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U–Pb single zircon study of gabbroic and granitic rocks of Val Barlas-ch (Silvretta nappe, Switzerland)

by *Ulrike Poller*[1]

Abstract

In Val Barlas-ch, one of the Engadine valleys in the area of the Austroalpine Silvretta nappe, 14 gabbroic samples were investigated by geochemical and geochronological methods. The gabbroic rocks can be divided into fine grained metagabbros, blue quartz bearing "metagabbros" and xenolithic "metagabbros". The country rock of the xenoliths is the Mönchalpgneiss, a former S-type granitoid. The blue quartz bearing "metagabbros" are inferred to be the result of assimilation between a gabbroic intrusion and the Mönchalpgneiss.

U–Pb single zircon analyses yielded crystallisation ages around 470 Ma for the fine grained metagabbros and around 528 Ma for the Mönchalpgneiss. The blue quartz bearing "metagabbros" show different zircon types and both ages. Thus the co-existence of a gabbroic and a granitic magma in the late Cambrian is inferred.

Keywords: gabbro, S-type granite, blue quartz, U–Pb dating, Silvretta nappe.

Introduction

For this study fine grained metagabbros of the Val Barlas-ch were investigated by U–Pb single zircon dating. The aim was to determine the crystallisation age of these metabasites and to investigate if all metagabbros have the same intrusion age. For this purpose zircons from several fine grained metagabbros and one quartz bearing "metagabbro" were analysed. Additionally, some U–Pb data of the Mönchalpgneiss were included in this study to investigate the possibility of cogenetic basic and acidic magmas.

The Val Barlas-ch area is situated in the Engadine in the eastern part of Switzerland. It belongs geologically to the Austroalpine Silvretta nappe (Fig. 1). The most frequent rocks are orthogneisses of the "Flüelagranitic Association" and amphibolites. In addition to these gneisses, a second type of orthogneisses belonging to the Mönchalp suite and gabbroic rocks occur. All these rocks are intruded by diabase sills and dikes, the youngest crystalline rocks in Val Barlas-ch. Rb/Sr whole rock data of these diabase veins indicate that they intruded at 280 Ma (HELLERMANN, 1992).

Investigations of VON DER CRONE (1989) on so-called "Fleckengesteine", some metapelitic rocks with 1–2 cm large "Flecken" occurring only in the Val Barlas-ch, suggested P-T conditions of > 700 °C and > 8.5 kbar (decomposition of staurolite). Additional evidence for a high pressure event could be deduced from the orthogneisses bearing zoned garnets and garnet coronas around biotites and from phengites and granulated plagioclase (MAGGETTI and FLISCH, 1993). This metamorphic event caused intense recrystallisation of feldspars in the Mönchalpgneiss. The formation of blue quartz ubiquitous in this orthogneiss, may also be related to this metamorphic event. The absence of such phenomena in the orthogneisses of the "Flüelagranitic Association" gives a relative age determination. The metamorphic event can be dated before the intrusion of the "Flüelagranitic Association" (450 Ma, LIEBETRAU, 1996) but after the crystallisation of the Mönchalpgneiss (528 Ma, POLLER et al., 1997b). Consequently this pre-Variscan metamorphic event is inferred to be Late Cambrian or Early Ordovician.

Pb–Pb leaching of staurolites from metapelites (FREI et al., 1996) yielded 300 Ma for the follow-

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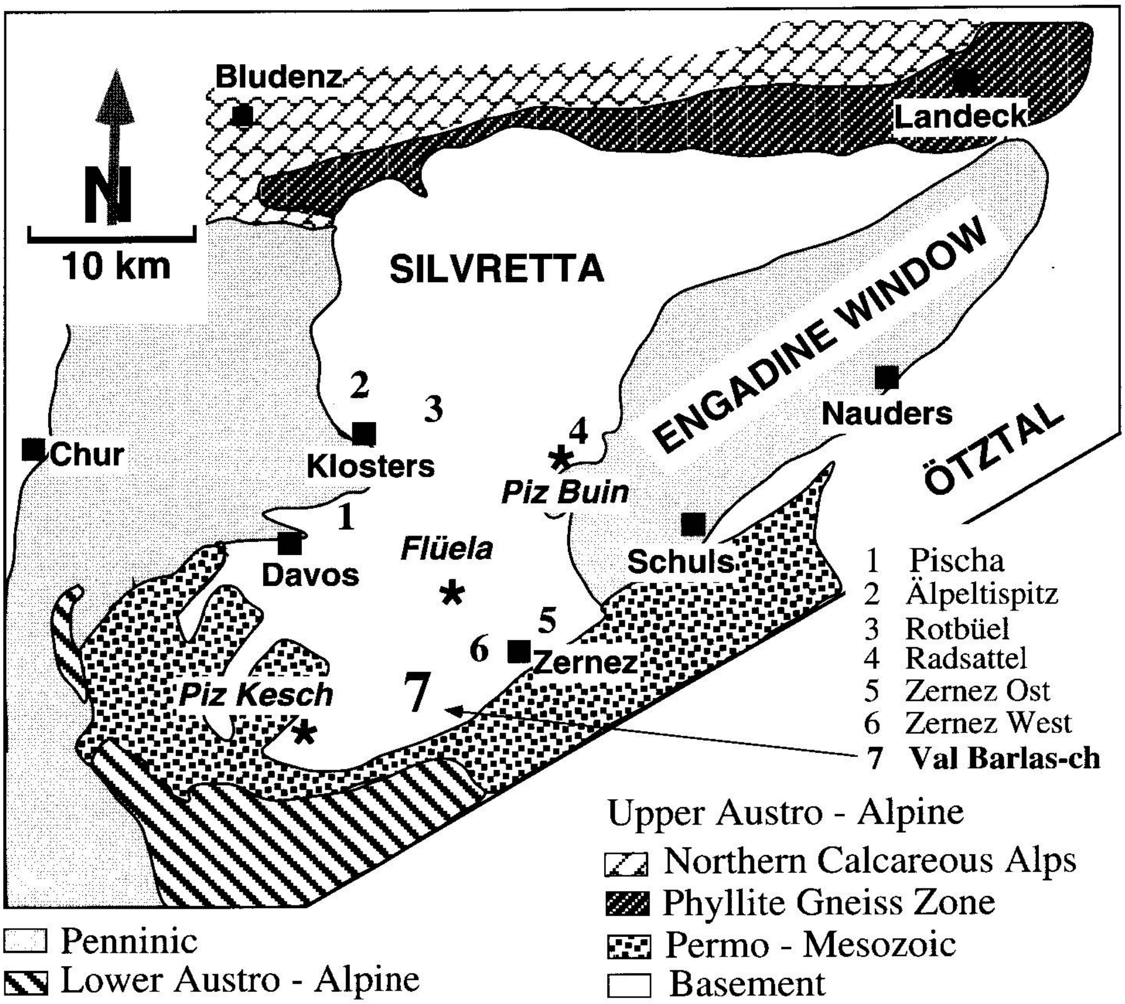

Fig. 1 Simplified map of the Silvretta region after THÖNI (1981) including the main Mönchalpgneiss outcrops and the Val Barlas-ch.

ing Variscan metamorphic event, a regional metamorphism with 600–680 °C and 5.5–7.5 kbar (FLISCH, 1987).

Characterisation of samples

FINE GRAINED METAGABBRO

These metagabbros of the Val Barlas-ch are exposed in the northern part of the valley around the Swiss coordinates 795.950 / 172.900. They are fine grained, aphyric rocks. The metagabbros sometimes show alteration crusts up to 0.5 cm thick. The mineral assemblage visible under the microscope shows plagioclase, amphiboles and corroded pyroxenes. The plagioclase is heavily saussuritized and the amphiboles are strongly altered. K-feldspar often changes to sericite and the biotites are converted to Fe-rich chlorite.

The contact of the fine grained metagabbro to the acidic Mönchalpgneiss is not very well exposed, but in a few cases a sharp contact is visible between the light mylonitic Mönchalpgneiss and the grey-green metagabbro.

The metagabbros near their contact with the Mönchalpgneiss are characterized by blue quartz crystals (see description below about "blue quartz bearing metagabbros"); the latter are ubiquitous in the Mönchalpgneiss. Outcrops of fine grained metagabbro situated far away from any Mönchalpgneiss are quartz free.

Analyses of major and trace elements (Tab. 1) of fine grained metagabbros indicate a tholeiitic character (POLLER, 1994). SiO_2 ranges between 47.5 and 51.0 wt%. With TiO_2 contents of 0.75 to 1.07 wt% and Zr contents of 49 to 74 ppm these metagabbros can be identified as island arc to mid ocean ridge basalts in the Ti–Zr discrimination plot of PEARCE (1982). This tectonic environment seems to be reasonable and corresponds with the results of MAGGETTI et al. (1990) and SCHALTEGGER et al. (this volume).

Tab. 1a Geochemical data of Val Barlas-ch rocks: major elements.

(wt%)	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
A. Finegrained "normal" gabbroic rocks											
UP 353	48.79	1.07	16.48	9.38*	n.a.	0.18	8.49	10.04	1.63	1.31	0.06
UP 357	47.68	0.44	10.38	10.59*	n.a.	0.17	19.53	6.44	0.69	1.70	0.02
UP 361	50.98	0.84	15.31	8.72*	n.a.	0.16	7.76	10.57	2.27	1.58	0.07
UP 364	47.41	0.74	16.45	8.21*	n.a.	0.16	8.87	11.87	2.16	0.91	0.04
B. Quartz bearing gabbroic rocks											
UP 367	60.29	0.79	15.20	6.83*	n.a.	0.11	4.46	6.48	3.43	1.23	0.09
UP 368	53.93	1.54	15.76	8.46*	n.a.	0.15	5.54	6.07	4.23	1.75	0.50
C. Mönchalpgneiss											
UP 250	66.51	0.84	15.15	1.39	3.16	0.07	1.94	2.21	3.14	2.75	0.08
UP 251	66.45	0.76	14.75	1.22	3.50	0.08	2.01	3.78	3.03	2.19	0.14
UP 252	68.42	0.78	14.45	0.96	3.04	0.07	1.55	2.64	2.77	2.75	0.11
UP 253	67.59	0.70	14.50	1.11	3.01	0.07	1.85	3.23	3.10	2.48	0.12
UP 255	66.69	0.75	15.67	1.32	2.72	0.07	1.47	3.40	3.63	2.43	0.22
UP 257	67.89	0.73	14.86	0.83	3.18	0.07	1.22	2.83	3.44	3.00	0.24

* Fe_{tot} as Fe_2O_3 n.a. = not analyzed

Tab. 1b Geochemical data of Val Barlas-ch rocks: trace elements.

(ppm)	Ba	Cu	Cr	Ga	Nb	Ni	Rb	Sr	V	Y	Zn	Zr
A. Finegrained "normal" gabbroic rocks												
UP 353	196	8	332	15	5	86	58	196	232	25	88	74
UP 357	119	27	1141	11	2	458	74	88	175	14	92	36
UP 361	138	1	373	14	5	67	37	103	230	26	85	66
UP 364	132	11	908	14	4	126	30	107	235	18	75	49
B. Quartz bearing gabbroic rocks												
UP 367	358	15	139	18	9	31	48	132	149	33	72	141
UP 368	376	34	148	18	9	56	56	223	144	32	72	202
C. Mönchalpgneiss												
UP 250	1011	29	53	15	14	25	64	211	89	32	92	313
UP 251	500	17	46	16	11	19	73	190	105	24	55	212
UP 252	800	20	60	16	14	25	74	220	80	33	63	280
UP 253	564	16	53	15	10	18	72	189	105	29	56	222
UP 255	908	21	32	17	11	16	62	183	70	30	50	295
UP 257	1407	18	33	14	14	10	68	148	50	33	48	266

BLUE QUARTZ BEARING "METAGABBROS"

In addition to the fine grained metagabbros blue quartz bearing gabbros are also present. They occur in the vicinity of a contact to the Mönchalpgneiss or as 5–25 cm small xenoliths in the Mönchalpgneiss itself. The gabbroic xenoliths within the Mönchalpgneiss contain blue quartz crystals. The quartz crystals are 0.1 to 0.5 cm in size and appear to be similar to those in the Mönchalpgneiss. There is no zoning of the quartz crystals within the gabbroic xenoliths. The fine grained green to grey coloured "metagabbroic" xenoliths also contain K-feldspar phenocrysts from the surrounding orthogneiss. The "gabbroic" xenoliths are often rounded, only in few cases their shape appears angular. Sometimes diffuse reaction zones with fine grained biotites occur between the acidic and the basic material. The chemical composition of the gabbroic xenoliths is different from that of the fine grained metagabbros (see Tab. 1). This is probably a consequence of the small size of the xenoliths which are incorporated into the acidic Mönchalpgneiss.

Tab. 2 U–Pb data of single zircons.

		Measured isotopic ratios (a)			Apparent ages (Ma) (b)		
	Ub/Pb*	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	$^{206}Pb^*/^{238}U$	$^{207}Pb^*/^{235}U$	$^{207}Pb^*/^{206}Pb^*$
A. Gabbroic rocks							
353-2	11.32	3797 ± 43	0.06039 ± 12	0.13574 ± 38	467.3 ± 2.6	468.9 ± 3.4	476.3 ± 2.6
361-2	10.91	488 ± 4	0.08673 ± 18	0.22683 ± 45	473.0 ± 3.1	476.9 ± 6.2	496 ± 24
361-3	10.95	789 ± 6	0.07536 ± 14	0.19238 ± 52	474.5 ± 2.3	477.4 ± 4.1	491 ± 15
361-7	11.52	554 ± 6	0.08304 ± 19	0.17177 ± 60	467.1 ± 3.4	470.7 ± 6.7	489 ± 25
361-10	11.06	914 ± 10	0.07159 ± 17	0.18583 ± 56	470.4 ± 2.6	465.9 ± 5.0	444 ± 17
364-3	10.81	697 ± 12	0.07688 ± 26	0.22659 ± 84	469.3 ± 3.4	467.8 ± 8.1	460 ± 29
364-4	11.35	486 ± 4	0.08592 ± 18	0.23352 ± 85	453.3 ± 3.4	455.2 ± 6.9	465 ± 20
364-5	10.60	1214 ± 9	0.06799 ± 13	0.25709 ± 66	459.7 ± 2.2	459.3 ± 3.6	457.0 ± 9.1
Mean (353-2 til 364-5)					467.0 ± 14.0	468 ± 15.4	472 ± 37.4
367-5	9.76	568 ± 10	0.08382 ± 27	0.19209 ± 80	537.0 ± 3.7	539.3 ± 9.9	549 ± 35
367-6	10.22	450 ± 9	0.09040 ± 24	0.21638 ± 79	510.5 ± 2.9	516.0 ± 9.9	540 ± 44
367-14	11.67	962 ± 21	0.07253 ± 32	0.09197 ± 47	482.4 ± 3.2	487.4 ± 7.6	11 ± 29
B. Mönchalpgneiss							
4899	7.50	1254 ± 14	0.12973 ± 20	0.08994 ± 29	693.3 ± 5.5	1072.4 ± 7.3	1953.0 ± 5.3
4901	10.84	2090 ± 21	0.06381 ± 9	0.08675 ± 27	510.3 ± 3.0	509.0 ± 3.7	503.4 ± 6.9
4904	5.52	1324 ± 29	0.15053 ± 22	0.04832 ± 16	938.6 ± 6.3	1421.0 ± 8.2	2242.8 ± 5.8
4908	8.86	1275 ± 7	0.06881 ± 11	0.29922 ± 83	527.5 ± 4.0	529.4 ± 4.8	537.4 ± 7.6
7004	12.60	270 ± 2	0.10932 ± 26	0.15804 ± 56	460.9 ± 3.2	462.6 ± 7.2	471.0 ± 36

* radiogenic
(a) corrected for fractionation
(b) corrected for blank and common Pb; errors refer to 95% confidence level

The quartz bearing "metagabbros" occur in the contact areas to the Mönchalpgneiss. Their mineralogy is very similar to the gabbroic xenoliths. Under the microscope the amphiboles appear heavily altered and the feldspars are saussuritized and sericitized. Few pyroxenes can be identified. Thin sections of contact areas show the enrichment of biotites which are sometimes altered to chlorite. The quartz phenocrysts show corroded rims and are rich of fluid inclusions. These rocks contain occasionally very thin and fine rutile needles.

The quartz bearing "metagabbros" contain 54 to 60 wt% SiO_2 and are somewhat more acidic than the fine grained metagabbros. Some other elements of the quartz bearing "metagabbros" show different contents (Tab. 1), especially the Na_2O, K_2O Ba, Nb Y and Zr values increase, whereas the MgO, CaO, Cr and Ni contents are diminished. These trends reflect either the presence of the quartz and K-feldspar phenocrysts or the influence of the acidic country rock. Both, the phenocrysts and the Mönchalpgneiss can be responsible for such changes in the chemical composition. A detailed study concerning the geochemical relationship of the fine grained metagabbro, the quartz bearing "metagabbro" (including the xenoliths) and the Mönchalpgneiss is in preparation.

MÖNCHALPGNEISS

The Mönchalpgneiss is a former S-type granitoid crystallised in a collisional environment (POLLER, 1994; POLLER et al., 1997a). The main mineral assemblage consists of blue coloured quartz, grey to white plagioclase, white-yellow K-feldspar and black to brown biotite. Besides granulated plagioclase, the blue quartz is very characteristic of this rock suite and can be used to distinguish the Mönchalpgneiss from other rocks. The reason of the colour remains uncertain but tectonic (deformation during metamorphism) as well as chemical (traces of titanium in the lattice) phenomena might be responsible. The latter hypothesis is not yet supported.

The Mönchalpgneisses can be divided into three groups on the basis of its structural characteristics. While type I shows mainly the primary magmatic texture of the granites, type II is a typical augengneiss, showing K-feldspar megacrysts

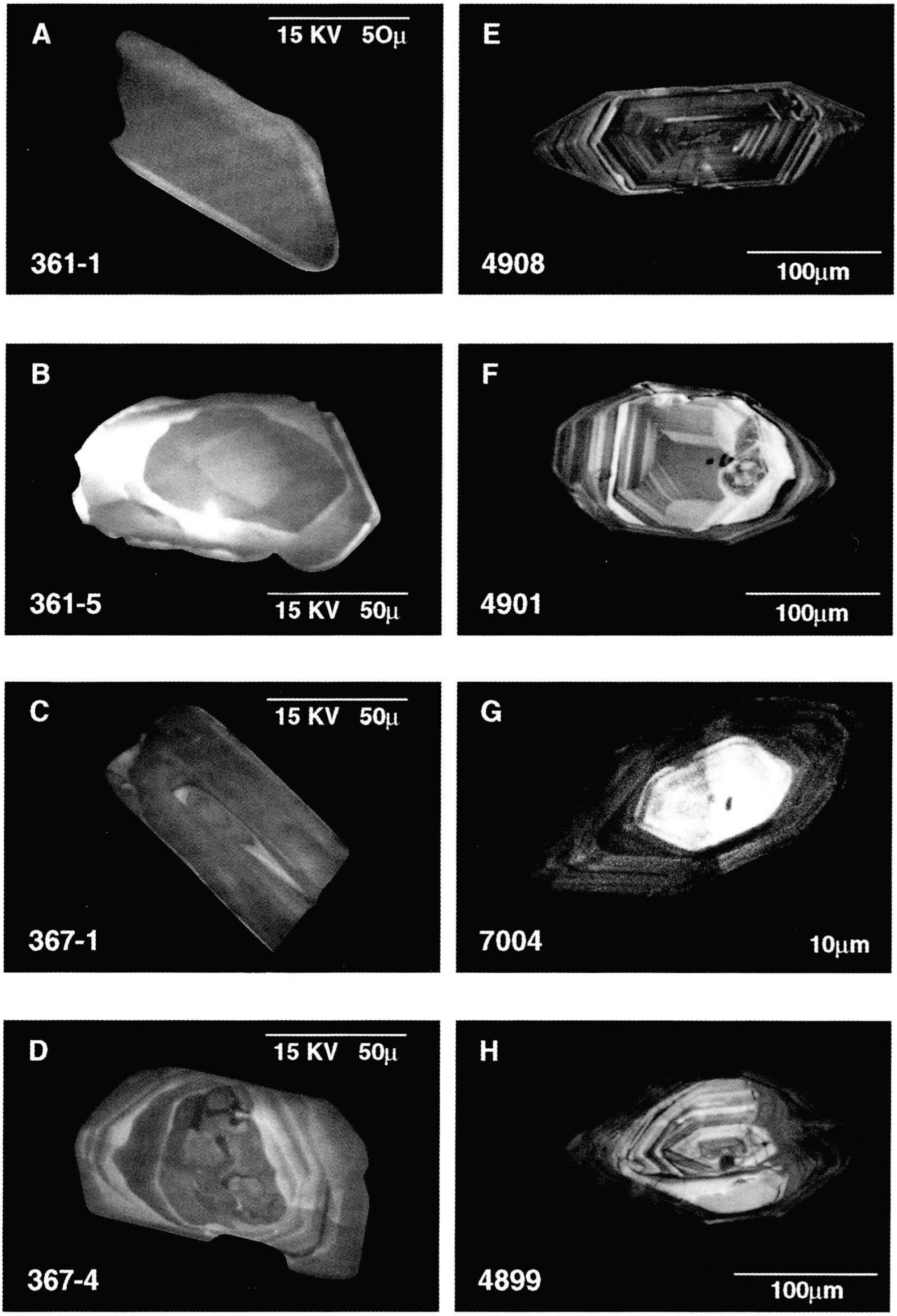

Fig. 2 Val Barlas-ch (A–D) and the Mönchalpgneiss (E–H). Explanations see text.

(2–4 cm) and gneissic texture. The mylonites of type III are the most intensely deformed containing thin light-coloured layers of quartz and feldspar alternating with narrow bands of dark biotite. The intensive recrystallisation of the plagioclases and of some K-feldspars seems to be caused by a high-pressure metamorphic overprint. This is supported by some high-pressure relics (biotite corona around garnet; phengites) in the Mönchalpgneiss of the Engadine area (MAGGETTI, 1986).

Analytical procedure

The zircons were separated using standard techniques like crushing, sieving, Wilfley table, heavy liquids. After separation the zircons were handpicked and the SEM-CL (scanning electron microscope-cathodoluminescence) mounts were made using low luminescent resin. For the CL documentation a Hitachi scanning electron microscope (SEM) at the Max-Planck-Institute for Chemistry, Department of Cosmochemistry was used. After the CL documentation suitable zircons of the same sample were dissolved and spiked with a ^{202}Pb–^{233}U spike. The sample weights range from 1.7 to 6.8 μg and were calculated on the basis of the CL-photographs. The U–Pb measurements were carried out at the Max-Planck-Institute for Chemistry in Mainz (Germany) using a MAT 261 mass spectrometer in multiplier mode. The total Pb blank was about 3 pg. For Pb blank corrections the following ratios were determined: $^{206}Pb/^{204}Pb = 18.59$, $^{207}Pb/^{204}Pb = 15.73$, $^{208}Pb/^{204}Pb = 39.01$. For the common Pb correction isotopic composition was obtained by measurements of leached feldspar ($^{206}Pb/^{204}Pb = 17.88$, $^{207}Pb/^{204}Pb = 15.55$, $^{208}Pb/^{204}Pb = 37.91$). All ratios were corrected for fractionation using the NBS–SRM 982 and NBS–SRM 981 standards as reference (TODT et al., 1996). The fractionation factors were calculated from the standard measurements done parallel to the zircon analyses on each carousel. These factors scattered between 2.9‰ and 3.1‰ per Δmu during the period of measurement. The linearity of the SEM was checked by running an NBS-SRM 982 (LOVERIDGE, 1986).

The major and trace element data of the metagabbroic rocks were obtained by x-ray fluorescence measurements at the Johannes Gutenberg University, Institute of Mineralogy.

The geochemical and isotopic data are given in tables 1 and 2, respectivly.

Cathodoluminescence of investigated zircons

Prior to the U–Pb single zircon analyses, cathodoluminescence (CL) investigations were done. There zircons were picked into a special mount and polished for the scanning electron microscope (SEM). The connected CL-system was used to do CL photographs of zircons from the samples.

For the U–Pb analyses of the Mönchalpgneiss the cathodoluminescence controlled dating (CLC-method) was used. The CLC-method combines CL-imaging with U–Pb measurements by TIMS on the *same* zircon grain. The detailed description of the method is given in POLLER et al. (1997b). The main advantage of the CLC-method is the specific selection of suitable zircons for the U–Pb analyses.

Some CL-photographs are given in figure 2 and will be described in the following.

Grain A, no. 361-1, fine grained metagabbro

The uppermost part of the asymmetric pyramid is lacking. The CL-structures are homogeneous but very diffuse. Neither a sharp zonation nor an inherited component is visible. This is typical for most of the analysed zircons from the metagabbros. The zircon is interpreted to be grown during one single stage, reflecting the crystallisation age.

Grain B, no. 361-5, fine grained metagabbro

This zircon shows no zonation or inherited components. The differences in luminescence are due to the crystallographic face boundaries. The left part shows very intense luminescence because of the orientation of the sample towards the detector (outshine effect). Nevertheless this grain is assumed to be homogeneous and "one-phase".

Grain C, no. 367-1, quartz bearing "metagabbro"

Grain no. 367-1 is a fragment from a prismatic zircon of the quartz bearing "metagabbro". It shows a longish inherited component in the centre. The outer region exhibits low luminescence without sharp structures. Such a weak and diffuse luminescence is typically for all investigated metagabbro zircons.

Grain D, no. 367-4, quartz bearing "metagabbro"

Grain 367-4 is typically for an at least "two-phase" zircon. The crystal bears a large inherited component with diffuse cloudy luminescence. The later grown outer rim is magmatically zoned. The shape is dominated by the {100} prism, the {110} pyramid is asymmetric.

Grain E, no. 4908, Mönchalpgneiss

This prismatic zircon is a very homogeneously zoned grain. It is a "one-phase" zircon without any older component, typical for magmatic growth. This grain was dated to get information about the crystallisation age of the Mönchalpgneiss.

Grain F, no. 4901, Mönchalpgneiss

In contrast to the grain no. 4908 the zircon 4901 shows a dominant {110} form with respect to {100}. In the left part and the centre the crystal shows magmatic zonation as well, but the right part is overlain by an area of diffuse luminescence. This might be due to later resorption.

Grain G, no. 7004, Mönchalpgneiss

Zircon no. 7004 can be described as "by-pyramidic" because of the dominance of the {110}. It has a strong luminescent inner part and a less luminescent outer rim. Both regions exhibit a homogeneous zonation due to magmatic growth. The orientation of the zones does not change between the light and the dark park. Thus this grain is interpreted to be a "one-phase" zircon. The differences in luminescence are due to changes in REE-contents during the crystallisation.

Grain H, no. 4899, Mönchalpgneiss

This zircon grain again has dominating {110} with respect to {100}. It bears a large core. This core component preserves an older zonation. The outer rim is homogeneously zoned. This grain was chosen to get information about the protolith of the Mönchalpgneiss.

The presented CL-photographs are examples of the investigated zircon grains. The zircons of the fine grained metagabbros (UP 361, UP 364, UP 353, UP 357) always have such a diffuse CL as shown in figure 2A without older components or zonation.

In contrast the quartz bearing "metagabbros" show besides these structureless grains also some zircons with inherited components as shown in figure 2D. This infers, in addition to the blue quartz content and to geochemical differences, different magma sources for Mönchalpgneiss and quartz bearing metagabbros.

The Mönchalpgneiss zircons show rarely purely magmatic zoned crystals, but a large variety of core bearing ones as expected from a former S-type granitoid.

U–Pb single zircon dating

In order to get the crystallisation age of the metagabbros and to investigate the age relation between the gabbros, the Mönchalpgneiss and the xenoliths, U–Pb single zircon analyses were done. In addition to several "normal" fine grained gabbros of the Val Barlas-ch, a sample with blue quartz was measured (UP 367). These data were compared with the U–Pb single zircon results obtained by the CLC-method for the Mönchalpgneiss. The data are compiled in table 2.

Eight analyses of single zircons from three fine grained metagabbros of Val Barlas-ch resulted in a mean $^{206}Pb/^{238}U$ age of 467 ± 14 Ma (Fig. 3). This Ordovician age is interpreted to be the crystallisation age of the fine grained metagabbros. It is well constrained by the homogeneous CL-photographs on zircons assuming a single stage character of the rock.

In contrast to the very consistent ages of the fine grained gabbros the quartz bearing sample UP 367 shows zircons with different ages (Fig. 3). The $^{206}Pb/^{238}U$ age of the youngest zircon is 482

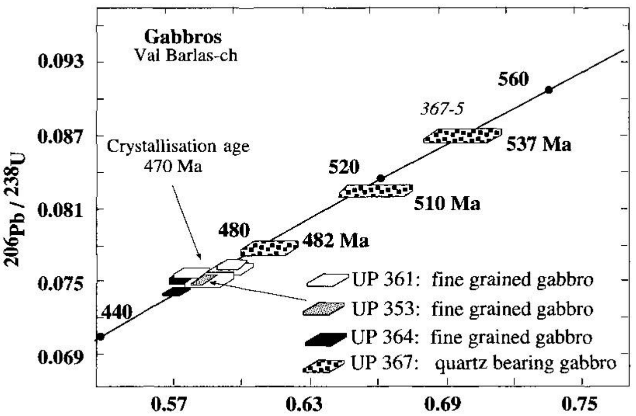

Fig. 3 U–Pb concordia plot for Val Barlas-ch gabbroic rocks.

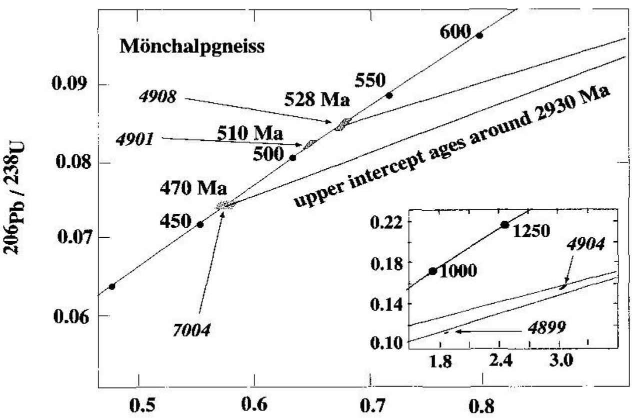

Fig. 4 U–Pb concordia plot for the Mönchalpgneiss.

± 3 Ma. Additional $^{206}Pb/^{238}U$ ages at 510 ± 3 Ma and 537 ± 4 Ma were measured (Tab. 2).

For the U–Pb age determination of the Mönchalpgneiss (Fig. 4) the CLC-method was used. The Mönchalpgneiss shows a Cambrian crystallisation age (grain 4908) around 528 Ma, a younger event (grain 4901) at 510 Ma (possibly the high pressure event proposed by MAGGETTI, 1986) and the final overprint (grain 7004) around 470 Ma. The core bearing grains 4899 (Fig. 2H) and 4904 (no photo) define discordia lines with upper intercept ages around 2.93 Ga (POLLER et al., 1997b).

Discussion

Combining the geochemical analyses and the geochronological data of the gabbroic rocks of the Val Barlas-ch an evolution model is developed to explain firstly the different zircon ages and secondly to present a solution for the relationship between the Mönchalpgneiss and the gabbroic rocks.

For the *fine grained metagabbros* of the Val Barlas-ch the situation is very straightforward: these typical island arc basalts crystallised around 470 Ma ago in Ordovician time. These results are in good correspondence to the investigations of SCHALTEGGER et al. (this volume), who also found Ordovician crystallisation ages (473 ± 5 Ma) for the gabbro pegmatite of Val Sarsura, situated north-east to the Val Barlas-ch.

The situation for the *quartz bearing "metagabbros"* is more complicated because of the variety of the occurring ages between Cambrian – Late Cambrian and Ordovician. With regard to the results of the investigations about the "older orthogneisses OOG" by SCHALTEGGER et al. (this volume) the following interpretation is possible.

The quartz bearing "metagabbros" have crystallised around 537 Ma ago, indicated by the concordant analyses of UP 367-5. This intrusion age is well represented by other rocks of the OOG, as reported by SCHALTEGGER et al. (this volume).

In Late Cambrian time (510 ± 3 Ma) another event is detected by the single zircon measurement. This event might be interpreted as high pressure overprint which has effected not only the OOG but also the Mönchalpgneiss.

The youngest found ages of the quartz-bearing "metagabbros" are also Ordovician. They correspond with the major gabbro intrusion in the Val Barlas-ch about 470 Ma ago.

For the *Mönchalpgneiss* nearly the same scenario can be envisioned: the crystallisation age is around 528 Ma, followed by the Late Cambrian (510 ± 3 Ma) age and the last major overprint with new zircon growth in Ordovician time (470 Ma).

Constraining the crystallisation ages and the last overprint there is a good correspondence with other studies on plagio-granites, metatonalites, gabbro pegmatites or metagabbros (MÜLLER et al., 1995; SCHALTEGGER et al., this volume).

Geologically the above interpretation of the U–Pb age data appears to be reasonable: the back-arc signature of the Mönchalpgneiss and the island arc signature of the fine grained metagabbros fit well with the model of a Cambrian ocean and its closure time in Ordovician. This is in agreement with the under collisional conditions intruded orthogneisses of the "Flüelagranitic Association", Late Ordovician to Early Silurian in age (LIEBETRAU, 1996; POLLER et al., 1997b). The intermediate age around 510 Ma is not yet interpreted definitely. It cannot be distinguished from a discordia between 528 Ma and 470 Ma but it might be a result of the high pressure event proposed by MAGGETTI (1986). Petrographic investigations on the OOG and the Mönchalpgneiss gave evidence for such a high pressure event. In contrast the fine grained metagabbros of the Val Barlas-ch and the orthogneisses of the "Flüelagranitic Association" show not at all influences of a high pressure metamorphism.

Considering the crystallisation age for the quartz bearing "metagabbros" (sample 367) and the Mönchalpgneiss (sample 4908; both around 530 Ma) and for the fine grained metagabbros and the orthogneisses of the "Flüelagranitic Association" (LIEBETRAU, 1996; POLLER et al., 1997b) around 470 Ma, this high-pressure event must have occurred between 530 Ma and 470 Ma.

The interpretation of the 510 Ma U–Pb ages as the possible high pressure event seems to be relevant. To constrain the model this age should be also found in all other OOG rocks affected by the HP event.

To summarise the situation in the Val Barlas-ch can be described as follows:

1. In Cambrian time an island arc produced tholeiitic basalts, today present as quartz bearing "metagabbros". The Mönchalpmagma intruded at the same time. Thus, 528 Ma ago two different magmas co-existed in the Val Barlas-ch. At the contact the metagabbro assimilated quartz and K-feldspar from the orthogneiss.

2. In Late Cambrian time a high pressure overprint affected the quartz bearing "metagabbros", the Mönchalpgneiss and the OOG. This event might also be responsible for the blue colouring of quartz.

3. In Ordovician time the ocean began to close and a new intrusion of gabbros was released.

These rocks are present as fine grained metagabbros of the Val Barlas-ch.

The orthogneisses of the "Flüelagranitic Association" intruded syn-collisional.

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