweizerische mineralogische und petrographische Mitteilungen = Bulletin suisse de minéralogie et pétrographie

Band: 56 (1976)

Heft: 3

Artikel: Fabrics and metamorphism from tonalite, granitic augen gneiss and tonale series at the S-margin of the Swiss Alps, E of Bellinzona

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DOI: https://doi.org/10.5169/seals-43708

Schweiz. mineral. petrogr. Mitt. 56, 635–640, 1976

Fabrics and Metamorphism from Tonalite, Granitic Augen Gneiss and Tonale Series at the S-Margin of the Swiss Alps, E of Bellinzona

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Abstract

This study contains a summary of results about the sequence of deformational acts and conditions of metamorphism within a zone N of the Insubric Line. Deformation of igneous rocks within this zone serves to study deformation quantitatively.

We distinguish the following zones from N to S:

Zone 1: Comprises the Zone of Roveredo in the N (1a) and the Zone of Bellinzona in the S (1b). 1a contains gneisses with garnet, sillimanite and kyanite, ortho-gneisses, calcsilicate-marbles, amphibolites and ultrabasic schists involved in repeated steepaxial folding with km-amplitudes. 1b contains rocks of the same kind. Platy deformation dominates. Migmatites of alpine age and alpine pegmatites are common in both.

Zone 2: Follows S-ward. It contains from N to S: a tonalite, a granitic augen gneiss and the Tonale Series. This series contains prealpine gneisses with marbles, quartzites and amphibolites. Alpine deformation and metamorphism caused widespread formation of garnet-staurolite-kyanite schists from these gneisses. This zone contains subvolcanic dykes in the Tonale series. All these rocks are strongly flattened.

Zone 3: Follows, separated by the Insubric Line, where lenses of non-metamorphosed triassic rocks are pinched in. Zone 3 contains the typical rock types of the Series dei Laghi (Seengebirge).

1. DEFORMATION OF ZONE 1

Zone 1 contains the roots of at least the Simano- and Adula-nappes. These nappes had already suffered refolding during nappe formation and are now

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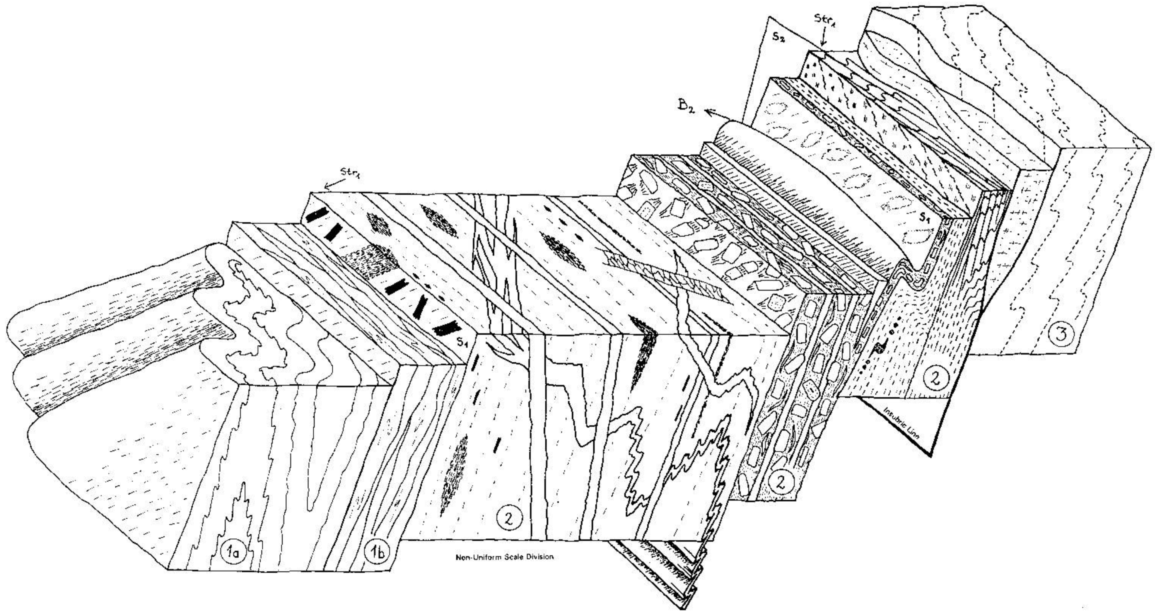

folded again in zone 1. Near Roveredo this refolding occurs round vertical to steeply NE plunging axes and is repeated several times. It occurs in the higher amphibolite facies (Barrow-type) and hornblendes are oriented with c parallel to the fold axes. This direction was also one of extension. High T and locally migmatization outlast deformation. In the S-part of zone 1 (1 b) all rock types show planar parallel textures including compositional layering parallel to the S-margin of the Alps. Hornblendes retain their parallel orientation with c parallel to a steeply NE plunging axis. We are not certain yet whether the platy structure of zone 1 b is the result of extreme flattening of steepaxial folds as they occur in 1 a or whether it is an original, preceding state. There too the T-climax and migmatization outlast deformation. Pegmatites from zones 1 a and 1 b have suffered considerable, but not all deformation of these zones.

2. DEFORMATION OF THE TONALITE

The tonalite is an intrusive magmatic body. This is proved by zoning in plagioclase and allanite-phenocrysts, by homogeniety and xenoliths. Clear contacts to zone 1 have not been found yet. Therefore the important division of structures older and younger than the intrusion could not yet be achieved.

The tonalite is deformed by strong flattening and stretching everywhere. The plane of flattening (s_1) strikes 70° and dips 65° NW. It contains a stretching fibre of constant attitude (str_1) plunging 45° NE. As in zone 1 c of hornblendes coincides with this str. Contrary to zone 1, however, s_1 is never refolded round str. Preferred orientation of quartz, micas and hornblendes yields diagrams displaying orthorhombic symmetry. Therefore it seems justified to regard deformation as a non-rotational flattening. The extents of flattening and stretching are derived from dyke – deformation and – especially – that of xenoliths. These xenoliths are flattened in s_1, stretched in str_1. Their principal axes are those of the strain ellipsoid. This we regard as produced from a sphere of equal volume though the xenoliths were certainly not spherical. Approximate values of deformation are then obtained from the main axes of the strain ellipsoid. The xenoliths are more finely grained and/or richer in hornblende and/or biotite. These differences, however, are small and we take the deformation of xenoliths to be the same as that of the tonalite as a whole.

Flattening and stretching within the tonalite increase continuously from N to S. To explain the kind of increase we distinguish 4 zones from N to S – though no such boundaries are found. The 1st zone, 600 m wide, is flattened to $^1/_5$ of the original width; the 2nd zone, 120 m wide, to $^1/_8$; the 3rd, 80 m wide, to $^1/_{15}$; the 4th, 200 m wide, to $^1/_{44}$. There is a slight decrease of flattening in the most southerly 100 m. In addition there is a narrow zone, 70 m wide, 200 m N of the tonalite S-margin where flattening increases sharply to $^1/_{96}$ of the original width. Now the width of the tonalite is just over 1 km. By a total narrowing of $^1/_{19}$ this has been achieved from an original width of 20 km. The principal extension correlated to this flattening coincides with str_1. From the 1st to the 4th zone this extension is to 3, 5, 9, 12 times the original length, 31 times at the most. An extension in s_1 and normal str_1 is usually to $1\frac{1}{2}$ the original length and may increase to $3\frac{1}{2}$ the original length in the more strongly deformed S-parts. From N to S there are several lamellae, 1–10 m wide, where deformation is either stronger or weaker than in surrounding rocks. The lamellae extend 20–200 m along the strike. Within them deformation increases or decreases by a factor 5.

Relics of magmatic plagioclase and allanite are frequently preserved. Preserved magmatic plagioclase still displays intimate normal oscillatory zoning. The same is true of magmatic allanite though this is changed more thoroughly towards epidote. Frequently allanite has been included by plagioclase growing from the melt. It is attached to growth surfaces, growing from core to margin of the including plagioclase. Deformation occurred under Barrow low amphibolite facies conditions. Hornblendes were largely changed into blue-green ones and partly recrystallized. Plagioclase recristallized as oligoclase – more in more strongly deformed rocks. Often it displays margins richer in An. As there is no coexisting albite we take this to indicate rising T. Allanite continues growing as epidote, again often with margins slightly poorer in Fe. Polygonal grain shapes of recrystallized feldspars indicate that maximum T outlasted deformation.

3. DEFORMATION OF THE AUGEN GNEISS (OF MELIROLO)

This augen gneiss is a younger intrusion following to the S. It includes xenoliths of tonalite and forms dykes in it. The augen gneiss has been affected by the same flattening and stretching. There are too few xenoliths to determine deformation quantitatively but deformation of magmatic quartzes yields similar amounts of flattening. We are certain that what we call str is a flow orientation neither in the tonalite nor in the augen gneiss, contrary to HEITZMANN's (1975) interpretation. The width of the augen gneiss is now 50 m. Assuming a flattening to approximately $^1/_{20}$ of the original width this must have been 1 km.

Feldspar phenocrysts are plagioclases displaying an excellent idiomorphic normal and oscillatory zoning. Other phenocrysts were K-feldspar, allanite, biotite and quartz. It is impossible to interprete the augen gneiss as a marginal zone of assimilation between tonalite and Tonale Series. Contacts against this series are always sharp (contrary to WEBER, 1957, and HEITZMANN, 1975).

Metamorphism during deformation is ruled by the same conditions as mentioned for the tonalite. K-feldspar and plagioclase may recrystallize, quartz and biotite are totally recrystallized.

4. PEGMATITES, APLITES AND THEIR DEFORMATION

Such dykes occurring within the tonalite may be divided into 4 generations. The oldest are found weakly deformed in the N (other generations are missing there), strongly folded in the S. In the N they lie normal to str_1, are thick (up to 3 m) and branching, contain aplite and pegmatite together. Dykes of a 2nd generation start at a more southerly limit and continue to near the S-margin of the tonalite. They are thin (up to 40 cm); in the N they are either filled with pegmatite or with aplite, in the S by both. They strike 90° dipping 50° S. Towards the S they are flattened more and more and rotated towards s_1. A 3rd generation starts even more to the S again continuing close to the S-margin. As the 1st dykes these are normal to str, up to 1 m thick. They are less folded than 1st dykes. Dykes of a 4th generation cover the same area as 3rd ones. They lie normal to s_1 and are the least deformed ones everywhere. At each point younger dykes are less deformed than older ones – i.e. formation of dykes and flattening interfere. Dykes of each generation are increasingly deformed from N to S.

Here within the augen gneiss all dykes are similar, in s_1 and strongly deformed. No dyke was found to cross into the tonalite. Dykes are missing in the S-margin of the tonalite and no cut dyke was found. Similar dykes occur within the Tonale Series and throughout zone 1. It seems likely that they belong to the same swarm and have no genetic relation to either tonalite or augen gneiss.

5. SUBVOLCANIC DYKES AND THEIR DEFORMATION

At its S-margin the augen gneiss interpenetrates the Tonale Series as lit par lit injection, using the pregiven layering. Contacts are sharp. Dykes forming this way were found W of Carena to 100 m away from the S-margin of the augen gneiss. Resulting subvolcanic dykes resemble quartz-rich dykes from zone 2 at Finero (KRUHL and VOLL, 1976) in detail. The width of these dykes does not exceed 15 cm. Their matrix is much finer than that of the augen gneiss which we take to be a preserved chill effect. We have no doubt that these dykes are derived from the augen gneiss and identical with those near Finero. Their plagioclase phenocrysts display the same zones as the ones from the main body of augen gneiss. These dykes have suffered the total flattening having affected tonalite and augen gneiss and also the same metamorphism.

6. DEFORMATION OF THE TONALE SERIES

Within the Tonale Series prealpine gneisses, marbles and amphibolites have gone through the same flattening and stretching as tonalite and augen gneiss. Intrusion of these magmatic rocks and subvolcanics separates prealpine from alpine fabrics. Parts of the Tonale Series adjoining the augen gneiss show str_1 in the same position as in this gneiss. Parts following to the S show lamellae of 1–30 m width with different attitudes of str_1 on s_1: plunging either 45° NE (as in the tonalite), or 55° W. s_1 is refolded everywhere by open to isoclinal folds. Their axes are subhorizontal, their axial plane dips steeply SSE. The correlated s_2 is narrowly spaced, pregiven micas are still largely oriented parallel to the folded s_1. s_2 intersects the pregiven layering (s_1) from N to S downwards. I.e. the vergency is the same as for refolding near Finero.

Assuming again a flattening to $^1/_{20}$ the original width of the Tonale Series must have been 2 km. Metamorphism during this deformation occurred during Barrow low amphibolite facies and led to late formation of garnet, staurolite and kyanite – as in zone 2 near Finero (KRUHL and VOLL, 1976). Marbles developed the paragenesis: amphibole + calcite + quartz + phlogopite. Older amphibolites recrystallize well above the oligoclase isograd. Acid plagioclases of older gneisses are increased in An under secretion of quartz droplets. A rise of T during this metamorphism is indicated by outer zones of plagioclases with higher An, with albite missing, as in the magmatics. Static annealing outlasts deformation.

7. DEFORMATION NEAR THE INSUBRIC LINE

A stack of rocks 50 m wide just N of the Insubric Line has suffered revived strong flattening at already lower T. Quartz recrystallizes again producing very small well oriented grains. An even colder deformation is restricted to this zone and causes mylonites and late kinkbands. Quartz does not recrystallize during this stage, T has sunk below 300° C.

Conclusions

We consider the deformation of zone 2 as alpine, for:

1. From zone 1a (where it is superimposed upon alpine nappes) through zone 1b into zone 2 we find str of always the same attitude. If str is prealpine in zone 2 but alpine in zone 1 this would lead to an unlikely coincidence.
2. Deformations within zone 2 here and zone 2 near Finero are identical. There it is superimposed upon the Monte Rosa root and therefore alpine (Kruhl and Voll, 1976).

Zones 2 + 1b are now c. 5 km wide. Extending the total flattening of the tonalite to the whole of zones 2 + 1b these must originally have been 90–100 km wide. Though it seems nowadays that at least the roots of nappes above the Tambo Nappe are cut out at the Insubric Line it remains to be considered whether they could not have maintained these zones before their late and extreme flattening. A possible cutting out of such roots can hardly have occurred during this late flattening as the Tonale Series continues unchanged from E of Bellinzona to W of Finero.

References

Heitzmann, P. (1975): Zur Metamorphose und Tektonik im südöstlichen Teil der Lepontinischen Alpen. SMPM *55*, 467–522.

Kruhl, J. H. and Voll, G. (1976): Fabrics and metamorphism from the Monte Rosa root zone into the Ivrea Zone near Finero, at the South margin of the Alps. SMPM *56*, 627–633.

Weber, J. (1957): Petrographische und geologische Untersuchung des Tonalitzuges von Melirolo–Sorico zwischen Tessintal und Comersee. SMPM *37*, 267–397.