Geochemistry of basaltic and gabbroid metaophiolites from the Susa Valley, Italian Western Alps

Autor(en): **Pognante, Ugo / Toscani, Lorenzo**

Objekttyp: **Article**

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

Band (Jahr): **65 (1985)**

Heft 2-3

PDF erstellt am: **21.07.2024**

Persistenter Link: https://doi.org/10.5169/seals-50224

Nutzungsbedingungen
Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.
Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.
Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss
Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Ein Dienst der *ETH-Bibliothek*
ETH Zürich, Rämistrasse 101, 8092 Zürich, Schweiz, www.library.ethz.ch

http://www.e-periodica.ch

Schweiz. mineral. petrogr. Mitt. 65, 265–277, 1985

Geochemistry of basaltic and gabbroid metaophiolites from the Susa Valley, Italian Western Alps*

by *Ugo Pognante*** and *Lorenzo Toscani****

Abstract

This paper presents geochemical data on basaltic metabasites and metagabbroids of the ophiolites of the western Alps along the Susa valley traverse. In this area the ophiolites occur in a few tectonic units and represent disrupted sections, tectonic slices or olistoliths of the oceanic-type lithosphere of the Jurassic western Tethyan basin. The analyzed rocks crystallized from melts having affinities to magmas producing normal-MORB. With respect to normal-MORB, the alpine basalts are enriched in some hygromagmatophile elements (in particular Zr). The similar ratios for some hygromagmatophile elements (Ti/Zr, Zr/Nb) in all the analyzed basalts are suggestive of derivation from not very heterogeneous peridotitic mantle sources, by slightly different degrees of partial melting and/or by more or less advanced crystal fractionation.

Keywords: Metamorphic ophiolites, geochemistry, Tethys, trace element, Italian Western Alps.

INTRODUCTION

A great amount of geological, petrological and geochronological data have demonstrated that the ophiolites of the western alpine belt formed during the Jurassic by tensional and transcurrent tectonics in a small basin of the western Tethys (ELTER, 1971; DAL PIAZ, 1974; LEMOINE, 1980; LOMBARDO and POGNANTE, 1982; AUZENDE et al., 1983; POGNANTE et al., 1986). In particular, the petrological and geochemical contributions indicate close similarities between the petrogenetic processes associated to the opening of this small basin and the processes occurring in mid-ocean ridges (LOMBARDO et al., 1978; LEWIS

---

* This paper is part of a C.N.R. (Centro di Studio sui Problemi dell'Orogeno delle Alpi Occidentali, Torino) programme.

** Dipartimento di Scienze della Terra, via Valperga Caluso 37, I-10125 Torino, Italy, and Centro di Studio sui Problemi dell'Orogeno delle Alpi Occidentali.

*** Istituto di Petrografia, via Gramsci 9, I-43100 Parma, Italy.

and Smewing, 1980; Dal Piaz et al., 1981; Pognante et al., 1982). In spite of these similarities a few recent works (Venturelli et al., 1981; Auzende et al., 1983; Beccaluva et al., 1984; Pognante and Piccardo, 1984; Pognante et al., 1986) have revealed that some ophiolites of the western Alps display more or less different lithostratigraphic and geochemical features that should testify the various stages of opening of the basin and/or different settings (i.e. closer to transform faults or to mid-ocean ridge-type structures).

This paper presents and discusses new geochemical data on metabasalts, metabasites and metagabbros from the ophiolites of the Susa valley traverse through the italian western Alps (west of Torino, Fig. 1).

GEOLOGIC SETTING

Along the Susa valley traverse the metaophiolites include more or less serpentinized tectonite peridotites (mainly lherzolites), metagabbros and metabasites often representing original pillow or brecciated flows; these rocks occur in several tectonics units (Fig. 1):

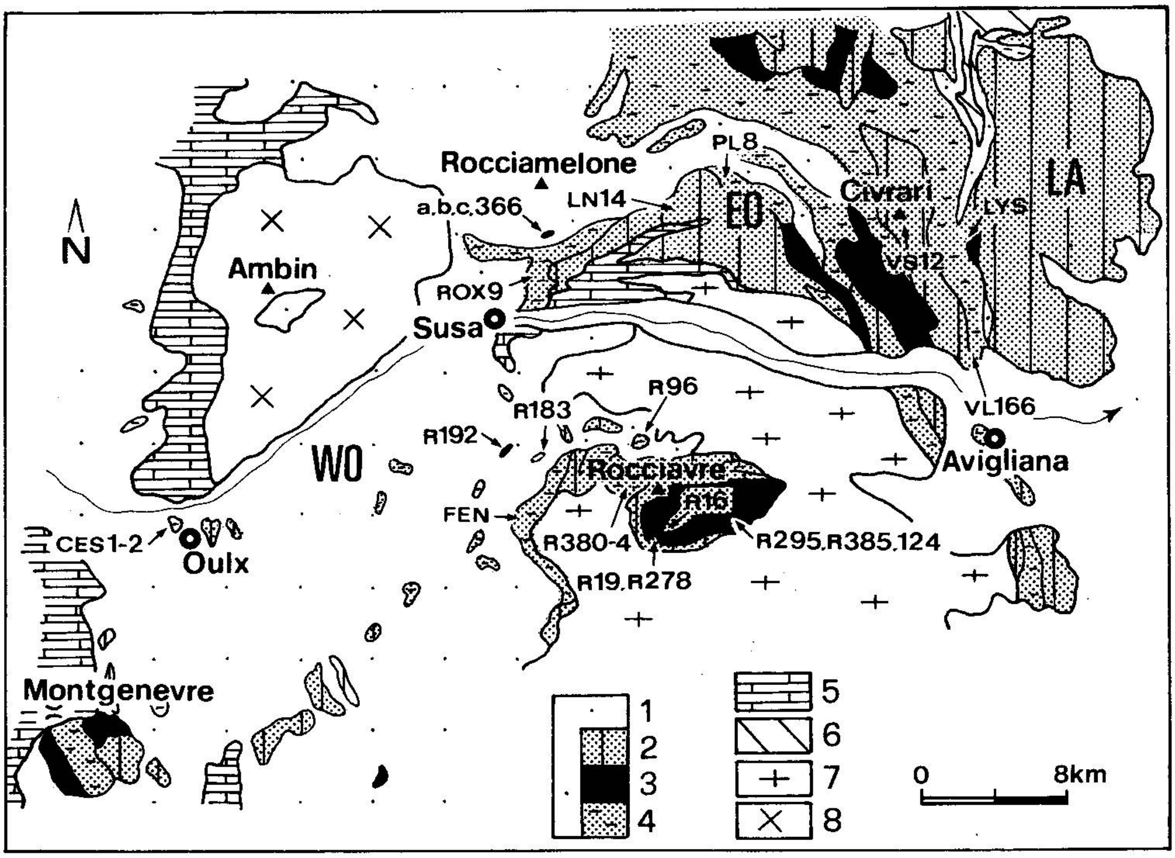


Fig. 1 Geologic sketch map of the western Alps in the Susa valley area. Composite ophiolite unit: 1) metasediments (mainly "schistes lustrés", "calcescisti"), 2) tectonite ultramafics, 3) metagabbros, 4) basaltic metabasites. 5) Epicontinental covers of Mesozoic age; 6) Sesia-Lanzo continental unit; 7) Dora-Maira continental unit; 8) Ambin continental unit. LA: Lanzo peridotite body; EO: eastern ophiolite nappe, WO: western ophiolite units.

a) The *Lanzo ultramafic body* consists of little-serpentinized tectonite peridotites (mainly spinel-lherzolites re-equilibrated into plagioclase-lherzolites) intruded by minor dykes of gabbro and porphyritic basalt (BOUDIER, 1978; POGNANTE et al., 1985).
b) The *eastern ophiolite nappe* represents dismembered sections of the oceanic-type lithosphere of the Jurassic basin; it consists of metaophiolites with subordinate metasediments (POGNANTE, 1980).
c) The *western ophiolite unit* consists of prevalent metasediments (mainly "schistes lustrés", "calcescisti") and minor metaophiolites (CARÒN, 1977); POLINO, 1984); it is a composite unit which includes the Chenaillet ophiolites near Montgenevre (BERTRAND et al., 1982). In the western units the ophiolites represent tectonic slices and/or olistoliths of an original oceanic-type lithosphere of Jurassic age.

All these rocks suffered an alpine metamorphic evolution distinguished by an early high pressure—low temperature stage followed by a later low pressure stage. In the Lanzo body and in the eastern ophiolite nappe the first stage produced, in the mafic rocks, eclogitic assemblages of Cretaceous age including Na-pyroxenes, garnets, zoisite, Na-amphiboles and chloritoid; in the western units the high pressure stage produced low temperature blueschist assemblages (lacking eclogites) with Na-amphiboles, lawsonite, epidote, Na-pyroxenes (POGNANTE, 1984; CARPENA et al., 1986).

FIELD RELATIONSHIPS AND PETROGRAPHY

The studied metagabbroids and metabasites have been selected among the rocks having the best preserved magmatic mineralogical and textural relics from the eastern ophiolite nappe and from the western ophiolite unit. The composition of the magmatic relics of some intrusive rocks, determined with an ARL-SEMQ microprobe, are also reported. Location and description of the analyzed samples are shown in Fig. 1 and Table 1 while the representative mineral compositions are included in Table 2.

The analyzed metagabbroids occur either in bodies ranging in thickness from a few tens of metres (Colle delle Finestre, south of Mt. Rocciamelone, Colle del Lys) up to 600 metres (Rocciavrè), or in dykes intruding tectonite lherzolites (Mt. Civrari) (Fig. 1). In the smaller bodies the metagabbroids are represented by augite gabbros and Fe–Ti gabbros with rare plagiogranites (Colle del Lys) and the only magmatic relics which have escaped the alpine recrystallization are clinopyroxenes and, at times, Fe–Ti oxides. At Rocciavrè a large body of olivine-Cr-diopside gabbros includes a layered sequence formed by gabbro-

Table 1 List and location of the analyzed samples reported in Tables 2-3-4.

Sample	Rocktype	Mineralogy	Location
VS12	gabbro dyke	cpx-ol-pl	Mt. Civrari
124	gabbro-norite	cpx-pl-opx-zo-gt-om-tc	Sangone valley
R295	Fe-Ti gabbro	om-gt-rut-ap-cpx	Sangone valley
R385	Fe-Ti gabbro	om-gt-rut-ap	Sangone valley
a	gabbro	cpx-anf-ab-zo	S Mt. Rocciamelone
b	gabbro	cpx-anf-ab-chl-sph	S Mt. Rocciamelone
c	Fe-Ti gabbro	cpx-Na anf-chl-ox-ab-sph-ap	S Mt. Rocciamelone
R19	gabbro	anf-zo-ab	Rocca Vergia, Chisone valley
R278	gabbro	cpx-hbl-zo-anf-om-gt-chl	Rocca Vergia, Chisone valley
R16	eclogite	om-gt-rut-Na anf-ap	P.ta del Lago, Sangone valley
R192	Fe-Ti gabbro	cpx-om-gt-Na anf-rut	Colle delle Finestre
LYS	plagiogranite	qtz-jd-ab-gt-Na anf-ap-zr	Colle del Lys
VL166	basalt breccia	om-ep-anf-ab-sph	Torre del Colle
LN14	pillow basalt	ep-ab-anf-sph	Col delle Coupe
R380-4	basalt breccias	ep-Na anf-anf-ab-sph-mb	SW P.ta Cristalliera
PL8	metabasite	ep-ab-anf-lw(?)-sph	Viù valley
ROX9	metabasite	ep-Na anf-ab-anf-sph	Rio Giandula, N Susa
R183	metabasite	ep-ab-anf-chl-sph	E Mt. Pelvo
FEN	metabasite	ep-anf-Na anf-chl-ab-sph	E Fenestrelle
R96	metabasite	ep-mb-anf-Na anf-ap-sph	P.ta il Villano
CES1-2	basalt breccias	Na anf-lw-ep-sph	W Oulx
366	Fe-Ti gabbro	cpx-Na anf-chl-ox-ab-ep-sph	S Mt. Rocciamelone

Abbreviations: cpx=clinopyroxene, ol=olivine, pl=plagioclase, opx=orthopyroxene, zo=zoisite, gt=garnet, om=omphacite, tc=talc, rut=rutile, ap=apatite, anf=amphibole, ab=albite, chl=chlorite, sph=sphene, ox=Fe-Ti oxides, hbl=hornblende, qtz=quartz, jd=jadeite, zr=zircon, ep=epidote, mb=white mica, lw=lawsonite. The underlined minerals are pre-alpine magmatic relics.

norites, Fe-Ti gabbros and rare plagiogranitic pods (POGNANTE, 1981). The sample from Mt. Civrari (POGNANTE et al., 1986) is a dyke, a few decimetres thick, of olivine-Cr-diopside gabbro crosscutting the host lherzolites. Compositional data of the magmatic relics indicate an evolution of the minerals from the most primitive gabbros (olivine: Fo 90-87; Cr-rich diopide), to intermediate gabbro-norites (augite, hyperstene) and finally to Fe-Ti gabbros (Fe-richer augite) (Table 2).

Many of the analyzed metabasites (Fig. 1) derive from extrusive flows up to a few hundred of metres thick; these flows show relics of pillowed or brecciated structures (Rocciavré, Torre del Colle, Col delle Coupe, Oulx). Elsewhere they form layers, a few tens of metres thick, lacking primary structures and are interlayered with phyllitic marbles ("schistes lustrés"), or occur as rare dykes crosscutting the ultramafic rocks (POGNANTE, 1980).

Table 2 Representative microprobe analyses of magmatic minerals from ophiolite metagabbros of the Susa valley.

	ol	cpx				opx
	VS12	VS12	124	R295	366	124
SiO_2	39.89	52.16	54.08	53.74	52.61	53.69
Al_2O_3	0.04	3.38	2.11	2.11	0.96	1.32
TiO_2	-	0.38	0.76	1.03	0.39	0.42
Cr_2O_3	-	0.96	n.d.	0.08	n.d.	-
FeOtot	12.62	4.67	6.58	7.49	12.80	16.43
MnO	0.20	0.13	0.19	0.17	1.31	0.39
NiO	0.23	0.06	n.d.	-	n.d.	-
MgO	47.42	18.47	16.60	13.44	11.17	26.69
CaO	0.04	19.24	19.04	20.15	18.81	1.72
Na_2O	-	0.27	0.70	1.43	2.55	0.08
	100.44	99.72	100.06	99.64	100.60	100.74
Si	0.988	1.903	1.972	1.987	1.990	1.939
Al^{IV}	0.001	0.097	0.028	0.013	0.010	0.056
Al^{VI}	-	0.045	0.063	0.079	0.033	-
Ti	-	0.011	0.021	0.029	0.011	0.011
Cr	-	0.028	n.d.	0.002	n.d.	-
Fe tot	0.261	0.142	0.201	0.232	0.405	0.496
Mn	0.004	0.004	0.006	0.005	0.042	0.012
Ni	0.005	0.002	n.d.	-	n.d.	-
Mg	1.751	1.004	0.902	0.741	0.630	1.437
Ca	0.001	0.752	0.744	0.798	0.763	0.067
Na	-	0.019	0.049	0.103	0.187	0.006
	3.010	4.010	3.986	3.989	4.071	4.024

Structural formulae are on the basis of 4 oxygens for olivine (ol) and 6 oxygens for clinopyroxenes (cpx) and orthopyroxene (opx).

BULK ROCK CHEMISTRY

Major and trace elements have been determined on 6 metagabbros and 12 metabasites from the eastern ophiolite nappe, and on 2 metabasalts from the western composite unit. SiO_2, TiO_2, Al_2O_3, $Fe_2O_{3\,tot}$, MnO, CaO, K_2O, P_2O_5, and Ni, Co, Cr, V, Sc, Ba, Nb, Zr, Y, Sr, Rb have been determind by X-ray fluorescence analysis (Philips PW1400). MgO was determind by atomic absorption and Na_2O by flame photometry. Location and description of the analyzed samples are reported in Fig. 1 and Table 1, while the chemical data are included in Tables 3 and 4. Table 3 also report 3 average compositions of metagabbros from the southern slope of Mt. Rocciamelone (Fig. 1) as reported by Perotto (1983).

Table 3 Major- (wt%) and trace- (ppm) element abundances in the ophiolitic metagabbroids of the Susa valley.

	R19	R278	a	b	R385	R16	R192	c	LYS
SiO_2	49.23	51.99	49.40	49.21	51.43	43.56	43.24	43.97	67.67
TiO_2	0.21	0.42	0.45	0.66	2.10	4.81	4.39	2.93	0.54
Al_2O_2	17.15	13.61	13.72	13.74	10.60	8.60	9.84	9.24	14.03
Fe_2O_3tot	4.70	5.64	6.92	8.29	15.09	24.49	21.68	21.37	7.17
MnO	0.07	0.11	0.31	0.24	0.23	0.32	0.29	0.13	0.12
MgO	11.38	10.81	11.25	8.76	7.24	5.50	6.11	5.75	0.53
CaO	11.00	14.11	12.23	10.77	9.86	9.81	10.05	10.76	1.59
Na_2O	4.06	1.44	2.12	3.78	3.42	2.80	3.68	2.00	7.77
K_2O	0.05	0.03	0.87	1.09	0.03	0.02	0.08	0.06	0.09
P_2O_5	0.01	0.02	0.02	0.04	0.01	0.09	0.01	1.40	0.17
H_2O	2.15	1.83	2.71	3.31	-	-	0.62	2.38	0.31
Nb	2	(1)			2	3	4		14
Zr	15	15			15	62	35		1016
Y	6	12			21	32	25		159
Sr	118	130			41	18	67		49
Rb	5	5			5	8	8		5
Ba	12	10			10	10	-		10
Ni	320	293			98	74	87		4.3
Co	34	36			47	44	44		6
Cr	1964	1726			249	(1)	42		8
V	103	166			678	1699	1575		10
Sc	28	47			46	58	53		9.7

a, b, c are average compositions of Cr-diopside gabbro (1 sample), augite gabbros (2 samples) and Fe–Ti gabbros (3 samples) from the southern slope of Mt. Rocciamelone (Susa valley) provided by PEROTTO (1983) by XRF analysis. Totals of major elements have been normalized to 100. Trace-elements have not been determined for samples a, b, c.

Metagabbroids

They display a wide spectrum of compositions (Table 2) ranging from (olivine-) Cr-diopside gabbros high in Mg, Cr, Ni and low in Zr, Y, Fe (samples R19, R278), through Fe-Ti gabbros (samples R16, R192) rich in Fe, Ti, V and relatively poor in Mg, to plagiogranite (sample LYS) rich in Si, Na, Zr, Y and poor in Mg, Cr, Ni, V. Sample R385 is a fine grained Fe–Ti gabbro poorer in Zr, Fe and Ti and richer in Cr and Mg than the other Fe–Ti gabbros. These data, in particular the Fe–Ti enrichment (Fig. 2) and the coexistence of olivine and plagioclase, are consistent with a tholeiitic fractionation at low pressure and low initial f_{O_2} similar to that typical of the oceanic gabbros.

Metabasites

The analyzed metabasites have a basaltic composition (Table 4) comparable to the other basaltic rocks of the western Alps (POGNANTE and PICCARDO, 1984,

Table 4 Major- (wt%) and trace- (ppm) element abundances in ophiolitic metabasalts and metabasites of the Susa valley.

	VL166	LN14	R380	R381	R382	R383	R384	PL8	ROX9	R183	FEN	R96	CES1	CES2
SiO_2	52.38	50.75	50.76	51.28	52.00	53.95	51.76	51.56	49.51	52.17	47.11	51.21	52.56	50.40
TiO_2	1.00	1.77	1.72	1.96	1.80	1.38	2.00	1.86	2.28	2.27	2.05	1.63	2.10	1.95
Al_2O_3	13.78	12.67	12.11	13.46	13,35	13.54	14.26	14.62	15.11	13.79	15.78	16.98	14.50	14.95
Fe_2O_3tot	7.76	9.49	10.90	12.37	10.90	9.17	11.14	11.66	13.74	10.11	11.98	9.89	9.52	11.29
MnO	0.11	0.11	0.13	0.21	0.19	0.16	0.13	0.20	0.15	0.13	0.16	0.14	0.08	0.06
MgO	5.35	5.08	4.87	5.17	5.45	7.17	5.30	5.79	4.61	4.73	2.83	2.16	5.59	5.85
CaO	12.39	12.55	13.18	10.25	10.54	7.69	9.50	9.35	6.57	10.54	11.48	11.06	5.17	5.07
Na_2O	3.74	3.93	3.41	4.37	4.57	4.87	4.34	3.13	5.07	4.46	4.40	4.68	6.19	6.09
K_2O	1.58	0.54	0.11	0.05	0.08	0.26	0.13	0.25	0.60	0.12	0.32	0.21	0.07	0.13
P_2O_5	0.11	0.21	0.30	<0.1	0.19	<0.1	<0.1	0.26	0.31	0.31	0.20	0.29	0.41	0.38
H_2O	1.80	2.90	2.51	0.87	0.94	1.80	1.36	1.33	2.05	1.36	3.69	1.76	3.82	3.83
Nb	3	7	5	6	5	4	6	7	4	6	5	11	5	5
Zr	66	173	150	176	146	106	185	177	185	207	151	145	199	173
Y	24	33	47	51	42	31	48	40	44	53	46	35	54	45
Sr	111	246	268	215	181	227	213	470	157	186	216	1150	235	263
Rb	24	7	5	5	5	5	5	5	18	5	5	5	5	5
Ba	38	23	10	10	10	32	13	15	54	13	14	18	10	21
Ni	115	107	82	58	68	112	71	63	118	83	97	75	71	77
Co	35	34	30	25	31	43	28	37	73	22	41	21	37	29
Cr	366	217	213	220	156	325	234	187	114	175	338	259	192	202
V	234	268	278	363	313	243	319	270	258	314	270	266	317	294
Sc	34	34	37	39	37	37	42	42	41	41	49	36	40	39

Totals of major elements have been normalized to 100.

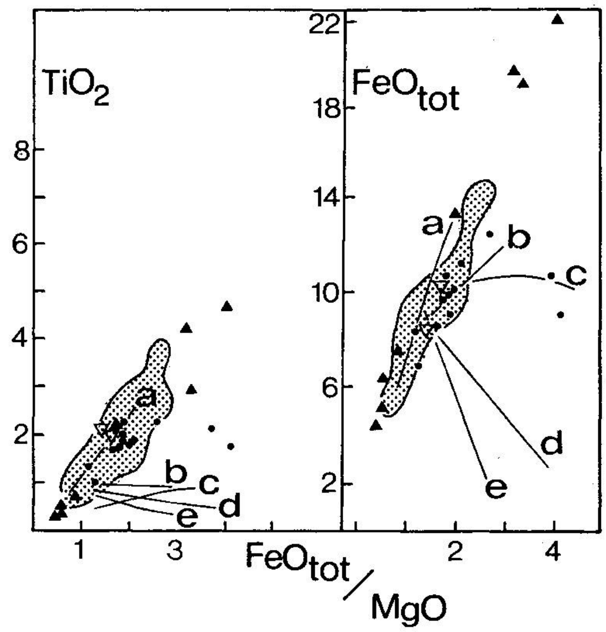
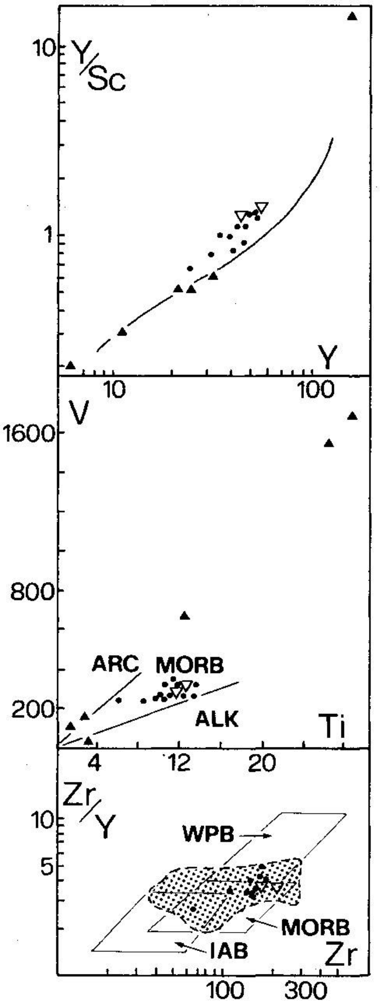


Fig. 2 TiO_2-FeO_{tot}/MgO and FeO_{tot}-FeO_{tot}/MgO diagrams for the basaltic and gabbroid metaophiolites reported in Tables 3–4. ●: basaltic metabasites from the eastern unit, ▽: basaltic metabasites from the western unit, ▲: gabbroids. The field of the other metabasites from the alpine ophiolites (reported by Pognante and Piccardo, 1984), and the fractionation trend for abyssal tholeiites (a), island arc tholeiites (b–c) and calk-alkaline series (d–e) (Miyashiro, 1975) are shown for comparison.

with references) and are partly similar to many mid-ocean ridge basalts (MORB: Sun et al., 1979; Wood et al., 1979). The tholeiitic fractionation trend and the ocean floor affinity are indicated by the Fe-Ti enrichment (Fig. 2) and by the Y/Sc-Y, Zr/Y-Zr, P_2O_5-Zr, Ti-Cr and Cr-Y diagrams (Fig. 3-4). The pillow breccias from the western unit (samples CES 1-2) are richer in P than the other metabasites and metabasalts from the eastern unit (Fig. 4). Compared to many MORB, elements lyke Na, K and Ca show a wide compositional range which reflects alteration during the alpine metamorphism. Alteration is probably responsible for the high K content of sample VL166 and for the high FeO_{tot}/MgO ratios of samples ROX9 and FEN. On the basis of these evidences it is clear that a reliable petrogenetic discussion can be only obtained by considering the high-field strength elements thought to be relatively immobile during metamorphic alteration (e.g. Ti, Zr, Y, Nb, P, Cr).

DISCUSSION AND CONCLUSIONS

In spite of the alteration during (and possible before) the alpine metamorphism the analyzed ophiolites of the Susa valley still show an ocean-floor tholeiitic affinity which is apparent from the marked trend of Fe-Ti enrichment and from the P_2O_5-Zr, Ti-Cr, Zr/Y-Zr, Cr/Y diagrams (Figs. 2-3-4). As to the



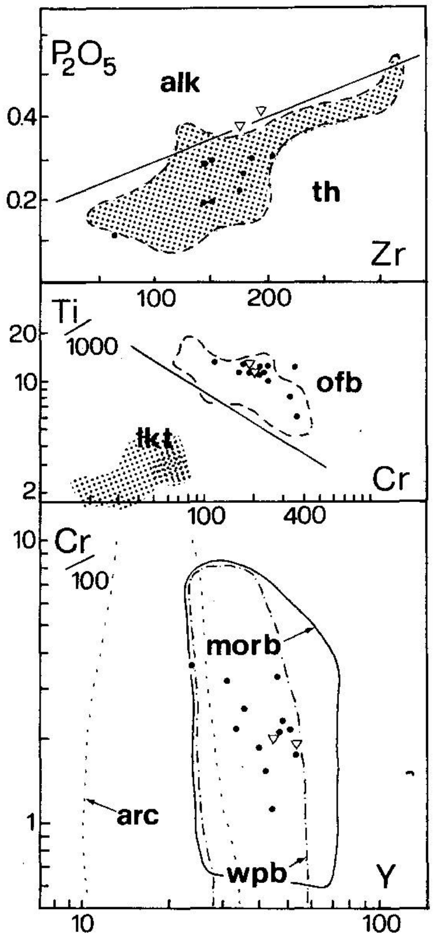


Fig. 3 Y/Sc-Y, V-Ti and Zr/Y-Zr diagrams for the analyzed ophiolites. ●: basalts from the estern unit; ▽: basalts from the western unit; ▲: gabbroids. The curve in the diagram Y/Sc-Y is the evolutionary trend for some alpine ophiolite gabbros (Pognante et al., 1982). In the V-Ti diagram the fields ARC (island-arc series), MORB (mid-ocean ridge basalts) and ALK (alkalic-series) are after Shervais (1982). In the diagram Zr/Y-Zr the fields IAB (island-arc basalts), MORB and WPB (within-plate basalts) are after Pearce and Norry (1979), while the dotted field (alpine ophiolite basalts) is after Pognante and Piccardo (1984).

Fig.4 P_2O_5-Zr, Ti-Cr and Cr-Y diagrams for the analyzed basaltic metabasites. alk and th are the fields of the alkaline and tholeiitic basalts (Floyd and Whinchester, 1975), ofb and lkt are the fields of the ocean-floor and of the island-arc tholeiites (Pearce, 1975), while morb, wpb and arc are the fields of the mid-ocean ridge, within-plate and volcanic-arc basalts (Pearce, 1982). The field of the other alpine basalts is shown dotted for comparison (references in Pognante and Piccardo, 1984). Symbols as in Fig. 2.

metabasites, which mainly derive from basalt flows, they plot rather well on a straight line passing through the origin on diagrams relating two hygromagmatophile elements (Ti-Zr; Fig. 5). Because ratios between hygromagmatophile elements showing similar KD only changes as a consequence of heterogeneities in the mantle source (Wood et al., 1979), an origin from more or less fractionated melts with normal-MORB affinity produced by partial melting of not very

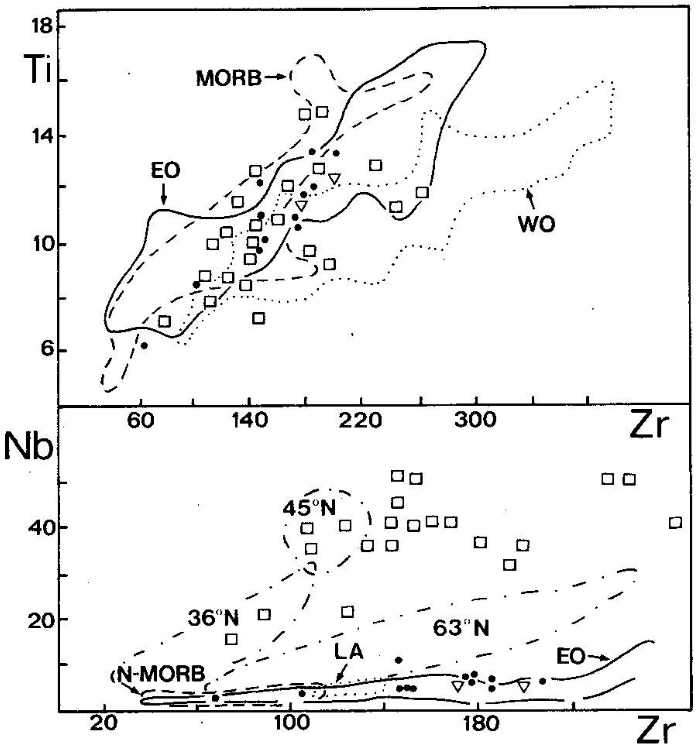


Fig. 5 Ti-Zr and Nb-Zr diagrams for the analyzed basaltic metabasites. The fields of some MORB and of some basalts sampled at different latitude in the north Atlantic (Pearce and Cann, 1973; Sun et al., 1979; Wood et al., 1979; le Roex et al., 1982) are shown for comparison. EO is the field of the alpine basalts from the eastern unit, LA from the Lanzo massif and WO from the western unit (Pognante and Piccardo, 1984). □: basalts from Zermatt (Bearth and Stern, 1979); other symbols as in Fig. 2.

heterogeneous peridotites is suggested. Moreover all the analyzed metabasites have Ba/Zr $(\overline{0.15})$ and Zr/Nb $(\overline{29.7})$ ratios which, according to Saunders et al. (1980), are typical of normal-MORB. On the other hand many samples are relatively enriched in Zr with respect to normal-MORB suggesting higher fractionation and/or origin by lower degrees of partial melting. In that view the slight alkaline affinity suggested by the P_2O_5-Zr diagram for samples CES 1-2, might reflect a primary rather than a secondary feature.

As to the intrusive rocks, the compositional data point to a marked tholeiitic trend of fractionation at low initial f_{O_2}. That is also apparent from the crystallization of progressively evolved mineral phases, as observed in Table 2 and in other intrusive analogues of the western Alps (Pognante et al., 1982). In terms of fractionation, being cumulate rocks, the gabbros should not have the composition of the original liquids from which they crystallized. Indeed they display different Ti/Zr, Zr/Y, Y/Sc and Ti/V ratios with respect to the basalts and their composition should reflect the proportion and chemistry of the cumulus phases with variable amounts of trapped residual liquid. On the other hand the existence of chilled dykes of Fe-Ti gabbro in the Lanzo peridotites and the evolved chemistry of the minerals (POGNANTE et al., 1982; 1985) suggest that Fe–Ti gabbros might represent "approximate" liquid compositions. Because effusive basalts with a comparable geochemistry are very rare in the ophiolites of the western Alps (POGNANTE and PICCARDO, 1984), the Fe–Ti gabbros could derive from extremely fractionated liquids which very rarely extruded and usually crystallized at depth. These liquids either crystallized in the original magma chamber during complex "cumulus" processes producing sequences similar to the Rocciavré body, or tapped off intruding as dykes the host peridotites as observed at Lanzo. An alternative possibility to an origin by extreme fractionation is supported by recent experiments (e.g. DIXON and RUTHERFORD, 1979; PHILPOTTS and DOYLE, 1983) which suggest that liquids similar to Fe–Ti gabbros (and to plagiogranites) are produced by liquid immiscibility.

Summing up, the previous evidences indicate that the ophiolites from the Susa valley traverse in the western Alps should derive from partial melting of not very heterogeneous peridotites which generated melts similar to those producing normal-MORB. As already observed by DAL PIAZ et al. (1981) and by VENTURELLI et al. (1981), the alpine basalts are enriched in hygromagmatophile elements with respect to normal-MORB. The less depleted character of the alpine basalts might be a peculiar feature of small and short-lived oceans like the western Tethys which probably never reached "mature" ocean-ridge-type structures (POGNANTE et al., 1986).

Acknowledgements

This work has been improved by G. Venturelli. Financial support has been provided by the Centro di Studio sui Problemi dell'Orogeno delle Alpi Occidentali, C.N.R., Torino, and by Ministero delle Pubblica Istruzione (60%, 1984, Giammetti). The C.N.R. is acknowledged for the installation and operation of the electron microprobe laboratory in the Dipartimento di Scienze della Terra, Milano.

References

AUZENDE, J.M., POLINO, R., LAGABRIELLE, Y. & OLIVET, J.L. (1983): Considération sur l'origine et la mise en place des ophiolites des Alpes occidentales: apport de la connaissance des structures océaniques. - C.R. Acad. Sci. Paris, 296, 1527–1532.

BEARTH, P. & STERN, W. (1979): Zur Geochemie von Metapillows der Region Zermatt-Saas. - Schweiz. Min. Petr. Mitt., 59, 349–373.

BECCALUVA, L., DAL PIAZ, G.V. & MACCIOTTA, G. (1984): Transitional to Normal MORB affinities in ophiolitic metabasites from the Zermatt-Saas, Combin and Antrona units, Western Alps: implication for the paleogeographic evolution of the Western Tethyan basin. Geol. en Mijnbouw. - 63, 165–177.

BERTRAND, J., COURTIN, B. & VUAGNAT, M. (1982): Elaboration d'un secteur de lithosphere océanique liguro-piémontais d'apres les données de l'ophiolite du Montgenevre (Hautes-Alpes, France e province de Turin, Italie). - Ofioliti, 7, 155-196.

BOUDIER, F. (1978): Structure and petrology of the Lanzo peridotite massif (Piedmont Alps). - Geol. Soc. Am. Bull., 89, 1574-1591.

CARON, J.M. (1977): Lithostratigraphie et tectonique des schistes lustrés dans les Alpes cottiennes septentrionales et en Corse orientale. - Sci. Géol., Mém., 48, 326 p.

CARPENA, J., POGNANTE, U. & LOMBARDO, B. (1986): New constraints for the timing of the Alpine metamorphism in the internal ophiolitic nappes from the Western Alps as inferred from fission-track data. - Tectonophysics, 127.

DAL PIAZ, G.V. (1974): Le métamorphisme de haute pression et basse température dans l'evolution structurale du bassin ophiolitique alpino-apenninique. Mem. Soc. Geol. Ital., 93, 437-468.

DAL PIAZ, G.V., VENTURELLI, G., SPADEA, P. & DI BATTISTINI, G. (1981): Geochemical features of metabasalts and metagabbros from the Piemonte ophiolite nappe; Italian Western Alps. N.Jb. Miner. Abh., 142, 3, 248-269.

DIXON, S. & RUTHERFORD, M.J. (1979): Plagiogranites as late stage immiscible liquids in ophiolite and mid-ocean ridge suites: an experimental study. Earth Planet. Sci. Lett., 39: 127-144.

ELTER, G. (1971): Schistes lustrés et ophiolite de la zone piémontaise entre Orco et Doire Baltée (Alpes Graies). - Géol. Alpine, 47, 147-169.

FLOYD, P.A. & WINCHESTER, J.A. (1975): Magma type and tectonic setting discrimination using immobile elements. - Earth Planet. Sci. Lett., 27, 211-218.

LEMOINE, M. (1980): Serpentinites, gabbros et ophicalcites in the Piemont-Ligurian domain of the western Alps: possible indicators of oceanic fracture zones and of associated serpentinites protrusions in the Jurassic-Cretaceous Tethys. - Arch. Sciences Geneve, 33, 103-115.

LE ROEX, A.P., DICK, H.J.B., REID, A.M. & ERLANK, A.J. (1982): Ferrobasalts from the Spiess Ridge segment of the Southwest Indian Ridge. - Earth Planet. Sci. Lett., 60, 437-451.

LEWIS, A.D. & SMEWING, J.D. (1980): The Montgenevre ophiolite (Hautes Alpes, France): Metamorphism and trace element geochemistry of the volcanic sequence. - Chem. Geol., 28, 291-306.

LOMBARDO, B. & POGNANTE, U. (1982): Tectonic implications in the evolution of the western Alps ophiolite metagabbros. - Ofioliti, 7, 371-394.

LOMBARDO, B., NERVO, R., COMPAGNONI, R., MESSIGA, B. KIENAST, J.R., MEVEL, C., FIORA, L., PICCARDO, G.B. & LANZA, R. (1978): Osservazioni preliminari sulle ofioliti metamorfiche del Monviso (Alpi occidentali). - Rend. Soc. It. Mineral. Petr., 34, 253-305.

MIYASHIRO, A. (1975): Classifications, characteristics and origin of ophiolites. - J. Geol., 83, 249-281.

PHILPOTTS, A.R. & DOYLE, C.D. (1983): Effect of magma oxidation state on the extent of silicate liquid immiscibility in a tholeiitic basalt. - Am. J. Sci., 283, 967-986.

PEARCE, J.A. (1975): Basalt geochemistry used to investigate past tectonic environment on Cyprus. - Tectonophysics, 25, 41-68.

PEARCE, J.A. (1982): Trace elements characteristics of lavas from destructive plate boundaries. In: Thorps R.S. (Ed.): Andesites, John Wiley & Sons, 525-548.

PEARCE, J.A. & CANN, J.R. (1973): Tectonic setting of basic volcanic rocks determined using trace element analyses. - Earth Planet. Sci. Lett., 19, 290-300.

PEARCE, J.A. & NORRY, M.J. (1979): Petrogenetic implications of Ti, Zr, Y and Nb variations in volcanic rocks. - Contrib. Mineral. Petrol., 69, 33-47.

PEROTTO, A. (1983): Studio geologico-petrografico dell'alta valle di Viù nel settore del M. Rocciamelone. - Unpublished thesis, University of Torino.

POGNANTE, U. (1980): Preliminary data on the Piemonte ophiolite nappe in the lower Val Susa-Val Chisone area, Italian western Alps. - Ofioliti, 5, 221-240.

POGNANTE, U. (1981): Magmatic and metamorphic evolution of two Fe–Ti gabbroic series from the Piemonte ophiolite nappe in the Susa valley area, Italian Western Alps. - Mem. Sci. Geol. Padova, 35, 21–34.

POGNANTE, U. (1984): Eclogitic versus blueschist metamorphism in the internal Western Alps along the Susa valley traverse. - Sci. Géol. Bull. Strasbourg, 37, 29–36.

POGNANTE, U. & PICCARDO, G.B. (1984): Petrogenesi delle ofioliti delle Alpi occidentali. - Mem. Soc. Geol. Ital., in press.

POGNANTE, U., LOMBARDO, B., VENTURELLI, G. (1982): Petrology and geochemistry of Fe–Ti gabbros and plagiogranites from the western Alps ophiolites. - Schweiz. Min. Petr. Mitt., 62, 457–472.

POGNANTE, U., PEROTTO, A., SALINO, C. & TOSCANI, L. (1986): The ophiolitic peridotites of the western Alps: record of the evolution of a small oceanic-type basin in the Mesozoic Tethys. Tsch. Min. Petr. Mitt., 35, 47–65.

POGNANTE, U., RÖSLI, U. & TOSCANI, L. (1985): Petrology of ultramafic and mafic rocks from the Lanzo peridotite body (western Alps). Lithos, 18, 201–214.

POLINO, R. (1984): Les séries océaniques du haut val de Suse (Alpes Cottiennes): analyse des couvertures sédimentaires. - Ofioliti, 9, 547–554.

SAUNDERS, A.D., TARNEY, J., MARSH, N.G. & WOOD, D.A. (1980): Ophiolites as oceanic crust or marginal basin crust: A geochemical approach. - Proceed. Int. Oph. Symp. Cyprus 1979, 193–204.

SHERVAIS, J.W. (1982): Ti-V plots and the petrogenesis of modern and ophiolitic lavas. - Earth Planet. Sci. Lett. 59, 101–118.

SUN, S.S., NESBITT, R.W. & SHARASKIN, A.Y. (1979): Geochemical characteristics of mid-ocean ridge basalts. - Earth Planet. Sci. Lett., 44, 119–138.

VENTURELLI, G., THORPE, R.S. & POTTS, P.J. (1981): Rare earth and trace elements characteristics of ophiolitic metabasalts from the alpine-apennine belt. Earth Planet, Sci. Lett., 53, 109–123.

WOOD, D.A., TARNEY, J., VARET, J., SAUNDERS, A.D., BOUGAULT, H., JORON, J.L., TREUIL, M. & CANN, J.R. (1979): Geochemistry of basalts drilled in the north Atlantic by IPOD LEG 49: implications for mantle heterogeneity. - Earth Planet. Sci. Lett., 77–97.

Manuscript received 10 September, 1985.