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Potassium-Argon Ages from the Valle d'Ossola Section of the Ivrea-Verbano Zone (Northern Italy)

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With 1 figure and 2 tables in the text

Introduction

In the publications of SCHMID (1966a+b, 1967) the dominating influence of a regional thermo-dynamo metamorphism in the Ivrea-Verbano zone was described. The record of this metamorphism can be seen today not only in the well preserved mineral paragenesis but also both microscopically and megascopically in the textural and structural patterns of the rock. The earlier history of the Ivrea-Verbano zone has been completely obliterated by this intensive metamorphism gradually decreasing from NW (granulite facies) to SE (upper amphibolite facies) perpendicular to the general strike of the zone. Later foliations and retrograde effects, some of which are cited in a later section of this paper, are generally very weakly developed and noteverywhere observable.

SCHMID (1966a) first referred to the surprisingly clear and regular chemical variations of garnet and biotite within the two major rock series of the Ivrea-Verbano zone. These variations correlate well with changes in mineral facies and thus reflect variations in the p, T, x conditions during the metamorphism.

The age measurements of two biotites and one hornblende were undertaken with the hope of obtaining an estimate for the age of the metamorphism. In particular, because of its high resistance to argon loss, it was expected that the hornblende would be unaffected by the weakly developed later effects mentioned above. The samples are located between 4 and 6 km from the Mont' Orfano granite (fig. 1), from which K-Ar and Rb-Sr biotite ages in the range 268—275 m.y. have been published (JÄGER et al. 1960, 1961).

Rb-Sr determinations from the two biotites as well as their associated total rocks are currently in progress.

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Sample Description

The dated samples are of importance for a biotite-garnet investigation presently in preparation. Thus they have been taken from rocks containing garnet which lies on the chemical variation lines discussed by SCHMID (1966a). Since insufficient fresh material satisfying this point could be obtained directly from outcrops, these samples have been obtained from large boulders which were found near their outcrop position.

The two biotite samples come from pyroxene- and hornblende-free paragneisses (no. SD 1035 and SD 1031 E) of metamorphic grade consistent with their position in the NW-SE profile of gradually decreasing metamorphic grade. The hornblende has been obtained from a hornblende granulite (no. SD 1034 D) also consistent with this profile.

Additional information on these minerals and their parent rocks is given in table 1 as well as in the literature cited in that table. Chemical analyses of the parent rocks and their minerals will be published in the biotite-garnet study. The location of the samples is shown in figure 1.

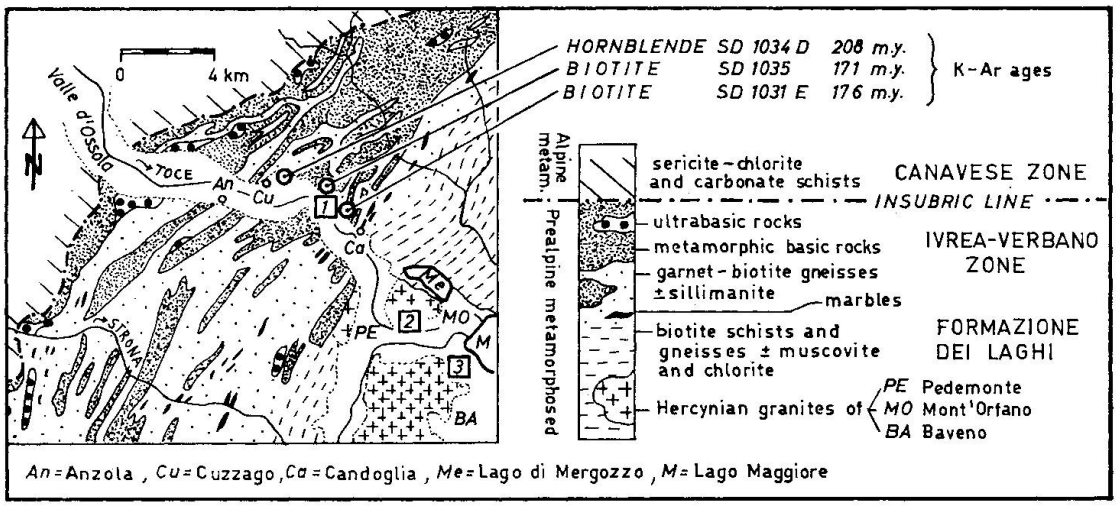

Fig. 1. General geological map of the middle part of the Ivrea-Verbano zone showing the locations of the samples investigated by us (circles) and published by JÄGER et al. (quadrats):

No.	sample	reference	mineral	K-Ar age	Rb-Sr age
1	amphibolite	JÄGER et al. (1967)	biotite	—	172 m. y.
2	granite of Mont'Orfano	JÄGER et al. (1960, 1961)	biotite k'fsp.	268 m. y. —	274 m. y. 275 m. y.
3	granite of Baveno	Jäger et al. (1960)	biotite	269 m. y.	—

Age Results

The data obtained for the three mineral separates used for age determination are given in table 2. Standard isotope dilution techniques have been employed for both argon and potassium analyses, and the errors placed on the ages represent 95% confidence intervals.

The two biotite results agree within experimental error at about 173 m.y. while the hornblende has a higher apparent age of 208 m.y. We interpret these ages as reflecting argon losses of varying magnitude in response to a disturbance which occurred later than the primary metamorphism. The granulite to upper amphibolite facies metamorphism recorded in the region as well as the chemical equilibrium obtained in garnets from widely varying rock types imply conditions sufficient to cause complete release of argon from all preexisting minerals. The case for the older, primary metamorphism is supported by the K-Ar and Rb-Sr results of JÄGER et al. (1960, 1961) in the range 268—275 m.y. from the Baveno and Mont'Orfano granites (fig. 1), since SCHILLING (1957) has shown the closely related Pedemonte granite (also fig. 1) to be younger than the metamorphic fabric of the Ivrea-Verbano zone rocks. Also a preliminary total rock isochron from paragneisses of the Ivrea-Verbano zone by GRAESER and HUNZIKER (1968) indicates a Rb-Sr rehomogenization around 280 m.y. ago. It therefore appears that the high grade metamorphism could not have occured later than the Hercynian, and that even the relatively resistant hornblende gives a very poor minimum estimate for this metamorphism.

It is apparent that post-metamorphic events in the Ivrea-Verbano zone have had an important effect upon the ages we have measured. The most important of such effects known to us are the deformation of the antiform structures in the Valle d'Ossola (see SCHMID 1966b and 1967) as well as secondary foliations, cataclasis, and mylonitization, which are known to occur not only along the Insubric line but in various other parts of the region (for example secondary foliation of paragneisses, amphibolites and pegmatites in the southern part[1]). These mechanical processes are often accompanied (or followed) by recristallization which has occured under amphibolite facies or greenschist facies conditions. The greenschist facies recristallization is mainly developed along the Insubric line and related fracture zones (VENKAYYA 1956, p. 155—157, VOGT 1962, p. 70ff., and SCHMID 1967, p. 1050ff.), but partial recrystallization has also been recognized in undeformed parts of the Ivrea-Verbano zone (PAPAGEORGAKIS 1961, p. 247, and SCHMID 1967, p. 1095).

Recrystallization under amphibolite facies conditions is known from many parts of the zone (see for example in SCHMID 1967: „Rekristallisierte Mylonite",

[1]) Note that also the granites in the "formazione dei laghi" (fig. 1) show a corresponding foliation in their marginal parts (SCHILLING 1957, p. 482, 483).

Table 1

mineral	rock number	rock name: general after SCHMID	facies*	mineralogical composition (vol.%**) qz	k'fsp.	plag. (an-content)	sill.	bi.	garn.	clino-pyrox.	hbld.	accessory minerals	mineral-references*	rock-references*
biotite	SD 1035	garnet-biotite gneiss „Stronalith B"	A	71	4	10 (39 ± 3)	*1*	*7*	*7*			< 1: ore < 1: graphite	SD 67, p. 985	SD 67, p. 979, 961
biotite	SD 1031E	garnet bearing biotite gneiss „augiger, grobflaseriger Kinzigitgneiss"	A	15	4	26 (29 ± 2)	*16*	*34*	*5*			< 1: ore < 1: zircon	SD 67, p. 985	SD 67, p. 980, 962
hornblende	SD 1034D	hornblende granulite „P-H-Granofels"	G			39 (51 ± 2)			7	26	24	3: ore 1: apatite < 1: biotite	SD 67, p. 997	SD 67, p. 962, and HU 42, p. 343–348

* abbreviations:
A = sillimanite-almandite-orthoclase subfacies of the amphibolite facies
G = (hornblende-) granulite facies
SD 67 = SCHMID (1967)
HU 42 = HUTTENLOCHER (1942)

** *bold face:* determined by point-counter
normal face: estimated

p. 1041, and „Basische Ganggesteine", p. 1040, 1042 and 1044). Attention should be drawn also to the weak recrystallization processes in the ultramylonites (SCHILLING 1957, p. 459, and SCHMID 1967, p. 1049) and to the (disequilibrium-?) association of two amphiboles-cummingtonite and hornblende (BORIANI 1965) — which seems to occur more frequently in some basic rocks in the zone than assumed till now. Of special importance are kelyphites and symplectites in the basic granulites which have been formed in a static phase following the thermo-dynamo metamorphism, probably in response to decreasing pressure (SCHMID 1967, p. 1017ff. and 997).

The absence of uniform, widespread retrograde mineral reactions in the Ivrea-Verbano zone, as mentioned in the first section, does not necessarily imply a lack of metamorphic conditions during the later history of the region. More probably a lack of sufficient quantities of water retarded the reactions. Therefore later epithermal or higher graded conditions could have played an important role in creating the age pattern we see today.

The time at which these ages were lowered to their present values is therefore not yet clearly established. Agreement among the ages of biotites from Ivrea-Verbano zone gneisses and an amphibolite both by the K-Ar method and Rb-Sr methods (JÄGER et al. 1967, p. 20; GRAESER and HUNZIKER, 1968) indicate that the disturbance occurred around 170 m.y. ago. However, since argon and strontium results from biotites have been shown in some cases to agree at geologically meaningless age values, one must be cautious in reaching this conclusion. In addition pegmatitic muscovites from Brissago (216 m.y.) (JÄGER et al., 1967) and Candoglia (236 m.y.) (GRAESER and HUNZIKER, 1968),

Table 2

Sample	Locality Swiss coordinates Ital. coordinates	mineral	% K	% rad. Ar	rad. Ar^{40} (x 10^{-5}scc/gm)	Age (m. y.)
garnet bearing biotite gneiss no. SD 1031e	Albo 674 800/93 950 53 930/93 650	biotite	7.911 7.923	92.1 95.1	5.798 5.807	176 ± 5
garnet-biotite gneiss no. SD 1035	Bettola 675 650/93 050 54 740/92 740	biotite	7.956	96.2 96.4	5.661 5.638	171 ± 5
amphibolite no. SD 1034d	Cuzzago 672 950/94 500 52 100/94 230	horn-blende	1.347	92.0	1.177	208 ± 6

a phlogopite from the ultrabasic rocks at Finero (246 m.y.) (KRUMMENACHER et al. 1960) and the hornblende age given here all indicate incomplete loss of argon or strontium during this disturbance. A pegmatitic biotite from Ronco gives an age of 160 m.y. (JÄGER et al., 1967). It does not seem valid to conclude that the gneissic biotites completely lost argon and strontium during the later disturbance, particularly since these ages occur in a rather small area. Thus the possibility remains that this disturbance occured later than 170 m.y. ago. Additional age determinations from more widely distributed samples, particularly argon measurements on hornblendes, should greatly improve our understanding of the post-Hercynian history of the Ivrea-Verbano zone.

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