**Zeitschrift:** Eclogae Geologicae Helvetiae

**Herausgeber:** Schweizerische Geologische Gesellschaft

**Band:** 81 (1988)

**Heft:** 1

**Artikel:** Aplitic intrusions in the Central Aar massig basement : geology, petrography and Rb/Sr data

**Autor:** Abrecht, Jürgen / Schaltegger, Urs

**DOI:** https://doi.org/10.5169/seals-166177

| Eclogae geol. Helv. | Vol. 81 | Nr. 1 | Pages 227–239 | Basel, March 1988 |
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# Aplitic intrusions in the Central Aar massif basement: Geology, petrography and Rb/Sr data

By JÜRGEN ABRECHT[1]) and URS SCHALTEGGER[2])

ABSTRACT

The geologic sequence between the Variscan Central Aar Granite (south) and the sedimentary Mesozoic cover (north) in the Grimsel Pass area (Central Aar massif) consists of basement rocks of Pre-Variscan age. A map is presented based on recent regional studies with a modified subdivision of these geologic units. In the high-grade metamorphic portions of the newly defined Guttannen Unit and the migmatitic Ofenhorn–Stampfhorn Unit, numerous small granitic intrusions occur. Aplitic types predominate a porphyritic facies. For the formation of these post-migmatitic intrusions, a mechanism is proposed which involves the melting of the Variscan crust induced by the ascending Aar-granitic magma. A Rb–Sr whole rock isochron was determined on samples from one of these intrusive stocks. Two independent measurements (made in 1974 and 1986) using the same samples yielded ages of 234.1±26 and 207.6±26 Ma. Geologic and petrographic evidence argue against an emplacement age and the observed isochron is tentatively interpreted as resulting from a Triassic or later hydrothermal overprinting.

ZUSAMMENFASSUNG

Verschiedene tektonische Einheiten prävariskischen Alters sind im Tal längs der Grimselstrasse zwischen dem Zentralen Aaregranit (im Süden) und den autochthonen Sedimenten (im Norden) aufgeschlossen. Dazu gehören die beiden Einheiten Guttanner Einheit und Ofenhorn–Stampfhorn-Einheit, welche auf einer Karte neu definiert werden. Diese beiden Einheiten weisen zahlreiche kleine granitische Intrusionen auf, die in einen aplitischen und einen porphyrischen Typ unterteilt werden. Ein Bildungsmechanismus dieser postmigmatitischen Schmelzen infolge einer durch das zentral-aargranitische Magma induzierten kleinräumigen Krustenaufschmelzung wird als Möglichkeit vorgestellt.

An einer einzelnen Intrusion aus dem Gruebengletscher-Gebiet wurde eine Rb–Sr-Gesamtgesteinsisochrone bestimmt. Zwei unabhängige Messungen an jeweils den gleichen Proben (in den Jahren 1974 und 1986) ergaben Alter von 234.1±26 und 207.6±26 Ma. Geologische und petrographische Evidenzen sprechen gegen ein solches triadisches Platznahme-Alter. Das beobachtete Alter wird vorläufig als Folge einer triadischen oder späteren hydrothermalen Überprägung interpretiert.

## Introduction

The age of the pre-Aargranitic rocks and pre-intrusive events in the Aar massif is still largely unknown. A number of detailed regional petrographic studies (PFLUGSHAUPT 1927, LABHART 1965, NIGGLI 1965, STECK 1966, ABRECHT 1975, SCHALTEGGER 1984) within the pre-Aargranitic basement proved the existence of widespread migmatitic rocks throughout the different geologic units of the Central Aar massif. So far few attempts

[1]) Mineralogisch-Petrographisches Institut, Bernoullistrasse 30, CH–4056 Basel.

[2]) Abteilung für Isotopengeologie, Universität Bern, Erlachstrasse 9A, CH–3012 Bern.

| Innerkirchen-Lauterbrunnen Crystalline Complex (ILC) | |
|---|---|
| Erstfeld Gneiss Zone (EGZ) | Variscan basement |
| Guttannen Unit (GU) | |
| Trift-Formation (TF) | |
| Ofenhorn-Stampfhorn Unit (OSU) | |
| Diechtergletscher Formation (DF) | |
| Mittagflue Granite (MiGr) | Aar Granite s.l. |
| Central Aar Granite s.str. (ZAGr) | |
| Grimsel Granodiorite (GrGr) | |

Fig. 1. Geologic zonation of the Central Aar massif along the Oberhasli Valley. Nomenclature as proposed in this paper.

Lithologic content of the pre-Aargranite basement units referred to in this study (from N to S)

| | |
|---|---|
| Erstfeld Gneiss Zone | Reference: |
| Susten area (N): bi-plg-qtz-gneisses, granitic gneisses with migmatitic character calcareous metasediments, mafic to ultramafic rocks | Schaltegger, 1984 |
| Oberhasli area (S): granitic gneisses (locally with large xenoliths of migmatitic gneisses), bi-gneisses and -schists | Huber, 1922<br>Hügi, 1955<br>own data |
| Mylonite zone (with mesozoic sediments at Furtwangsattel) | Kammer, 1985 |
| Guttannen Unit<br>bi-chl-schists, chl-ser-schists } greenschist facies rocks (N)<br>banded bi-plg-gneisses, migmatitic leucocratic gneisses, calc-silicate inclusions, mafic rocks } amphibolite facies rocks | Hügi, 1955<br>Jequier, 1985<br>own data |
| Volcano-sedimentary Trift-Formation: metatuffaceous rocks, lacustrine sediments | Jequier, 1985<br>own data<br>Schenker, 1986 |
| Ofenhorn-Stampfhorn Unit<br>banded bi-plg-gneisses, migmatitic leucocratic gneisses, bi-gneisses, mafic and occasionally ultramafic rocks | Abrecht, 1980<br>Jequier, 1985 |
| Volcano-sedimentary Diechtergletscher-Formation: pyroclastic rocks, lacustrine sediments | Schenker, 1986<br>Schenker & Abrecht, 1987 |

Fig. 2. Lithologic content of the pre-Aargranitic basement units referred to in this study (from north to south).

have been made to use radiogenic isotope studies to obtain age data for the migmatization event(s) in this area. WÜTHRICH (1965) obtained an age of 286 Ma (Rb–Sr whole rock isochron) on several granites from the Aar massiv and ages between 297 and 315 Ma on biotites (Rb–Sr) from basement gneisses (new constants).

In the Grueben- and Ärlengletscher area (Fig. 3) in the Grimsel Pass area (Oberhasli) a detailed petrographic study (ABRECHT 1975) revealed the existence of small granitic intrusions, never seen in contact with the Aar granite. These small scale intrusions were interpreted by ABRECHT as melts generated during the main anatectic event, which produced the widespread migmatitic rocks occurring in this area. Accordingly an attempt was made to date this anatectic event by dating the time of crystallization by the Rb–Sr whole rock method. However, the obtained isochron yielded the surprising age of 234±29 Ma (219±29 Ma with old constants) which was interpreted as the effect of some undefined Triassic hydrothermal event. Because a similar Rb–Sr age was also recorded from the Mittagflue Granite, which is related to the main Aar granite intrusive body

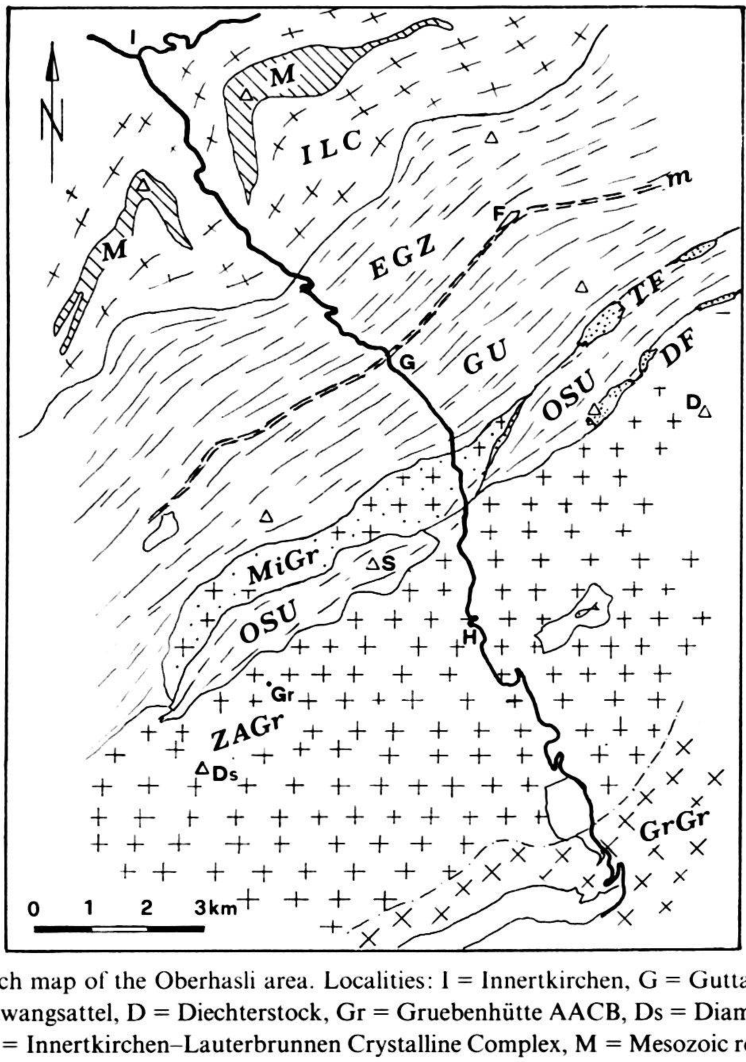


Fig. 3. Tectonic sketch map of the Oberhasli area. Localities: I = Innertkirchen, G = Guttannen, H = Handegg, F = Furtwangsattel, D = Diechterstock, Gr = Gruebenhütte AACB, Ds = Diamantstock.
Geologic units: ILC = Innertkirchen–Lauterbrunnen Crystalline Complex, M = Mesozoic rocks, EGZ = Erstfeld Gneiss Zone, GU = Guttannen Unit, OSU = Ofenhorn–Stampfhorn Unit, TF = Triftgletscher-Fm, DF = Diechtergletscher-Fm, ZAGr = Central Aar Granite, MiGr = Mittagflue Granite, GrGr = Grimsel Granodiorite, m = mylonite zones.

(Schaltegger 1987), the Rb–Sr measurements of the aplitic granite were repeated with today's analytical precision. The new results confirm the age given in Abrecht (1975) within the analytical error.

## Geological frame and petrographic descriptions

The section along the Grimsel road between Innertkirchen and the Grimsel Pass reveals the majority of the main geologic units in the Central Aar massif. Definitions and names of the units have changed with time and have been based mainly on lithological aspects and also genetic interpretations, the latter to some extent no longer tenable. Today a widely accepted general subdivision separates the Variscan Aar Granite (including Grimsel Granodiorite and Mittagflue Granite) from the pre-granitic basement, consisting of the Innertkirchen–Lauterbrunnen Migmatite Complex in the north and basement units in the south, formerly called "Schieferhülle" or "Altkristallin" (Hügi 1967, Labhart 1977). To avoid further confusion with outdated names we propose the subdivision of the basement given in Figures 1 to 3. South of the Innertkirchen–Lauterbrunnen Migmatite Complex (ILC) the following units can be defined (from north to south):

— Erstfeld Gneiss Zone (EGZ)
— Guttannen Unit (GU)
— Trift Formation (TF)
— Ofenhorn–Stampfhorn Unit (OSU)
— Diechtergletscher Formation (DF)

According to Kammer (1985), all these units are separated by mylonite zones of Variscan age but partly reactivated during the Tertiary orogeny. These zones occasionally contain Carboniferous sediments (Kammer 1985). Both the Trift and the Diechtergletscher Formations are volcano-sedimentary sequences of pre-granitic age (Schenker & Abrecht 1987).

In the Guttannen Unit, greenschist-facies rocks predominate. In its southern part migmatitic rocks also occur with small, but locally abundant calcsilicate lenses which indicate the sedimentary origin of these rocks. The Ofenhorn–Stampfhorn Unit is characterized by high-grade gneisses and migmatites and widespread mafic rocks.

A summary of the lithologic content of these units is given in Figure 2.

## The granitic intrusions within the Guttannen Unit (GU) and the Ofenhorn–Stampfhorn Unit (OSU)

Small intrusive granitic bodies are numerous in the GU and the OSU, especially in the Gruebengletscher area. They generally occur as stocks, usually elongated up to 150 m in SW–NE direction, or as crosscutting large dikes (Fig. 4). Several other occurrences were found within the Guttannen and the Ofenhorn–Stampfhorn Units (see also Jequier 1985, Kammer 1985). The localities are all close to either the Mittagflue Granite (MiGr) or the Central Aar Granite s.str (ZAGr) although they apparently do not occur within these Variscan granite bodies. The aplitic dikes related to the Aar granite which intrude the country rock can easily be distinguished from the much darker granitic stocks referred to above. The latter all display sharp intrusive contacts (Fig. 5) with the country rock which

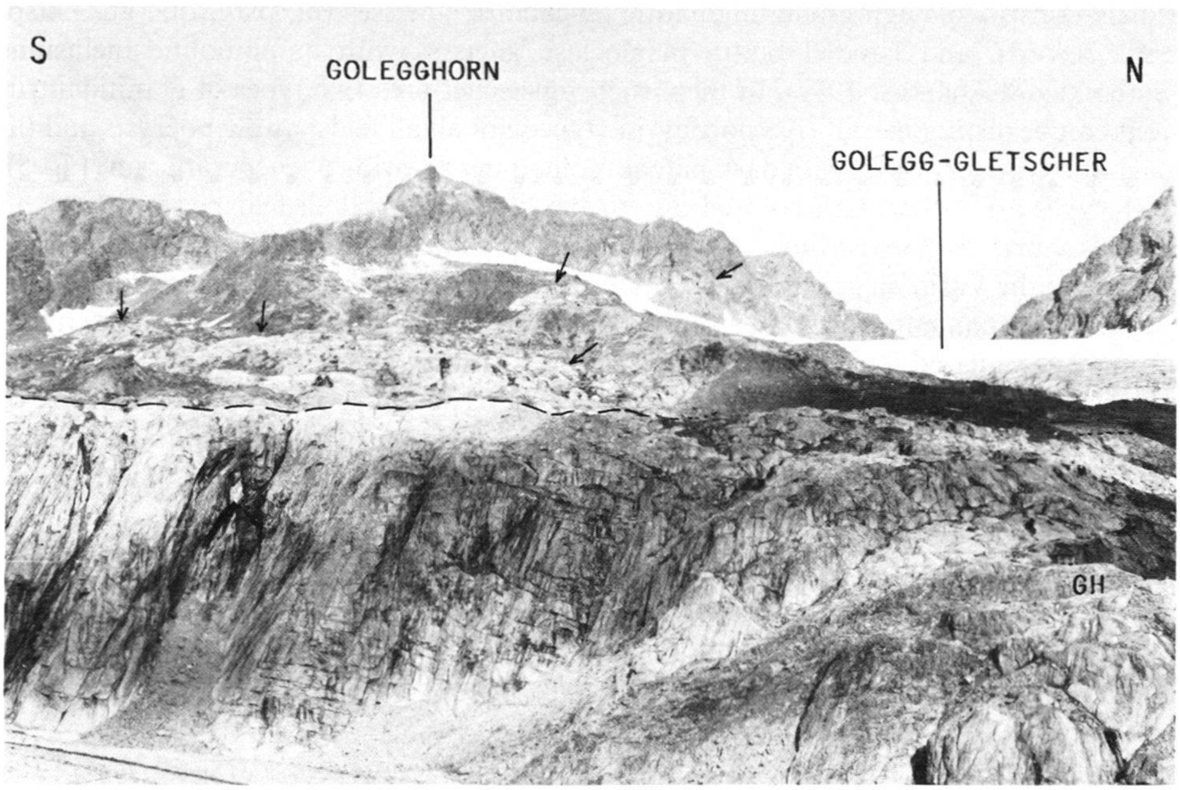


Fig. 4. Photograph of the area to the north of the Gruebengletscher. Foreground: Central Aar Granite. Dashed line: Contact with basement. Aplitic intrusions within the basement are marked with an arrow.
GH: Grubenhütte AACB.

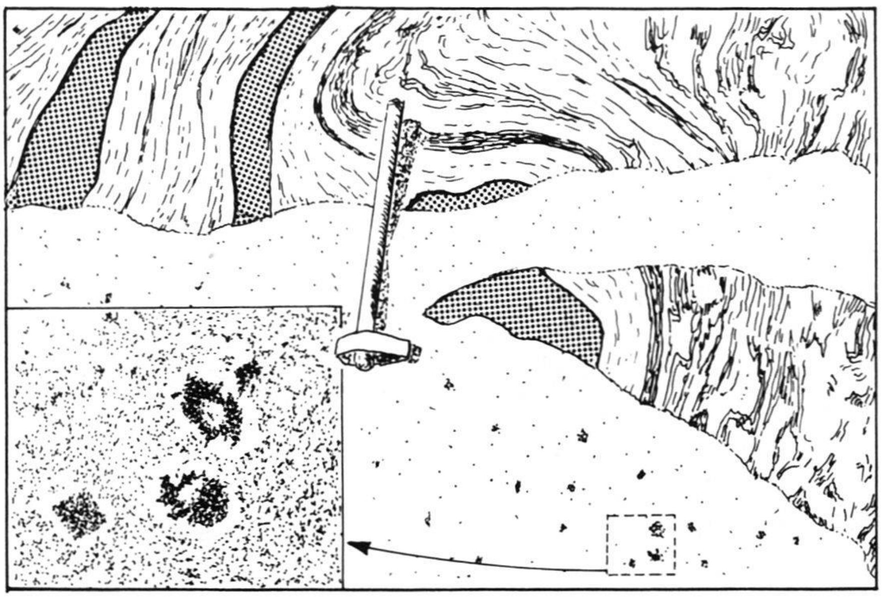

Fig. 5. Aplitic granite (type ii) intruding migmatitic gneisses (with basic sills). Length of hammer: 50 cm. Inset: Mafic patches ( = pinitized cordierite) with leucocratic rims in granite. Gruebengletscher (coord. 662.330/162.300/2850 m).

mostly consists of high-grade migmatitic leucocratic gneisses (bi, plag, qtz, gt, ±kfsp, ±sill, ±cord), and banded biotite-plagioclase gneisses with amphibolitic inclusions (Schenker & Abrecht 1987). In the Gruebengletscher area two types of granitic intrusions can be distinguished: (i) a porphyritic type with alkali feldspar phenocrysts and (ii) an aplitic type very often with dark patches sometimes showing a leucocratic rim (Fig. 5). Both types are rather dark colored due to the bluish-grey alkali feldspar and have an igneous fabric. So far the bluish-grey alkali feldspars have only been observed in rocks older than the Variscan granites. Deformation is strongest in the porphyritic type with its higher biotite content producing a slight foliation. While the inclusions within type (i) are strongly assimilated banded gneisses with diffuse contacts, type (ii) contains inclusions which clearly originated in the adjoining banded bi-plag-gneisses. The crosscutting of migmatitic gneisses indicates that the emplacement of the small granitic bodies postdates the formation of the migmatites in this area.

*Sample description*

Porphyritic type (i): Fine grained (0.5–2 mm) granite. Heterogeneous texture with alkali feldspars up to 2 cm in length. Occasional dark patches of micaceous material (see below).

Aplitic type (ii): Fine grained (0.1–1 mm) granite. Homogeneous equigranular texture. Sometimes diffuse strings of dark alkali feldspars. Irregularly distributed dark patches (spheres or ellipsoids) of 1 to 1.5 cm size, often with a leucocratic rim (0.3–0.5 mm). Both types are granites according to Streckeisen (1975).

Quartz: often corrodes alkali feldspar.

Plagioclase: low-Ca albite (An 0–4%), sometimes relictic high-Ca albite to oligoclase (An 9–11%).

Alkali feldspar: perthitic (Or > 95%). Frequent inclusions of corroded plagioclase. Is typically corroded by quartz (Fig. 6a). The corrosion of feldspar by quartz is typical for both types and may best be explained by sub-solidus reactions.

Biotite: In type (i) 5–10%, with red-brown color, strongly altered to chlorite and Ti-phases. In type (ii) 1–3%. Either greenish-brown (sometimes with brown core) strongly altered grains with abundant inclusions of sphene, epidote, and opaques, or olive-green, fresh looking, fine-grained flakes.

Secondary minerals: Sericite, chlorite, epidote/clinozoisite, sphene.

Accessories: allanite, zircon, apatite, broken garnet.

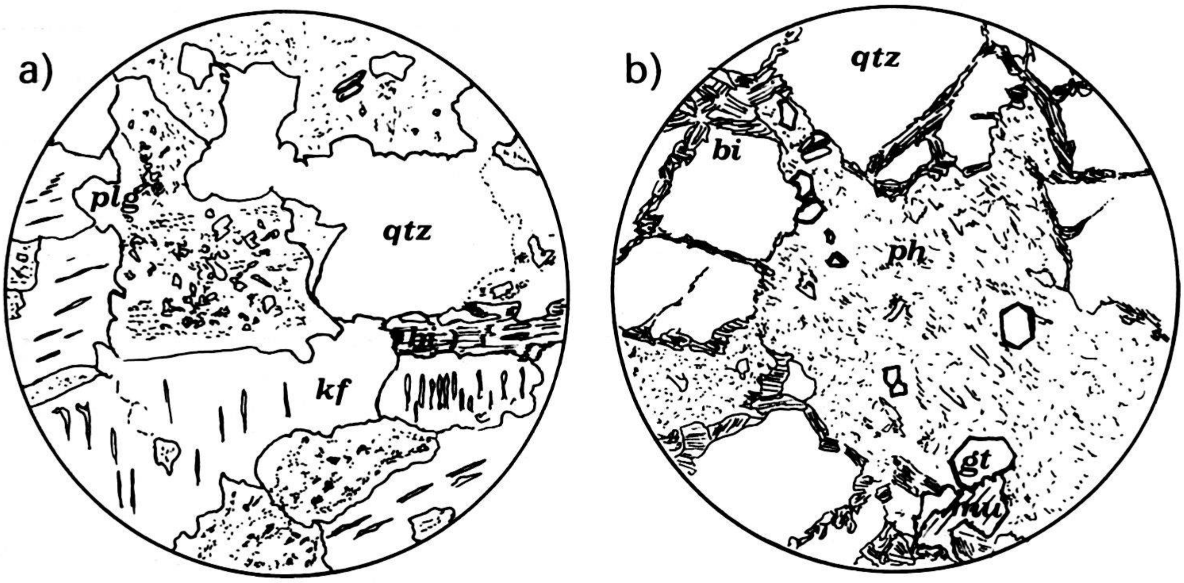


Fig. 6. a) Thin section of the matrix of an aplitic granite with quartz (qtz), corroded plagioclase (plg), perthitic alkali feldspar (kf), and biotite (bi) with secondary Ti-phases. Diameter of figure: 1.25 mm.
b) Thin section of a mafic patch, now consisting of quartz (qtz), phengite (ph), muscovite (mu), biotite (bi), and garnet (gt). Diameter of figure: 1.1 mm.

*Mafic patches or clusters:* Very fine-grained agglomerate of pale green phengite, with larger flakes of corroded muscovite and green biotite (Fig. 6b) together with quartz and frequent idiomorphic garnets showing a slight zonation ($Gross_{44}Spess_{24-35}Alm_{17-29}Pyr_{0.5-1.7}$).

*Chemical data*

The compositions of the two types of granites are given in Table 1. The differences between the two types may be explained by variations in their modal content (biotite for FeO, $Fe_2O_3$, $TiO_2$). However, the higher CaO content in the porphyritic type may be due to more calcic plagioclases. The Sr values of this type range between 220 and 520 ppm (only 3 samples!). The aplitic type shows a more homogeneous distribution with lower contents between 100 and 180 ppm. Rb contents of both types are fairly uniform with about 260 ppm for the aplitic type versus slightly lower values around 200 ppm for the porphyritic type. The data are given in Figure 7, together with data from plag-qtz(-bi) leucosomes from the adjoining gneisses, which have varying Sr contents comparable to the porphyritic granite, but lower Rb contents. In a Q–Ab–Or diagram the available aplitic granite analyses fall near the cotectic line connecting the eutectic point of the system Q–Or with that of the system Q–Ab at $P(H_2O) = 3$ kbars. The data of the porphyritic type are not considered here because their composition may be too strongly influenced by assimilation and relics of gneiss material and therefore not represent the composition of the melt.

*Radiometric data*

*Analytical procedure:* Seven whole rock samples were taken from the same aplite-granite stock above the Gruebengletscher within about 300 m$^2$ (coord. 662.390/162.230). The 12 to 15 kg samples were crushed and milled in agate mills for 15 hours in ethanol p.a. Both Rb and Sr analyses were made by isotope dilution on an AVCO mass spectrometer with triple filament ionization. For the first set in 1974 analytical errors are assumed to be 0.3% on the $^{87}Sr/^{86}Sr$ ratio and 1% on the $^{87}Rb/^{86}Sr$ ratio (1 $\sigma$ standard deviation). The unexpected whole-rock isochron

Table 1: *Chemical compositions of granitic intrusions. PoGr = Porphyritic type (i), AplGr = Aplitic type (ii), with mafic patches. Samples AJ 190–AJ 334 are from the same intrusion as samples used for isotopic analyses.*

| Sample | AJ 32 | AJ 169 | AJ 326 | AJ 35 | AJ 51 | AJ 190 | AJ 332 | AJ 333 | AJ 334 | AJ 382g |
|---|---|---|---|---|---|---|---|---|---|---|
| Type | Po Gr | Po Gr | Po Gr | Apl Gr | Apl Gr | Apl Gr | Apl Gr | Apl Gr | Apl Gr | Apl Gr |
| $SiO_2$ | 71.6 | 70.3 | 72.5 | 75.6 | 75.4 | 74.8 | 74.6 | 77.0 | 76.3 | 74.1 |
| $TiO_2$ | 0.40 | 0.36 | 0.19 | 0.10 | 0.14 | 0.16 | 0.17 | 0.12 | 0.15 | 0.18 |
| $Al_2O_3$ | 14.4 | 14.4 | 15.5 | 14.1 | 14.5 | 14.3 | 14.6 | 14.4 | 14.3 | 13.8 |
| $Fe_2O_3$ | 0.6 | 0.8 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.3 | 0.2 | 0.3 |
| FeO | 1.6 | 1.6 | 0.9 | 0.9 | 0.9 | 0.7 | 1.0 | 0.9 | 0.8 | 0.9 |
| MnO | 0.03 | 0.05 | 0.03 | 0.02 | 0.05 | 0.03 | 0.03 | 0.04 | 0.03 | 0.02 |
| MgO | 0.8 | 1.2 | 0.6 | 0.1 | 0.2 | <0.1 | 0.2 | <0.1 | 0.1 | 0.4 |
| CaO | 1.7 | 2.2 | 2.1 | 0.5 | 0.6 | 0.8 | 0.9 | 0.5 | 0.7 | 0.5 |
| $Na_2O$ | 3.4 | 3.3 | 3.4 | 3.3 | 3.1 | 3.3 | 3.4 | 3.3 | 3.2 | 3.2 |
| $K_2O$ | 4.7 | 4.5 | 4.6 | 5.4 | 4.9 | 5.6 | 5.1 | 5.3 | 5.3 | 5.6 |
| Sum | 99.3 | 98.9 | 100.1 | 100.3 | 100.0 | 100.1 | 100.2 | 102.0 | 101.1 | 99.1 |
| Barth-Niggli-Norm | | | | | | | | | | |
| Q | 27.8 | 25.8 | 27.3 | 32.0 | 34.2 | 30.2 | 31.2 | 33.2 | 32.7 | 29.9 |
| Or | 28.2 | 27.1 | 27.3 | 31.9 | 29.2 | 33.6 | 30.9 | 30.9 | 31.1 | 33.9 |
| Ab | 31.0 | 30.0 | 30.7 | 29.7 | 28.0 | 29.7 | 31.4 | 29.2 | 28.9 | 28.1 |
| An | 7.3 | 9.6 | 9.8 | 2.0 | 2.5 | 3.4 | 4.0 | 2.2 | 3.3 | 2.1 |

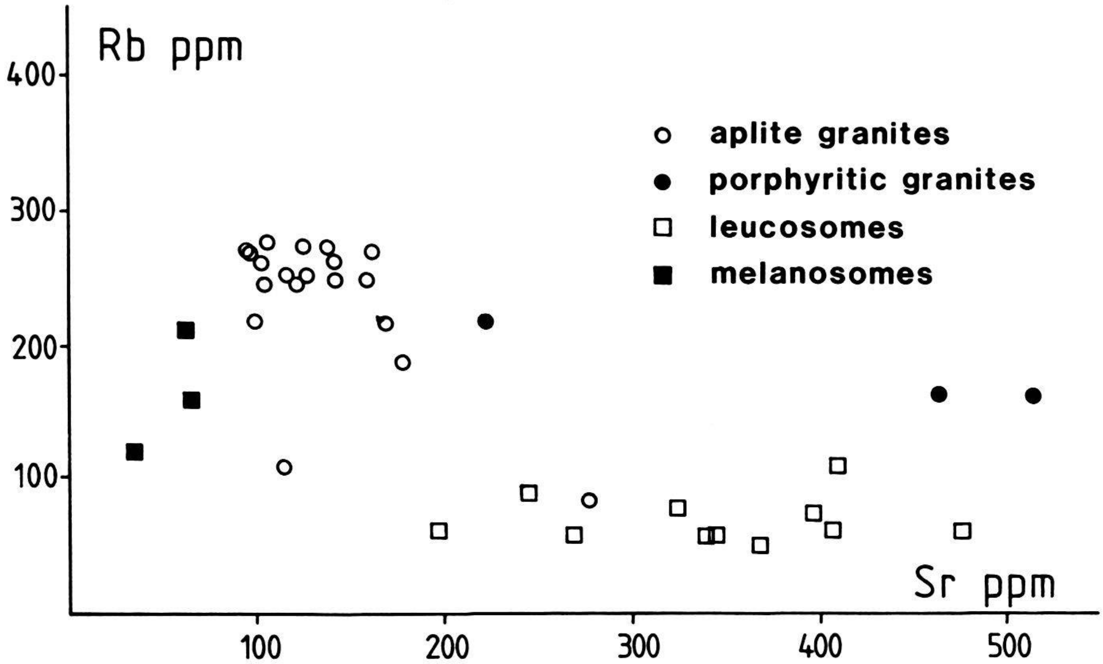


Fig. 7: Rb–Sr diagram for porphyritic granites of type i (filled circles) and aplitic granites of type ii (white circles); leucosomes from migmatitic gneisses of the Gruebengletscher area given for comparison (back squares).

age justified a repeat of the analyses in 1986 with greatly improved precision. The original rock powders were reanalyzed on the same instrument which today has better signal amplification and data processing. The present analytical accuracy is 0.010% on the $^{87}Sr/^{86}Sr$ ratio and 1% on the $^{87}Rb/^{86}Sr$ ratio (1 $\sigma$). Analyses of the NBS 987 standard yielded results of 0.71024 ± 0.00006 (1 $\sigma$) during the 1986 period. For the age calculation the constants recommended by STEIGER & JÄGER (1977) were used, and the isochron calculation was performed following YORK (1969).

*Results:* Rb and Sr results for both measurement periods are given in Table 4. The whole rock isochrons (Fig. 9) yield ages of 234.1±26 Ma (1974 determination recalculated with new constants) and 207.6±26 Ma (1986 determination). Because of the higher accuracy of the newer data set, the age of 207.6±26 and the initial $^{87}Sr/^{86}Sr$ value of 0.716 were taken as the reference values.

## Discussion and conclusions

The relationship between the two types of granitic intrusions is not yet clear. Despite the differences in chemical composition and to some extent in texture, there are strong similarities in their occurrence and modal composition. A similar origin is therefore assumed for the two types. The fact that they crosscut all migmatitic structures of the country rock clearly indicated an emplacement after the anatectic event which is supposedly of pre-Variscan age (SCHENKER & ABRECHT 1987). Therefore these small intrusions cannot be directly related to the migmatitization but have rather been formed by some later event. Another mechanism is proposed which takes into account both their postanatectic intrusion age, as well as their occurrence restricted within areas of pre-Aar-granitic rocks generally lying close to the large Variscan intrusions. According to SCHENKER & ABRECHT (1987) the Aar granite (including the more mafic Grimsel granodiorite and the leucocratic Mittagflue granite) intruded along thrust faults into the Variscan basement. For the large Variscan granites these authors assumed a melting of

Table 2: *Isotopic data for aplitic granite (type ii) form the two measurement periods 1974 (1) and 1986 (2).*

| Sample | | $^{87}$Rb ppm | Sr ppm | $^{87}$Sr/$^{86}$Sr | $^{87}$Rb/$^{86}$Sr |
|---|---|---|---|---|---|
| KAW 1409 | 1) | 54.767 | 144.209 | 0.7280 | 3.883 |
| | 2) | 54.756 | 144.092 | 0.72806 | 3.892 |
| KAW 1410 | 1) | 67.647 | 94.568 | 0.7382 | 7.314 |
| | 2) | 67.893 | 94.018 | 0.73843 | 7.404 |
| KAW 1411 | 1) | 64.044 | 112.198 | 0.7308 | 5.836 |
| | 2) | 64.555 | 112.554 | 0.73155 | 5.877 |
| KAW 1412 | 1) | 64.373 | 99.751 | 0.7374 | 6.598 |
| | 2) | 65.219 | 101.381 | 0.73749 | 6.595 |
| KAW 1413 | 1) | 61.999 | 132.174 | 0.7274 | 4.796 |
| | 2) | 62.625 | 133.430 | 0.72852 | 4.808 |
| KAW 1414 | 1) | 67.156 | 92.381 | 0.7394 | 7.433 |
| KAW 1415 | 1) | 26.760 | 178.178 | 0.7202 | 1.536 |
| | 2) | 26.805 | 178.061 | 0.72194 | 1.541 |

1) Analyses 1974, 2) Analyses 1986

Isochron age: 1) 234.1 ± 26 Ma, initial $^{87}$Sr/$^{86}$Sr = 0.714 ± 0.002
2) 207.6 ± 26 Ma, initial $^{87}$Sr/$^{86}$Sr = 0.716 ± 0.002

the crust due to crustal thickening caused by compressive tectonics. However, such an origin is not supported by unpublished chemical and isotopic data (SCHALTEGGER, in prep.).

We propose a mechanism whereby convective heat loss in the magma body causes partial fusion in higher portions of the granitoid basement gneisses, which in turn results in newly formed granitic melts which segregate and ascend as small diapirs, intruding the rocks which are exposed today. Intrusions of the large Aar granite body took place at the same shallow crustal level somewhat later (ABRECHT 1975, KAMMER 1985).

Compositional differences between the aplitic and the porphyritic rock type might reflect different melting conditions as well as variable starting materials. The relatively high amount of redbrown biotites and textural inhomogeneities in the porphyritic type may be remnants of the source rock indicating a less advanced separation of melt and solid rock than in the aplitic type. The granitic character of the intrusions makes it unlikely that they originated from the alkali feldspar-free or feldspar-poor gneisses which are typical for the OSU and GU. Granitic gneisses of the "Erstfeld" type may be more likely source rocks.

The mafic patches within the aplitic type were interpreted by ABRECHT (1975) as completely altered cordierites (pinite) comparable to the strongly pinitized cordierite reported from the Innertkirchen–Lauterbrunnen Crystalline Complex by RUTISHAUSER (1972). The formation of cordierite in anatectic rocks is a widespread phenomenon described by various authors (see e.g. WIMMENAUER 1950). The cordierite (and garnet?) may be formed by a reaction such as:

bi+als+qtz+ab = kfspar+cord+gt+melt (ASHWORTH 1985).

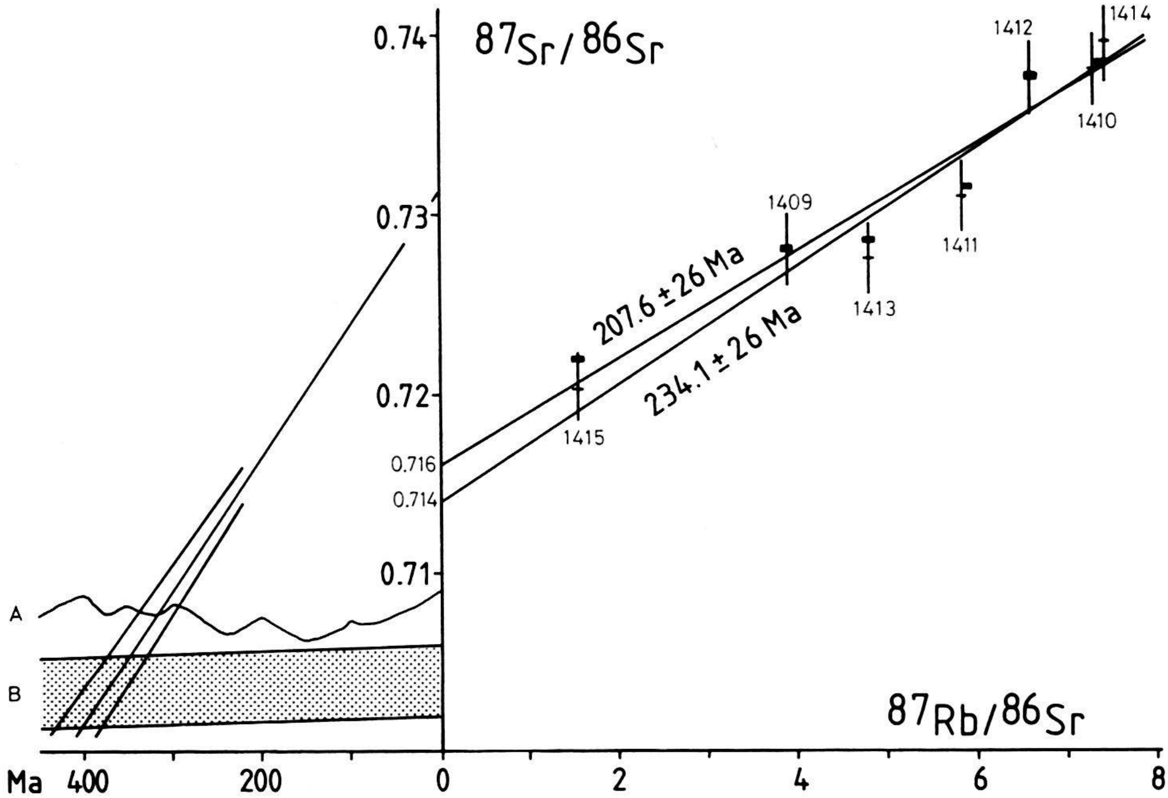


Fig. 8. Combined Sr-evolution and Compston-Jeffery diagram. The two isochrons were obtained during two measurement periods: 1974 data are indicated by large crosses, 1986 data by filled rectangles. The Sr-evolution line of the granitic rock crosses the seawater line (A) of BURKE et al. (1982) at about 315 Ma, the upper mantle limit (B; FAURE 1977) at about 350 Ma, the two points defining the lower and upper limit for the emplacement age.

The fresh appearance of the small idiomorphic garnets suggests that they are of secondary origin, probably contemporaneous with the green biotites. The fine-grained phengite may even be an alteration product of sillimanite which has been formed at the expense of cordierite as described by WIMMENAUER (1950). However the lack of any relics of these minerals makes all further considerations purely speculative. The replacement textures involving feldspars and quartz observed in both rock types suggest an intense post-emplacement hydrothermal activity which may also be responsible for the alteration of the mafic clusters. Based on these considerations, the obtained isotopic age of 207.6±26 Ma does not represent the time of emplacement which must be at least as old as the intrusion of the Central Aar Granite, that is 290 Ma (SCHALTEGGER 1987).

Hence either an alpine rejuvenation of the Rb–Sr system or a Triassic or younger hydrothermal overprinting have to be considered as possible causes for the observed age.
1. Alpine rejuvenation of the Rb–Sr whole rock system: The alpine metamorphism increases continuously from north to south (FREY et al. 1980). The Gruebengletscher area is still in lower greenschist facies, showing partially or completely reset isotopic mineral systems (DEMPSTER 1986), demonstrating that the alpine metamorphism was obviously not able to reset the whole-rock systems in the investigated area. Rb–Sr whole-rock systems stay more or less intact up to amphibolite facies conditions in the Lepontine area making an alpine rejuvenation unlikely.

2. Microscopic observations of sub-solidus reactions in the granites are supposed to be due to the infiltration of (prealpine) hydrothermal fluids. This hydrothermal activity may well have been of Triassic or Jurassic age and the cause of the Rb–Sr whole rock age. The infiltration of the fluids caused a clockwise rotation of the isochron with an increase of the initial $^{87}Sr/^{86}Sr$ ratio by a redistribution of the daughter products in a more or less closed system. A Jurassic age for this infiltration cannot be excluded because an incomplete reset of the isochron would result in the inheritance of the old Sr component. In such a case the isochron would not reach a zero slope and thus yield a maximum age. The scatter of the data points in the Sr evolution diagram (Fig. 8) can be explained by the incomplete reseting of the system. The relatively low initial value of 0.716 indicates rather low primary initial $^{87}Sr/^{86}Sr$ and Rb/Sr values. A two-component mixture (e.g. with the Sr of the fluid phase) can be excluded because the data points do not show any correlation in a $^{87}Sr/^{86}Sr$ vs. $1/^{86}Sr$ diagram. Strong support for this hypothesis is given by a Rb–Sr whole rock isochron of the Mittagflue Granite which yielded an age of $230 \pm 8$ Ma with an initial $^{87}Sr/^{86}Sr$ value of 0.745 (SCHALTEGGER 1987). At present this age is assumed to represent a reset age rather than the intrusion age.

Origin of the fluid phase: The infiltrating fluid affecting the Rb–Sr system of the granites was related either to the cooling Mittagflue Granite or to another origin unrelated in time and space to the intrusion. In the latter case both the aplitic granites and the MiGr were affected simultaneously by the same event. So far we have no indication of a post-granitic volcanic activity in the Central Aar massif. The volcanic rocks along the northern margin of the Variscan ZAGr are intruded by this granite and therefore are older (SCHENKER & ABRECHT 1987). On the other hand we have knowledge of some ore deposits in Triassic sediments of the Central Alps which supposedly are of synsedimentary origin. The triassic sediments were deposited at least some hundred meters above the present surface. However, some small scale fluid convection due to seawater infiltration of the sediments and of underlying basement can be assumed. A possible Jurassic event might be related to a rifting phase as discussed by TRÜMPY (1982). The isotopic re-equilibration of the whole-rock system of large granitic bodies by circulating low-temperature fluids is questionable and not yet understood.

Accepting a secondary effect as responsible for the observed Triassic age, we are still left with the question of the age of emplacement of the granitic intrusions. An estimate may be obtained by extrapolation of the Sr evolution line backwards in time using the average Rb/Sr and initial $^{87}Sr/^{86}Sr$ ratios of the granite (Compston-Jeffery diagram, Fig. 8) making the assumption that the Rb/Sr value of the seven samples is representative for the investigated aplitic granite body. The growth line crosses the seawater evolution curve (curve A) of BURKE et al. (1982) at about 315 Ma and the upper limit of the mantle evolution (curve B, FAURE 1977) at about 350 Ma, both with some 20 Ma error. The intercept of these two evolution lines represent the lower and upper limit for the crystallization age of the granite i.e. the time of homogenization of the granitic material originating from the crust.

Summarizing we would like to give the following conclusions:

— The aplitic granites in the Guttannen Unit and in the Ofenhorn–Stampfhorn Unit are of pre-Aargranitic age, i.e. older than some 290 Ma.

— They were generated by the Aargranitic magma body at deeper crustal levels. They postdate the regional high-grade metamorphism producing the basement gneisses and migmatites today exposed at the same level.
— In Triassic or Jurassic times the aplitic granites were affected by a low-temperature hydrothermal event which reset the Rb–Sr whole rock age.

## Acknowledgments

We would like to thank E. Jäger, M. Satir and P. Stille for the analytical work in 1974. The paper benefitted from critical reviews by S. Ayrton, M. Flisch, R. Hänny, T.P. Labhart, and T. Hurford who translated our Swinglish into English. U.S. would like to thank also E. Jäger and her colleagues at the Labor für Isotopengeologie for discussions and various help. U.S. was supported by a fund of the Schweizerischer Nationalfonds.

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Manuscript received 16 September 1987
Revision accepted 20 December 1987