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Geology and Nickel Mineralization of the Eastern End of the Finero Ultramafic-Mafic Complex (Ct. Ticino, Switzerland)

by *F. Bianconi**, *E. G. Haldemann*** and *J. E. Muir****

Abstract

The Finero complex, which forms the lower part of the Ivrea-Verbano Zone, has been subdivided into two ultramafic-mafic cycles, each of which consists of "peridotite" overlain by metagabbro. At its eastern end in Switzerland, economically interesting Fe-Ni sulphide mineralization occurs in Val del Boschetto within a black, serpentinized dunitic breccia zone in the "amphibole peridotite" of the upper cycle. Mineralization consists of relict primary magmatic blebs and secondary disseminations of predominantly pentlandite (± magnetite) with lesser heazlewoodite, awaruite, native copper, mackinawite, pyrrhotite, violarite, chalcocite, bornite, covellite, chalcopyrite and djerfisherite, the latter a rare K-Cu-Fe-Ni sulphide. Nickel mineralization has been traced over a true width of 32 m and averages 0.51% Ni with some intersections grading upwards to greater than 2% Ni. The nickel mineralization is in many respects comparable to that of the Dumont deposit in Canada, where serpentinization has produced a conversion of silicate nickel into sulphide nickel, resulting in an "upgrading" of the Fe-Ni sulphide content of the ultramafic host.

Zusammenfassung

Der Finero-Komplex, der den tieferen Teil der Ivrea-Verbano-Zone darstellt, ist in zwei ultramafitisch-mafitische Zyklen unterteilt worden; jeder dieser Zyklen besteht aus «Peridotit», der von Metagabbro überlagert ist. Am Ostende des Komplexes, in der Schweiz, tritt im Val del Boschetto in einer schwarzen, serpentinisierten dunitischen Brekzien-Zone im «Amphibol-Peridotit» des oberen Zyklus eine wirtschaftlich interessante Fe-Ni-Sulfidmineralisation auf. Diese Mineralisation umfasst Relikte von primär-magmatischen Tropfen und sekundäre Disseminationen von vorwiegend Pentlandit (± Magnetit) und kleineren Mengen von Heazlewoodit, Awaruit, gediegenem Kupfer, Mackinawit, Pyrrhotin, Violarit, Chalkosin, Bornit, Covellin, Chalkopyrit und Djerfisherit, letzteres ein seltenes K-Cu-Fe-Ni-Sulfid. Die Nickelmineralisation konnte über eine Mächtigkeit von 32 m nachgewiesen werden mit durchschnittlich 0.51% Ni; einzelne Proben von kurzen

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Abschnitten ergaben bis über 2% Ni. Die Nickelmineralisation ist in mancher Beziehung vergleichbar mit derjenigen der Dumont-Lagerstätte in Kanada, wo die Serpentinisierung Nickelsilikate in Nickelsulfide verwandelte und dadurch eine Erhöhung des Fe-Ni-Sulfidgehaltes des ultramafitischen Ausgangsgesteins bewirkte.

Riassunto

Il complesso di Finero, che corrisponde alla parte inferiore della Zona Ivrea-Verbano, è suddiviso in due cicli ultramafici-mafici, ciascuno formato da «peridotite» alla base e da gabbro metamorfizzato al tetto. All'estremità orientale, in Val del Boschetto su territorio svizzero, affiora una mineralizzazione a solfuri di Fe e Ni di interesse economico in una zona brecciata di dunite serpentinizzata nera nella «peridotite a anfibolo» del ciclo superiore. La mineralizzazione comprende relitti guttiformi di formazione primaria magmatica e disseminazioni secondarie con pentlandite (± magnetite) predominante, accompagnata dai minerali subordinati seguenti: heazlewoodite, awaruite, rame nativo, mackinawite, pirrotina, violarite, calcosina, bornite, covellina, calcopirite e djerfisherite, quest'ultimo un raro solfuro di K, Cu, Fe e Ni. La mineralizzazione affiora su una potenza di 32 m e ha un tenore medio di 0.51% Ni con alcune intercalazioni sopra i 2% Ni. La mineralizzazione è paragonabile per vari aspetti a quella del giacimento di Dumont nel Canadà, dove il processo di serpentinizzazione ha trasformato silicati di nickel in solfuri di nickel e di conseguenza aumentato il tenore in solfuri di Fe-Ni della roccia ultramafica originaria.

INTRODUCTION

The Finero ultramafic-mafic complex has been the subject of geological investigations over many years (e. g. WALTER 1950, VOGT 1962, LENSCH 1968; CAWTHORN 1975, STECK & TIECHE 1976) but its genetic interpretation is still controversial. The complex has been interpreted as an alpine-type peridotite (WALTER, VOGT), an up-thrust slice of the mantle (LENSCH) or as the product of fractional crystallization from a hydrous magma (CAWTHORN). STECK & TIECHE (loc. cit.) discuss the structure of the Finero complex, basically an antiform, and the structural evolution, which comprises seven phases, six of which are deformational.

The nickel mineralization in serpentinized peridotite in Val del Boschetto south of Palagnedra was discovered by WALTER (loc. cit.) in 1941 when he was mapping the eastern end of the Finero complex. This mineralization has been the subject of mineralogical studies by FRIEDENREICH (1956) and DE QUERVAIN (1967). Both have discussed the genesis of the nickel mineralization. DE QUERVAIN (loc. cit.) has also referred to unpublished studies by HUTTENLOCHER and analyses of mineralized material carried out in 1943. He has mentioned that the mineralization in Val del Boschetto is limited to an outcrop of 250 m^2 and that it has not been recognized elsewhere in the vicinity.

One of the authors (EGH) relocated the nickel occurrence in 1971 and started to reconnoitre the area. On May 7, 1975, he was granted an exploration licence over 4 km^2 from the Italian border to Bordei by the "Consiglio di Stato della Repubblica e Cantone Ticino". The intention was to re-assess the nickel mineralization and potential of the area by detailed mapping and geophysical methods (magnetometer and VLF-EM). The first author (FB) carried out the geological mapping on scale 1:5000 in August 1975. In July/August 1976, four holes totalling 102.44 m were drilled with a Winkie GW-15 at the original discovery site in Val del Boschetto. Most of the petrographic studies and related laboratory work was carried out by the third author (JEM).

REGIONAL SETTING

The Finero ultramafic-mafic complex is a lenticular mass of interlayered peridotite and gabbro covering an area 12 km by 4 km. The main portion of the Finero complex lies in Italy and only its eastern end, which is presently described in detail, occurs in Switzerland on the south flank of the Centovalli about 10 km west of Locarno in Ct. Ticino (see Key Map in Plate 1). The complex forms part of the Ivrea-Verbano Zone within the Insubric Basement of the Southern Alps. To the north, the Finero complex is bounded by the Tonale Line (also called the Insubric Line) which delimits the Canavese Zone and southern extent of Alpine orogenesis and metamorphism. Tectonic movements which affected the Tonale Line and the Finero Complex have probably taken place in late- to post-Alpine times (GANSSER, 1968).

Age determinations (GRAESER & HUNZIKER, 1968; JAEGER, 1962) can be interpreted as supporting a date of 310 M.y. for the intrusion of the Finero complex into basement country rock, followed by regional metamorphism during the Hercynian orogeny. No Alpine ages are reported from this area south of the Tonale Line.

LOCAL GEOLOGY

In the area investigated, the following sequence occurs from north to south (see Plate 1): Canavese Zone, Tonale Line, and Finero complex. Stronalite and kinzigite gneisses which form the upper part of the Ivrea-Verbano Zone lie to the south of the area mapped and are excluded from discussion.

(i) The Canavese Zone

The southern part of this zone consists predominantly of fine-grained, quartz-sericite schists with local intercalations of medium-grained, dark grey, often graphitic mica schists. In the western section, fine-grained chlorite schists are common in this suite of metasediments. At Fornàs, a few metres north of the Tonale Line, the intensely folded schists contain a thin layer of laminated calcitic marble.

(ii) The Tonale Line

The line itself is commonly masked by a covering of detritus and finds its topographic expression in small E-W trending ravines. Within the map area, the plane of the zone dips 40° to 50° to the north. Relative movements along the Tonale Line are believed to have been essentially vertical.

(iii) The Finero Complex

The Finero complex, which forms the lower part of the Ivrea-Verbano Zone, is subdivided into two ultramafic-mafic cycles, each of which consists of "peridotite" overlain by metagabbro.

Phlogopite peridotite of the lower cycle occupies the core of an easterly plunging antiform and crops out in Val di Capolo and on the east side of Val di Bordei. In Val di Capolo, its exposed thickness is of the order of 400 m. In outcrop, fresh phlogopite peridotite appears medium-to coarse-grained, very hard, of light greenish-grey colour and weathers to a reddish-yellow colour. Phlogopite is irregularly distributed and is oriented parallel to the main tectonic fabric of the rock [second schistosity, at 15° to the primary layering, phase 4 of Steck & Tieche (1976)]. Monomineralic concentrations of subordinate light green amphibole are frequently observed as thin layers. Alteration of the rock is minimal and serpentinization is generally limited to an irregular network of very thin veinlets.

The observed thickness of the overlying mafic unit, termed the *lower metagabbro*, varies from a few metres to about 200 metres in Val di Capolo, according to the tectonic position. The main mass of lower metagabbro forms the upper part of the Val di Capolo antiform. A smaller body occurs in the east side of Val di Bordei (see Plate 1). Both are very close to or are in contact with the Tonale Line. Another layer of lower metagabbro, roughly in the central part of the amphibole peridotite, can be followed from Val di Capolo through Val di Front to the west side of Val del Boschetto. It possibly represents a second, sheared isoclinal antiform, parallel to the main one to the north. In outcrop, the metagabbro appears as a medium- to coarse-grained, layered, massive to weakly schistose, dark green rock. Layering is conspicuous and consists of alternating cm-dm wide mesocratic, amphibole-rich and leucocratic, plagioclase-rich bands. Close to the contact zones, the unit contains numerous lenses and bands of hornblendite up to 1 m thick. The metagabbro is generally more massive in the core and more gneissic at the contact zones. In close proximity to the Tonale Line, the metagabbro has been transformed into a sheared, laminated, dark green chlorite schist.

The *amphibole peridotite* unit of the upper cycle occurs immediately above the lower metagabbro and reaches an apparent thickness of 600 m due to tectonic repetition. It gradually thins out to the east where it completely disappears east of Valle di Mezzo at the end of the Finero complex (see Plate 1). Fresh amphibole peridotite appears medium-grained, massive, layered and dark green in colour. Weathering produces a yellowish-brown colour. In contrast to the relatively uniform phlogopite peridotite, the "amphibole peridotite" ranges from dunite to clinopyroxenite in composition. Layering is well defined throughout and is locally marked by thin amphibole-rich bands that become more frequent towards the structurally higher parts in the south.

Portions of the amphibole peridotite, particularly to the north and east, in proximity to the Tonale Line, are serpentinized to various degrees. In the field, three main types have been recognized: predominantly unaltered peridotite, partly serpentinized amphibole peridotite, and black serpentinite (totally serpentinized amphibole peridotite). Contacts between types are gradational and boundaries indicated in Plate 1 are arbitrary.

Even the freshest sections of the amphibole peridotite exhibit signs of incipient serpentinization: a network of thin (mm to cm) veinlets of black serpentine cut the peridotite parallel to and at various angles to the layering. On the east side of Val di Capolo and Val di Bordei, a 200 m thick section of alternating bands (few cm to 20 cm) of unaltered, grey peridotite and black serpentinite can be observed.

Zones of particularly intense serpentinization are common to almost every fault or shear zone. The thickest of them which are about 2 m wide have been mapped and are shown on Plate 1. A serpentinite zone with an apparent thickness of some 60 to 100 m can be traced at the contact with the Tonale Line from Val di Front to Val del Boschetto and at the east end of the complex (see Plate 1). This serpentinite is invariably strongly sheared, laminated to lenticular, fine- to very fine-grained, dense and of bluish-black colour. As a rule, the original layering of the peridotite has been obliterated by shearing. The serpentinite often contains boudins of relict peridotite. The black serpentinite of Val del Boschetto which carries the strongest mineralization belongs to a tectonic breccia zone. Fibrous asbestos veinlets are rarely found and talc/carbonate alteration has been observed only locally in pyroxenites in Val di Front.

The *upper metagabbro* is the uppermost unit of the Finero complex and has an apparent thickness of over 1000 m. Only the northern contact zone has been mapped (see Plate 1). This unit exhibits the same megascopic characteristics as the lower metagabbro: clear layering, defined by alternating amphibole-rich and plagioclase-rich bands, dark green colour and gneissic texture. At or close to the contact with the amphibole peridotite, the metagabbro is rich in monomineralic, melanocratic bands of brown to dark green hornblende or pyroxene. They have a lenticular structure and a thickness of a few dm up to 3 m.

DETAILED STRUCTURE

For a detailed account of the structural evolution of the Finero complex, the reader is referred to STECK & TIECHE (op. cit.). In the area investigated, the general structural trend of the complex is ca. N 75° E. It is cut by the E-W striking Tonale Line at a slight angle resulting in a decrease in thickness of the complex, particularly the peridotites, from west to east.

As shown on the sections (Plate 1), the Finero complex has been physically distorted and individual sections are difficult to correlate. In general, the rock units dip steeply to the north, with the exception of antiform structures. The Val di Capolo antiform (see Section C) can be followed to the western end of the complex. The core of the antiform consists of phlogopite peridotite; the upper part and the flanks of lower metagabbro. The axis of the antiform strikes N 80° E and plunges 38° to the east, disappearing just west of Val di Front. On the east side of Val di Bordei, it again outcrops (see Section A) and appears to have been emplaced in the form of a wedge with a westerly plunge. Between these two areas lies an axial low. The southern continuation of the antiform is obscured by intense shearing and thrusting of the southern flank. As previously mentioned, there is possibly a second isoclinal antiform with a core of lower metagabbro (see Section C).

An antiform also occurs between Val del Boschetto and Val di Bordei (see Section B). In this area, it is defined by the upper metagabbro which surrounds a core of amphibole peridotite and serpentinite and which, in places, is in contact with the Tonale Line. This fold is combined with younger shearing, as documented by the tectonic discordance between the peridotite and overlying metagabbro on the west side of Val di Bordei. This section corresponds to an axial low and explains the sudden tectonic changes from section to section and the apparent lack of correlation between them. The folding event corresponds to Phase 5 of STECK & TIECHE (op. cit.).

The youngest deformations in the area comprise intense shearing and faulting, particularly of the amphibole peridotite, followed by serpentinization. Faults and shear zones are steep, with down-throw of the north block and in most cases with a north dip. They are parallel to the Tonale Line, and belong to the same deformational event which is believed to be of late- to post-Alpine age. Structures in the amphibole peridotite are not clearly understood. The repetition of steep shear zones and faults could be interpreted as an imbricate structure of possibly isoclinally folded peridotite layers. The contact between the lower metagabbro and the amphibole peridotite is clearly tectonic, whereas the contacts between the remaining ultramafic-mafic units have apparently not been affected by the differential movements.

PETROGRAPHY OF THE ULTRAMAFIC ROCKS

Phlogopite Peridotite

The lowermost unit of the complex is relatively fresh, as well as uniform in composition, and consists of the following minerals: olivine-Fo_{91} (65–90 vol.%), serpentine (5–10), orthopyroxene (2–10), clinopyroxene (0–20), amphibole (0–4), phlogopite (1–3), carbonate (tr), chrome-spinel (<1), magnetite (1–2), sulphides (tr). Somewhat porphyroclastic, anhedral, partly serpentinized olivine grains, which commonly exhibit undulose extinction and strain lamellae, together with deformed orthopyroxene grains and blocky amphibole are arranged in a mosaic-like aggregate. A fine-grained cataclastic assemblage of olivine, serpentine and clinopyroxene occurs interstitially. Minor radiating sheaves of phlogopite appear in irregular lenses with fine-grained serpentine filling cross-cutting veinlets. Partly oxidized chrome-spinel grains and traces of sulphides are disseminated throughout.

Amphibole Peridotite

As reported by CAWTHORN (1975), this unit has been observed to vary from dunite to clinopyroxenite in composition. The dunitic "black serpentinite", which is generally the most highly mineralized of the ultrabasic rocks within the complex, consists of >85% partly to completely serpentinized, coarse-grained, interlocking, equant olivine grains (Fo_{88}). Undulose extinction and strain lamellae are frequently observed within relict grains. Variable proportions of lesser colourless to pale green amphibole, orthopyroxene, chlorite, carbonate and opaques occupy the interstices between olivine grains. In those rocks which contain less olivine (i.e. true peridotites and pyroxenites) when clinopyroxene and orthopyroxene are both present, the former is consistently more abundant. Olivine (Fo_{87}) and orthopyroxene grains are frequently found pseudomorphed by serpentine/talc/carbonate and serpentine/chlorite assemblages respectively. Clinopyroxene may exhibit weak replacement by a colourless amphibole. Opaques occupy <5% by volume and are comprised of partly oxidized chrome-spinel and lesser sulphides. In contrast to the moderately schistose nature of the "black serpentinite", the olivine-poor rocks in this unit often exhibit in addition a granulated texture.

NICKEL MINERALIZATION

During the mapping of the eastern end of the Finero complex, numerous nickel-sulphide showings were observed in the ultramafic rocks. Their locations are shown on Plate 1. Sulphides are visibly more common in the lowest portion of the amphibole peridotite, in a ca. 150 m thick zone of black serpentinite south of the Tonale Line.

Barren and very weakly mineralized peridotites and their serpentinized equivalents have the following "background" values (see Table I for the individual analyses):

Ni	0.13	to	0.28	Wt. %
Cu	0.030	to	0.058	Wt. %
Co	0.012	to	0.041	Wt. %
Fe	3.4	to	7.4	Wt. %
Cr	0.05	to	0.29	Wt. %
S	0.022	to	0.490	Wt. %

The nickeliferous mineralization of Val del Boschetto occurs in a N-S trending outcrop that follows the bed of the creek Ri della Serra. Results of detailed mapping (see Fig. 1) and of four short diamond drill holes show the following distribution of mineralization from north to south:

a) A barren northern zone of approximately 12 m true width consisting mainly of fresh to slightly altered amphibole peridotite with thin layers of hornblendite. The zone contains shear zones up to 1 m wide filled with light to dark green, laminated dense serpentinite.

b) A central zone in sharp contact follows with a true width of 7 m. It consists of a tectonic breccia with a chaotic network of mylonitic shear zones which include lenses of dark grey to black serpentinite (4 m) and partly serpentinized amphibole peridotite (3 m). The upper 4 m contain the strongest mineralization, which varies from 0.6 to 2.24% Ni and averages ca. 1.0% Ni. It has been traced by drilling over a length of 16 m and was generally found to be of a lenticular nature. The mineralization, in the form of disseminated sulphide blebs, is restricted to the black serpentinite fragments of the breccia, whereas the mylonite matrix is barren.

c) The central zone grades into a southern zone of partly serpentinized amphibole peridotite which has a true width of ca. 25 m. The intensity of serpentinization decreases towards the south. The rock is dark olive to grey, massive, and consists of an intense net-like pattern of black, thin serpentine veinlets enclosing lighter grey remnants of partly serpentinized olivine aggregates. The nickel mineralization has a very irregular distribution and varies from weak to moderate, with scarce rich patches.

The overall Ni content of the mineralized section has been determined on 3 chip-samples taken over a total outcrop length of 42 m (representing a true

Table I: *Chemical Analyses of the Elements Ni, Cu, Co, Fe, Cr and S from Different Rock Types of the Eastern End of the Finero Ultramafic-Mafic Complex (Wt. %)*

	Sample No.	Location	Ni	Cu	Co	Fe	Cr	S
Fresh Phlogopite Peridotite	4349	Val di Capolo	0.24	0.015	0.013	6.8	0.24	0.022
	4350	Val di Capolo	0.28	0.020	0.014	6.4	0.24	0.062
Fresh Amphibole Peridotite	4354	Val del Boschetto	0.22	0.027	0.013	7.4	0.22	0.15
Partly Serpentinized Amphibole Peridotite, Partly Mineralized	4351	Val di Bordei	0.13	0.028	0.012	7.4	0.25	0.29
	3437	Val del Boschetto	0.24	0.003	0.036	3.7	0.22	0.04
	3438	Val del Boschetto	0.16	0.009	0.041	3.4	0.11	0.14
	2808	Val del Boschetto	0.31	0.052	ND	4.2	ND	0.19
	3436	Val del Boschetto	0.44	0.014	0.048	3.7	0.19	0.22
	2809	Val del Boschetto	0.45	0.062	ND	7.3	ND	0.25
	4359	Val di Capolo	0.27	0.066	0.02	11.7	0.11	0.30
Serpentinite, Not Mineralized	4357	Val di Front	0.18	0.052	0.016	7.9	0.29	0.49
	4363	Val del Boschetto	0.27	0.058	0.012	5.6	0.05	0.11
Mineralized Serpentinite	4348	Val del Boschetto	0.64	0.081	0.02	7.2	0.23	0.60
	4361	Val del Boschetto	0.99	0.033	0.023	8.9	0.07	0.80
	4362	Val del Boschetto	0.94	0.076	0.024	4.6	0.06	0.93
	3443	Val del Boschetto	0.66	0.039	0.036	3.9	0.13	0.77
	3444	Val del Boschetto	0.88	0.017	0.032	3.9	0.10	0.77
	2807	Val del Boschetto	2.24	0.34	ND	8.3	ND	2.30
	C1	Val del Boschetto, Chip Sample 0–18 m	0.58	0.065	ND	6.6	ND	0.31
	C2	Val del Boschetto, Chip Sample 18–30 m	0.46	0.027	0.032	3.8	0.34	0.20
	C3	Val del Boschetto, Chip Sample 30–42 m	0.47	0.071	0.027	3.9	0.32	0.17
Mineralized Pyroxenite	4358	Val di Front	0.45	0.19	0.02	6.3	0.20	0.47
Metagabbro	3439	Val di Bordei	0.05	0.037	0.036	5.9	0.04	0.67
	3440	Val di Capolo	0.04	0.019	0.100	5.6	0.08	1.26

ND=Not Determined

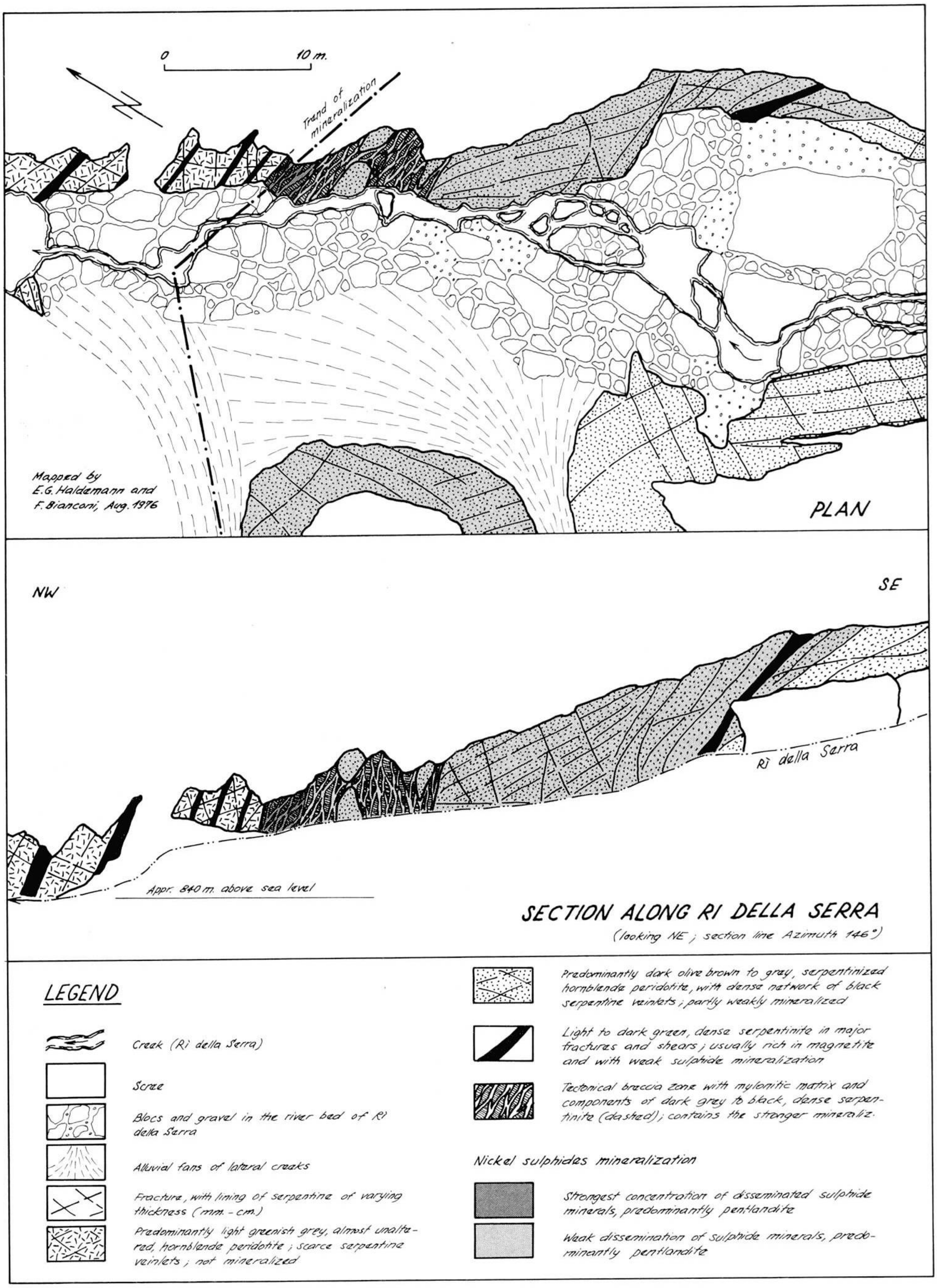

Fig. 1: Geological plan and section of the nickel mineralization of Val del Boschetto, Palagnedra.

width of ca. 32 m) and averages 0.51% Ni. Results of individual drill-hole intersections are as follows:

Drill Hole	Apparent Width (m)	% Ni
P1	35.29	0.45
P2	26.15	0.55
P3	30.00	0.55
P4	11.00	0.54

Weak mineralization has been encountered in the central part of Val di Front, some 50 m south of the Tonale Line within a 100 m wide serpentinite zone. The mineralized section has a true thickness of 5 m and strikes in an E-W direction. The host rock is partly altered amphibole clinopyroxenite. The alteration assemblage includes talc/carbonate in addition to serpentine. Chemical analysis of one mineralized sample is given in Table I and shows a relatively high Cu content (0.19%) compared to weakly mineralized samples of black serpentinite.

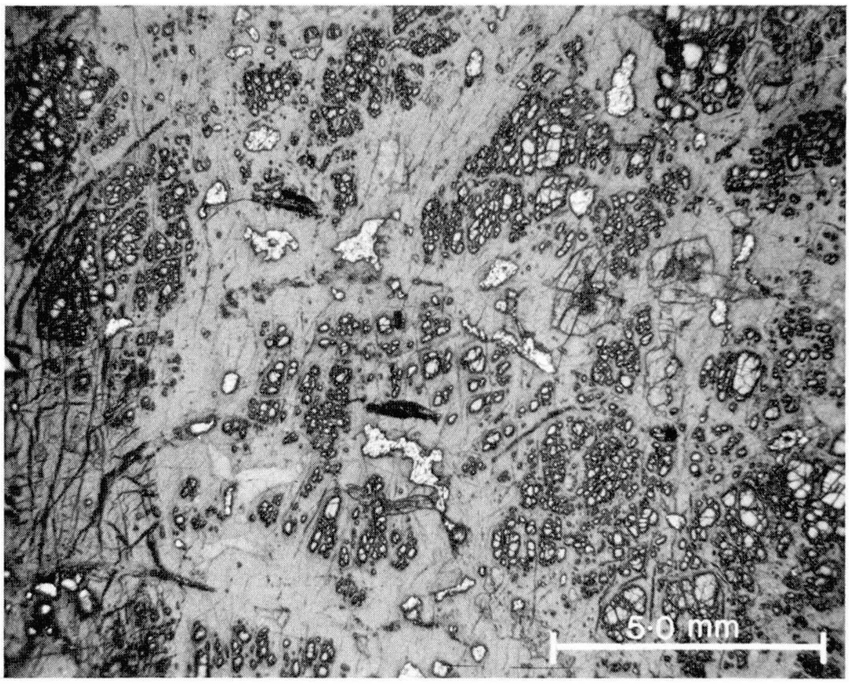

Fig. 2: Intercumulus sulphide/oxide blebs (white) in a partly serpentinized dunite (reflected light).

Sulphides in the mineralized zones occur in two distinct modes. The first is the irregular, intercumulus bleb form (see Fig. 2) which comprises upwards to 3% by volume of samples of the most highly mineralized black serpentinite. Grain sizes vary from <0.10 mm to 0.80 mm and average about 0.50 mm. Blebs commonly consist of an aggregate of phases with blocky pentlandite and magnetite blades the most abundant. Other phases identified in lesser quantities are

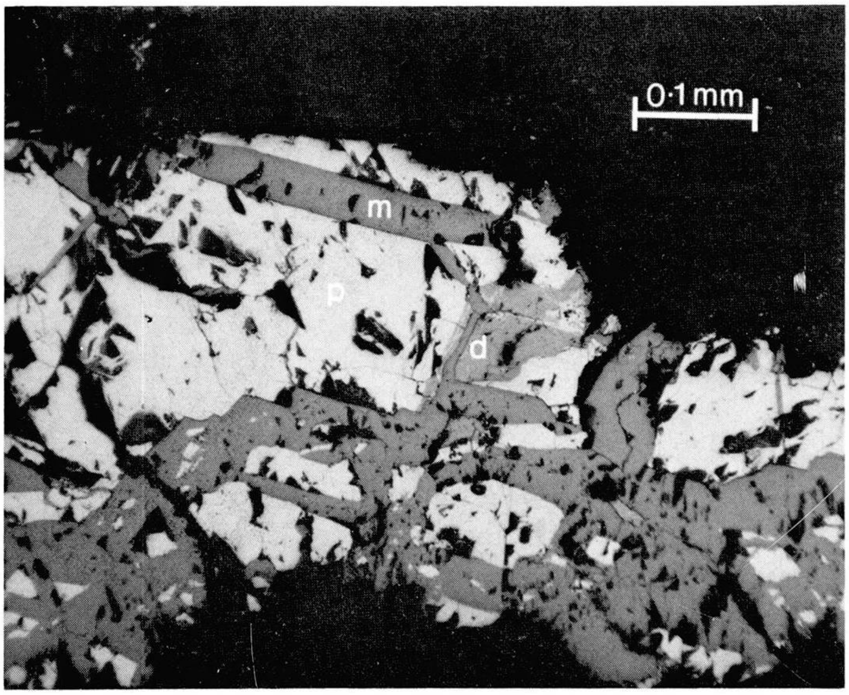

Fig. 3: Djerfisherite (d) pseudomorphing pentlandite (p). within an intercumulus sulphide/magnetite (m) bleb (reflected light).

heazlewoodite, awaruite, native copper, mackinawite, pyrrhotite, violarite, chalcocite, bornite, covellite and chalcopyrite. Gersdorffite, cobaltite and rammelsbergite have been observed in only one sample from near the Val del Boschetto showing. Djerfisherite, a rare K-Cu-Fe-Ni sulphide, has also been identified in the Val del Boschetto material. Electronmicroprobe analysis gave the following composition: $K_{2.95}Cu_{2.98}(Fe_{9.69}Ni_{0.65})_{10.34}S_{14}$. It occurs partly pseudomorphing blocky pentlandite (see Fig. 3). To the authors' knowledge, only one other terrestrial occurrence has been documented to date. GENKIN *et al.* (1970) have described djerfisherite from the copper-nickel ores at the Talnakh deposit in the U.S.S.R. This rare sulphide has also been reported from several meteorites (FUCHS, 1966; GORESY *et al.*, 1971).

Sulphides also occur as sub-micron disseminated grains in serpentine. In many instances, a distinctly needle-like crystal morphology can be discerned. Because of their extremely fine grain size, these sulphides can only be tentatively identified as heazlewoodite and/or pentlandite. In several samples, late-stage valleriite and cubanite veinlets are also found.

DISCUSSION

The nickel mineralization of the Finero complex is in many ways comparable to that of the Dumont deposit described by ECKSTRAND (1975). The two modes of occurrence (i.e. bleb and disseminated) and the opaque assemblage are common features. As in the Dumont deposit, serpentinization has *upgraded* (in a metallurgical sense) weakly mineralized ultramafics. This does not imply any change in the total nickel content of the ultramafics, only a change in the form in which nickel occurs. The irregular sulphide blebs are interpreted as originally magmatic and most likely consisted of an assemblage of pyrrhotite, pentlandite and minor magnetite. Subsequent serpentinization has transformed this assemblage to one which is characteristic of more reducing conditions (i.e. awaruite, heazlewoodite, native copper). At the same time, nickel contained in silicate form (i.e. mainly olivine) has been converted into nickel contained in sulphide form (i.e. disseminated sulphide grains).

It is interesting to note that of all the rock types within the amphibole peridotite unit, the dunitic "black serpentinite" is the most highly mineralized. In addition, this rock type appears volumetrically more abundant towards the base of the amphibole peridotite unit. These findings would be in accord with an origin of the Finero complex by gravitational settling of crystals from a fractionally crystallizing magma, as proposed by CAWTHORN (op. cit.).

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SMPM=Schweiz. Mineral. petrogr. Mitt.

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PLATE I

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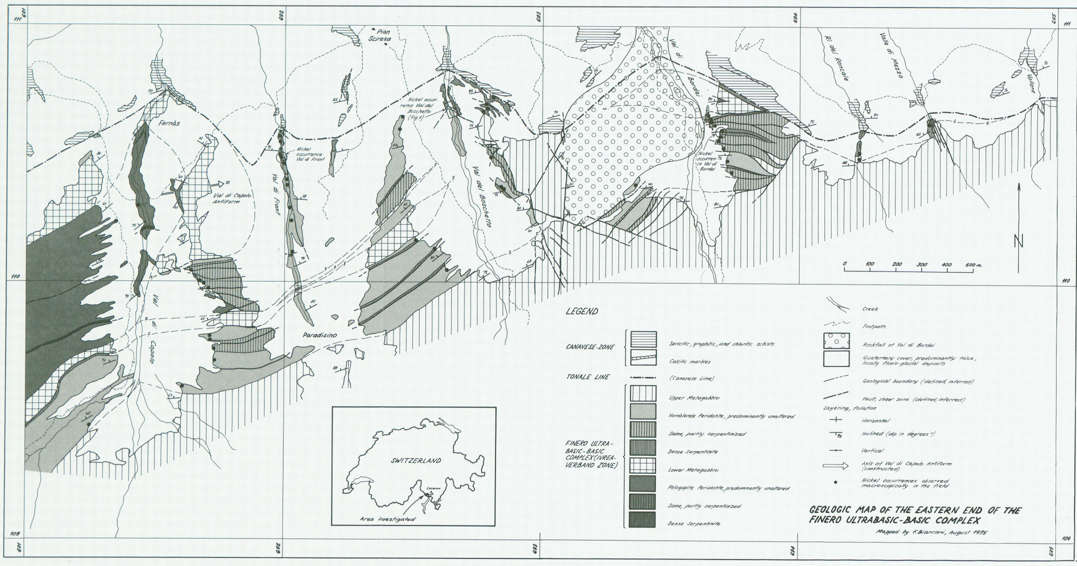
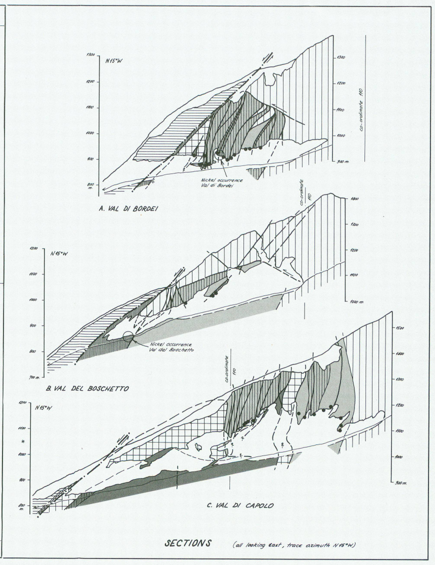
Geology and Nickel Mineralization of the Eastern End of the Finero Ultramafic-Mafic Complex (Ct. Ticino, Switzerland)



GEOLOGIC MAP OF THE EASTERN END OF THE FINERO ULTRABASIC-BASIC COMPLEX

Mapped by F. Bianconi, August 1975



SECTIONS (all looking east, trace azimuth N15°W)