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HYDROTHERMAL CONTRIBUTIONS TO CHERTS DEPOSITION IN NORTHERN APENNINES: A PRELIMINARY REPORT

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ABSTRACT

Siliceous fine-grained sediments diffusely crop out upon the ophiolitic sequences of the Jurassic Piedmont-Ligurian basin (Ligurian Alps and Northern Apennine). Their stratigraphic features provide an insight of the lateral variability of cover sedimentation until Palombini Shales deposition.

Basement-cover relationships suggest a prominent control of palaeotopography on deposition event at narrow scale.

Within the thickest siliceous sediments, Mn mineralizations exhibit two main occurrences: 1) stratiform braunite associated to hematite with evident grading in composition and grain size. The layers generally preserve sedimentary turbiditic textures (Type 1 mineralization); 2) massive Mn-ore originated by folding and metamorphism (Type 2 mineralization).

Preliminary geochemical data evidence a sharp partitioning of major elements (Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5) among type 1 and 2 Mn-ore and the host hematite cherts. Trace elements in cherts and manganiferous mineralizations are compared to abundances in present-days Pelagic Clays and Metalliferous Sediments.

RIASSUNTO

Sedimenti silicei a grana fine sono comunemente presenti al tetto delle sequenze ofiolitiche del bacino giurassico Piemontese-Ligure (Alpi Liguri e Appennino Settentrionale). I caratteri stratigrafici forniscono un quadro della variabilità laterale della sedimentazione di tali coperture fino alla deposizione delle Argille a Palombini. Le relazioni tra basamento e coperture inoltre suggeriscono un controllo della paleotopografia sulla deposizione, anche a scala ridotta.

Nelle sequenze più potenti di diaspri le mineralizzazioni a manganese si presentano come: 1) braunite stratiforme associata ad ematite con evidenti gradazioni composizionali e dimensionali. Gli orizzonti generalmente conservano tessiture sedimentarie torbiditiche (mineralizzazione di Tipo 1); 2) mineralizzazione massiccia originata per ripiegamento e metamorfismo di orizzonti sedimentari (mineralizzazione di Tipo 2).

Dati geochimici preliminari evidenziano una netta ripartizione degli elementi maggiori (Fe_2O_3, MnO, MgO, CaO, Na_2O, TiO_2, P_2O_5) tra mineralizzazioni di tipo 1 e 2. Viene inoltre presentato un confronto tra contenuti di elementi in tracce dei diaspri e di attuali Argille Pelagiche e Sedimenti Metalliferi

INTRODUCTION

Siliceous fine grained sediments (cherts and quartzschists in metamorphosed sequences), commonly Mn-ores bearing, overlie the ophiolites of the Jurassic Piedmont-Ligurian basin (Burckhardt, 1959; Chiesa et al., 1976a; 1976b; Cortesogno and Haccard, 1984; Cortesogno et al., 1987; Dal Piaz et al., 1979; Martin-Vernizzi, 1982). Cherts from Ligurid Monte Alpe Formation (Vara Supergroup) are early Callovian to late Tithonian or

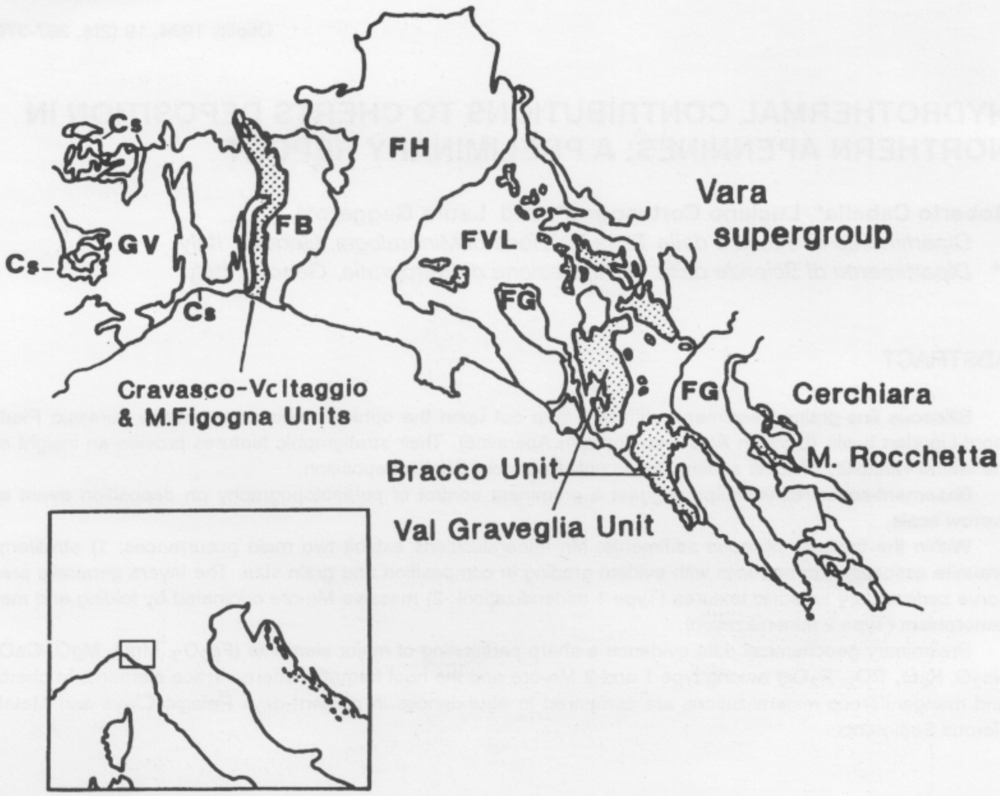

Fig. 1 - Geologic map of the studied Ligurian units: Cs. Calcescisti Formation; GV. Voltri Group; FB. Busalla Flysch; FH. Helmynthoid Flysch; FVL. Val Lavagna Flysch; FG. Mt. Gottero Flysch. Dotted areas: Cravasco-Voltaggio, Mt. Figogna and Bracco-Val Graveglia Units.

early Berriasian in age (Marcucci and Passerini, 1991).

The hydrothermal origin and chemical-biochemical deposition of silica as well as the hydrothermal contribution to Mn deposits have already been discussed (Thurston, 1972; Garrison, 1974; Bonatti et al., 1976; Folk and MacBride, 1978; Cortesogno et al., 1979; Dal Piaz et al., 1979; De Wever et al., 1986; Baumgartner, 1987). The origin of cherts and associated Mn-deposits has been related to the rock-water interaction affecting the whole ophiolitic sequence (ultramafics, gabbros, basalts) under extremely high thermal gradients.

Preliminary mineralogical and chemical data on cherts and associated ores have been presented at the meeting "Sedimentary cover in ophiolitic and oceanic sequences" (Firenze 1991).

STRATIGRAPHIC AND PETROGRAPHIC FEATURES OF THE CHERTS

Representative stratigraphic sequences from the Vara Supergroup and Sestri-Voltaggio Zone (Cravasco-Voltaggio and Mt. Figogna Units) (Fig. 1) are shown in Figs. 2 to 3, and 5, respectively. The rocks of the Internal

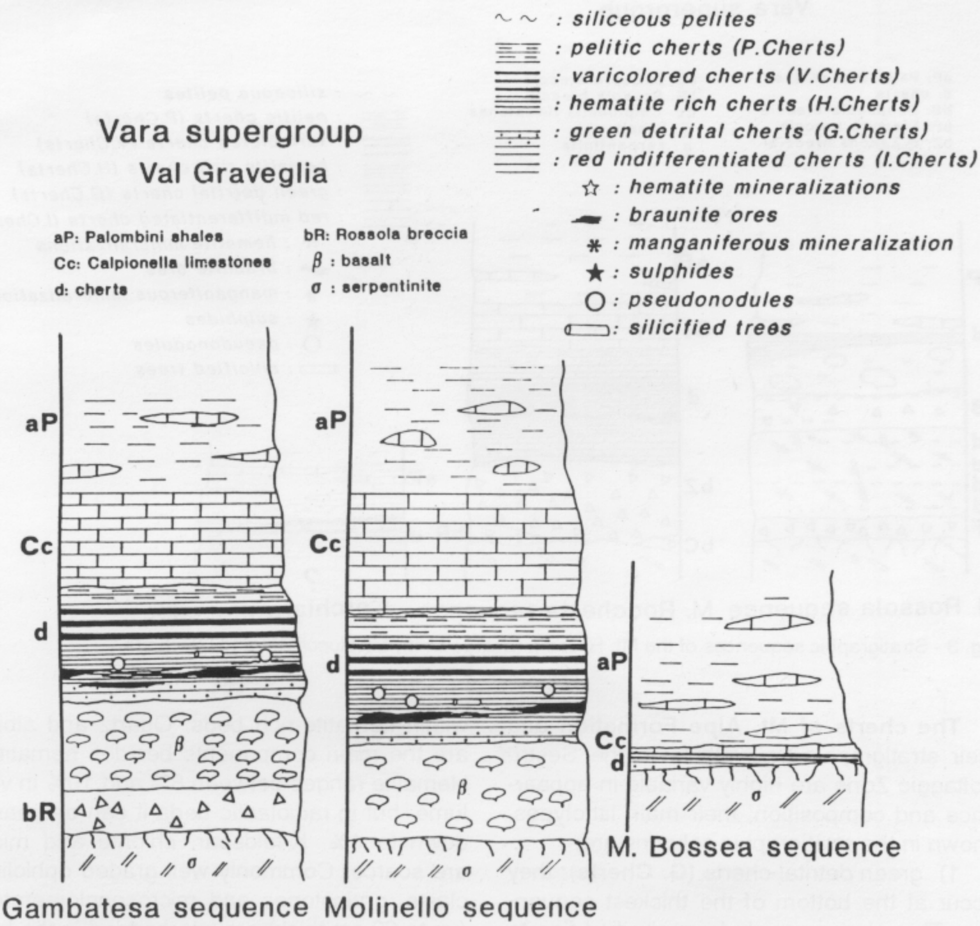

Fig. 2 - Stratigraphic sequences of the Val Graveglia Unit.

Ligurides Units show only minor tectonometamorphic overprints.

Siliceous pelites (Scisti Silicei - Cortesogno et al., 1987) stratigraphically underlying the Mt. Alpe Cherts. They form thin to very thin (1 to 100 cm), sometimes discontinuous levels, interbedded to ophiolitic breccias or basalts (Figs. 3, 5). They sometimes occur in the interstices or more rarely fill cavities of the pillows (e.g. Mt. Gropaggi, Mt. Tejolo). Generally reddish to brown-reddish, they are rich in hematite (5-20% in volume) and contain pelitic components (chlorite and illite), and fine grained, up to decimetric ophiolitic clasts; rarely, glassy basaltic clasts are present. Scattered Mn oxides are common; radiolarian tests are generally scarce. Siliceous pelites are rarely greenish and do not contain hematite whereas primary sulfides (mainly pyrite) occur. The well stratified siliceous pelites (>1 m) of the Mt. Rossola sequence (Fig. 3) are interbedded in basalts and radiolaritic beds and show parallel to convolute laminations.

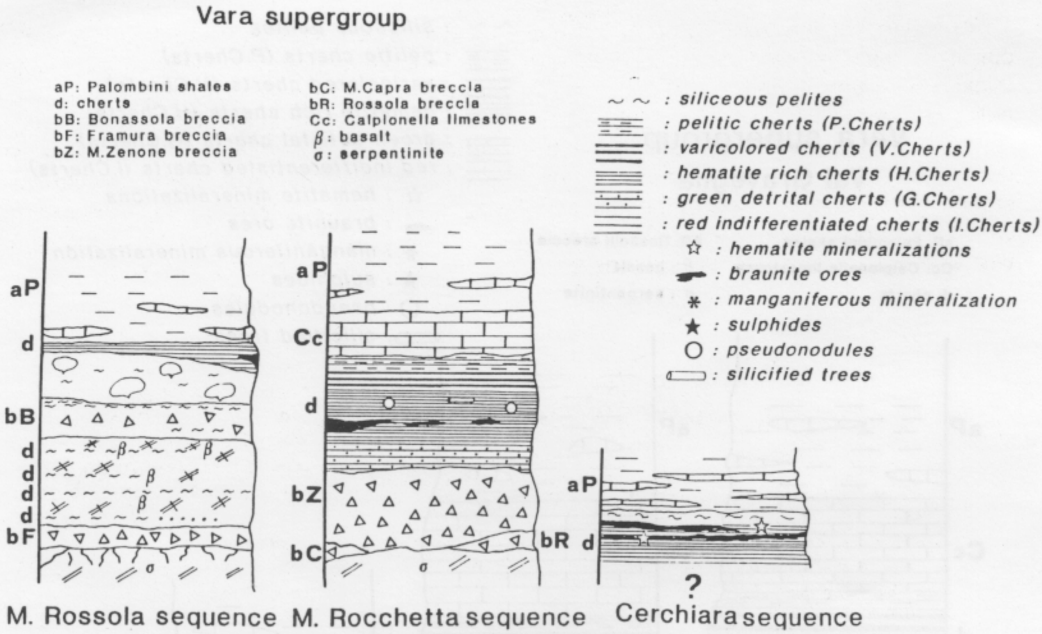

Fig. 3 - Stratigraphic sequences of the Mt. Rossola (Bracco Unit), Mt. Rocchetta and Cerchiara

The cherts of Mt. Alpe Formation and their stratigraphic equivalents in the Sestri-Voltaggio Zone are highly variable in appearance and composition; their main lithotypes, shown in the stratigraphic columns are:

1) green detrital cherts (**G. Cherts**); they occur at the bottom of the thickest sequences. They derive mainly from silicified fine to very fine grainstones and show decimetric bedding, parallel laminations and grading. Quartz, albite, white mica and minor K-feldspar and chlorite are the main components. Radiolaria are generally very scarce.

2) Hematite rich cherts (**H. Cherts**); they are typically associated to manganese deposits, they are red to brown and form centimetric to pluridecimetric strata (up to 30-40 cm). Radiolarian tests are generally subordinate but locally radiolaritic beds occur. Parallel laminations and grading are well developed. Pseudonodules are common (up to 60 x 35 cm, generally 10-20 x 7-10 cm) in the radiolaritic beds. Silicified trees sometimes occur within hematite-rich beds. Quartz and albite are the main components besides hematite. Hematite ranges between 8% and 10% in volume, but in radiolaritic beds it can decrease down to 4%. K-feldspar, chlorite and mica are scarce. Commonly well graded ophiolitic clasts, grainstones and microconglomerates (up to 60 cm thick) are interbedded in the hematite- rich beds.

3) varicolored cherts (**V. Cherts**); they are typically represented by alternating layers of:

a) reddish siliceous strata (generally ra-diolaritic, with hematite content ≤4% in volume);

b) greenish strata generally rich in micas, containing variable amounts of radiolaria but lacking hematite;

c) almost pure siliceous (radiolaritic) strata varying in thickness from 5 to 30 cm; parallel laminations and dimensional grading of radio-larian shells are sometimes recognizable.

4) pelite-rich cherts (**P. Cherts**); they occur in commonly reddish beds (5-10 cm thick), with greenish bands and patches; the pelitic components (illite, mica and chlorite) are abundant; carbonates often appear at the contact with the overlying Calpionella Limestones; radiolarian tests are commonly scarce. In contrast with the thickest sequences, where the lithotypes are well represented, and arranged in the same stratigraphic order, the thin sequences, generally a few meters thick, are relatively homogeneous and undifferentiated (**U. Cherts**); they are composed of reddish siliceous layers with local greenish bands, showing relatively high hematite contents (5-8% in volume), scarce pelitic components and dispersed radiolarians; manganiferous phases are generally lacking.

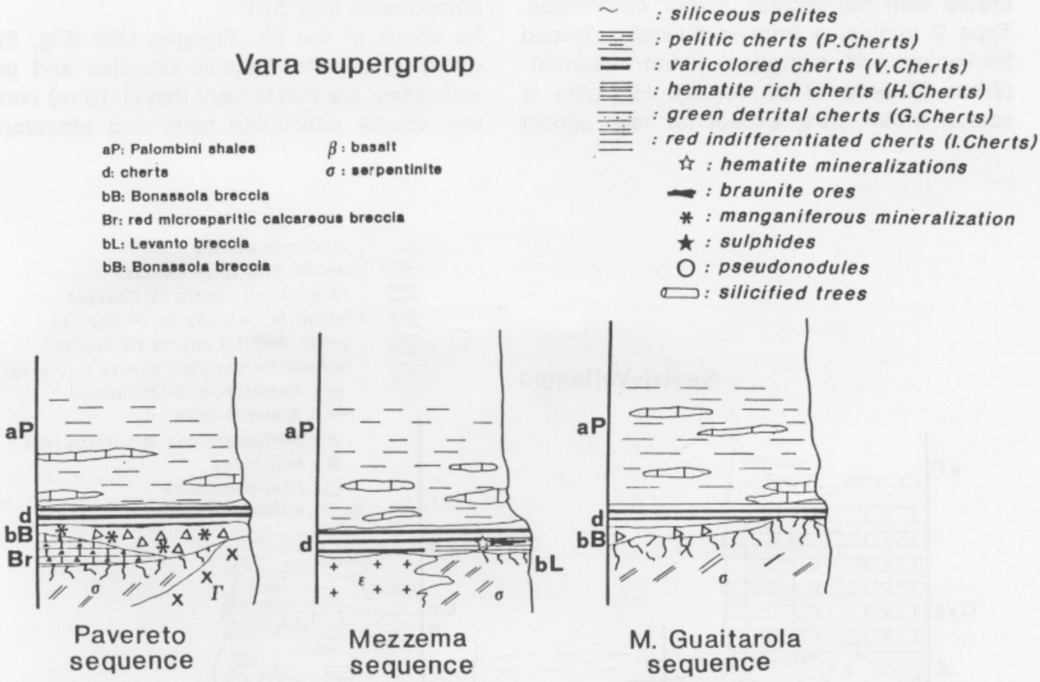

Fig. 4 - Stratigraphic sequences of the Bracco Unit.

Manganiferous mineralizations

Mn-ores are restricted to the bottom of the thickest chert sequences, interbedded in the H. cherts. Dispersed manganiferous mineralizations (carbonates, silicates, rarely braunite) also occur in the matrix of sedimentary ophiolitic breccias (Pavereto, Fig. 4; Mt. St. Nicolao).

The first type of mineralization (Type 1) rarely preserves primary sedimentary features: stratiform braunite ores occur at the bottom of individual strata whereas hematite and quartz occur at their tops; the hematite content generally decreases upwards. Radiolarian tests vary from rare to very abundant; they are graded, the larger and unbroken tests occur at the bottom (braunite bed), the smaller and more fragmented ones at the top (hematite + quartz bed). Load casts and sometimes fluidified load cast structures are relatively common at the base of the braunite beds. Lenticular ores (1 to 10 dm thick) show hydroplastic textures (e.g. sedimentary slumping).

The second type of mineralization (Type 2) is represented by massive Mn-ores some ten meters thick, lacking sedimentary features and characterized by braunite equilibrated with Mn-silicates and/or carbonates. Type 2 originates from tectonically induced thickening and migration during metamorphism (Cabella et al., 1991). Hematite is scarce in Mn-ores, except for rare almost monomineralic bands (0.1 to 50 cm thick) interlayered in massive (Type 2) braunite (Cerchiara and Mezzema mines, Figs. 3, 4).

The comparison of the studied sequences allows the following general considerations: the cherts of the Cravasco-Voltaggio (and Montenotte) Unit are relatively thin, they overlie an ophiolitic substratum (ultramafics, gabbros, breccias and basalts), are homogeneous in composition (U. Cherts), and contain radiolaria and generally scarce pelitic components (Fig. 5).T

he cherts of the Mt. Figogna Unit (Fig. 5), overlying basalts, basaltic breccias and jaloclastites, are thin to very thin (1-10 m) contain scarce radiolarian tests and abundant

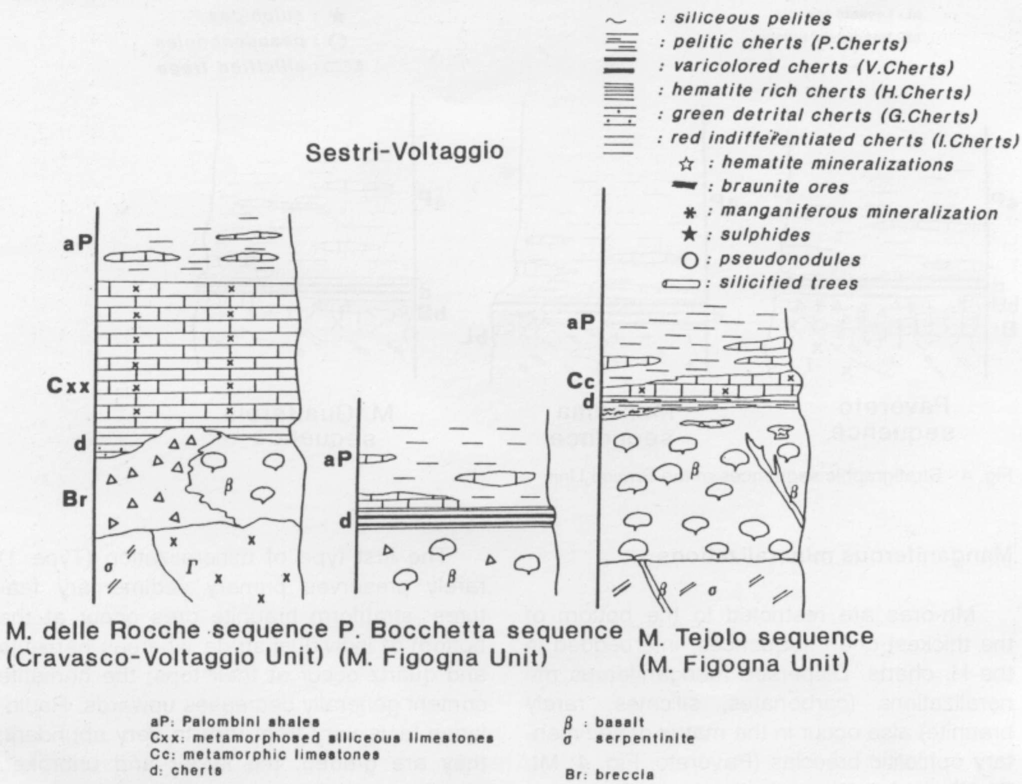

Fig. 5 - Stratigraphic sequences of the Sestri-Voltaggio Zone.

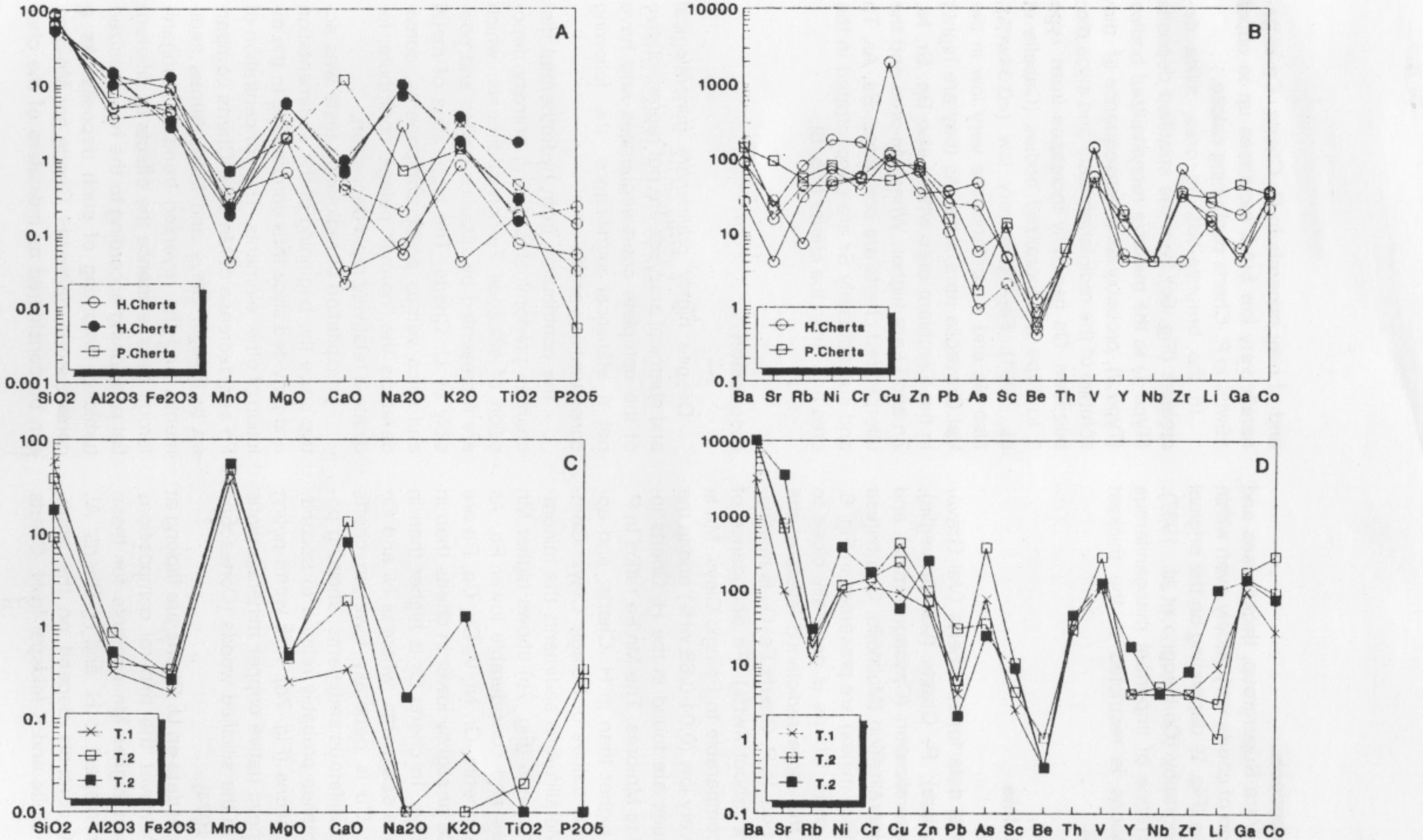

Fig. 6 - A, B. Major elements (wt%, average values) and trace elements (ppm) abundances for Hematite Cherts (H. Cherts; full circles: partial analyses from Cerchiara; open circles: analyses from Val Graveglia) and Pelitic Cherts (P. Cherts); C, D: major elements (wt%) and trace elements (ppm) abundances for Type 1 (T. 1, Cassagna ore), Type 2 (T. 2; full squares: Cerchiara ore; open squares: Molinello and Gambatesa ores) Mn-ores.

pelitic components.

In the Vara Supergroup, thicknesses and composition of cherts vary widely even within small areas (Fig. 2) depending on the original palaeotopography (Cortesogno et al., 1987). The occurrence of important manganiferous mineralizations is restricted to the thickest sequences.

Chemical data

Chemical data for H. Cherts (Val Graveglia, Cerchiara), P. Cherts (Val Graveglia), Type 1 mineralization (Cassagna mine) and Type 2 mineralization (Molinello, Gambatesa and Cerchiara mines) are presented in Fig. 6.

Fe_2O_3 of H. Cherts is generally close to 10wt% in the more radiolaritic levels at the top of the bed. In P. Cherts Fe_2O_3 is relatively constant (about 4wt%). Fe abundance of cherts is comparable to Pelagic Clays. Mn is generally very low (0.04-0.68 wt%) and in the lowest values are found in the H. Cherts interbedded to Mn-ores. The Mn/Fe ratios in P. Cherts is higher than in H. Cherts, and approaches the values of Pelagic Clays. Compared to Metalliferous sediments the mineralizations in cherts (Fig. 7b) shows higher Mn abundances and considerable lower Fe. As for trace elements, Cr, Ni, V, Cu, Co, Pb are comparable or slightly lower in cherts than in Pelagic Clays. In cherts Cr is higher than in Metalliferous sediments, whereas Ni and Co are lower; Cu is generally lower in cherts than in Metalliferous sediments, showing positive anomalies probably related to secondary mobilizations (Fig. 7b). It is worth noting that diagenetic native copper mineralizations are found in the silicified woods (Cortesogno and Galli, 1974).

Chemical data on U. Cherts are lacking at present; however the mineral compositions may support higher Mn contents for these cherts with respect to H. and P. Cherts. Al, Na and K contents depend on the abundances of albite and K-feldspar in H. Cherts and of clay minerals in P. Cherts. Ca is generally very low but it increases up to about 15wt% in P. Cherts containing calcite.

In the braunite-bearing ores, silica decreases (Fig. 6c) from the stratified deposits (Type 1) to the massive recrystallized bodies (Type 2), probably as a consequence of dissolution of the radiolarian tests and silica mobilization. Ca generally increases from Type 1 to Type 2 mineralized bodies (Cabella et al., 1991). Fe_2O_3 is very low (<0.34wt%); also Na and K contents are very low in the Val Graveglia ores, whereas they are higher in the Cerchiara ores where also Ba, Sr, Ni, Zn and Li are higher. When Mn-ores and the interbedded cherts are compared, Ba, As, Th and subordinately Sr are concentrated in the ores and Rb in the cherts (Fig. 6).

Discussion

Despite highly preliminary mineralogical and chemical analyses are not representative of the complete chert sequences and have not a statistical significance, the following considerations arise:

the contribution from hydrothermal discharges predominates during primary deposition of siliceous Fe-rich sediments, which are represented by siliceous pelites and possibly by U. Cherts. The high ratios of metal and silica versus pelitic components, considered as the "normal" pelagic contribute, indicate a relatively rapid deposition.

- precipitation of radiolarian tests was active since the beginning of the sedimentation and provided silica thus contributing to the dilution of other elements. The concentration of Fe and decrease of Mn in H. Cherts compared to Pelagic Clays and Metalliferous sediments, and the reversed trend in manganiferous beds, evidence the effects of differential partitioning according to the hypothesized turbiditic reworking of such deposits. As a consequence, neither H. Cherts nor Mn-ores can be considered as indicators of the che-

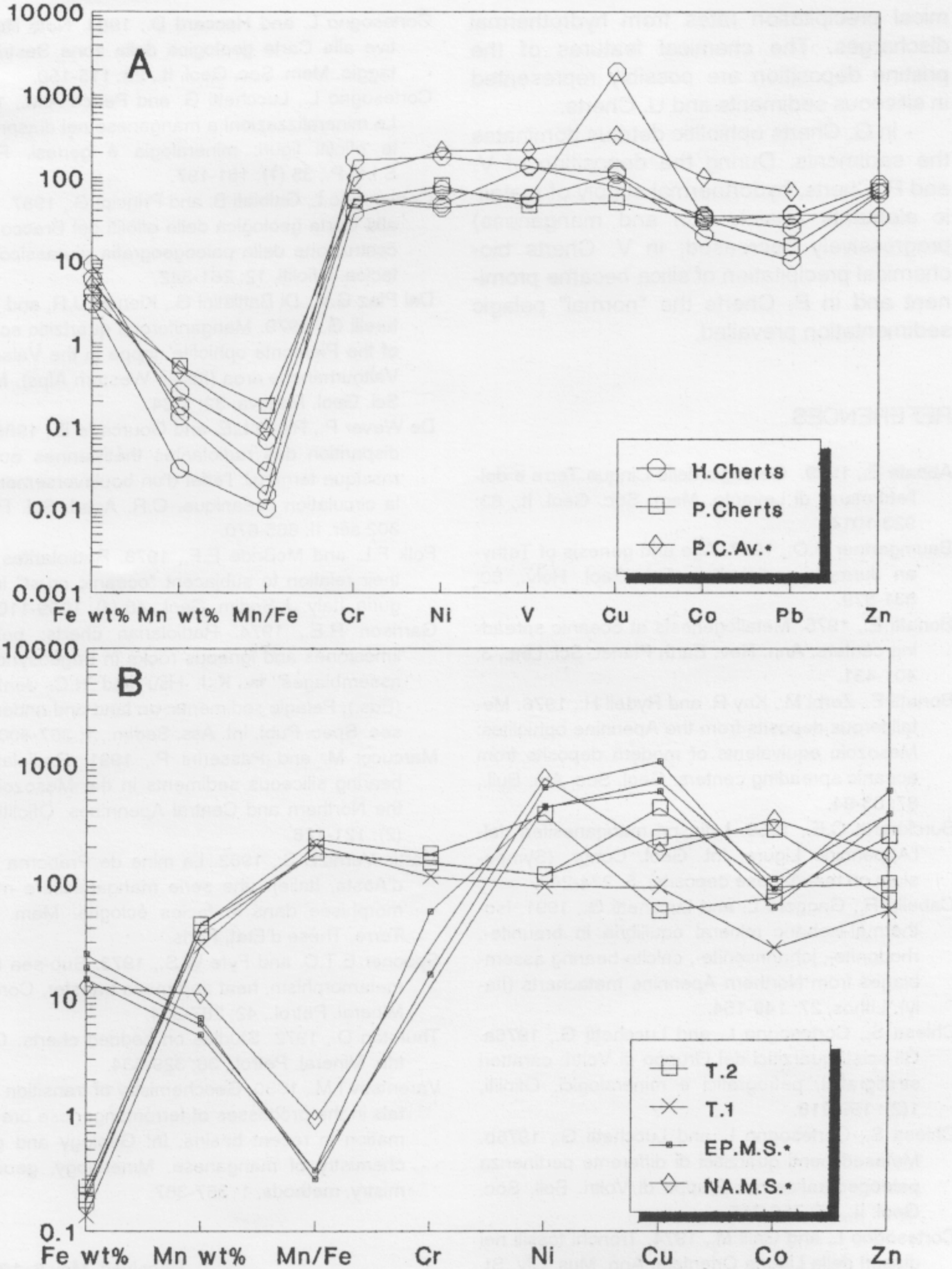

Fig. 7 - A. Comparative spider-diagram for H. Cherts, P. Cherts and Pacific Pelagic Clays Average (P.C.Av.); B: comparative spider-diagram for Type 1 (T. 1), Type 2 (T. 2), East Pacific Metalliferous Sediments (E.P.M.S.) and North Atlantic Metalliferous Sediments (N.A.M.S.).
*Data from Varentsov (1980).

mical precipitation rates from hydrothermal discharges. The chemical features of the pristine deposition are possibly represented in siliceous sediments and U. Cherts.

- in G. Cherts ophiolitic detritus dominates the sediments. During the deposition of V. and P. Cherts, hydorthermal supply of metallic elements (mainly iron and manganese) progressively decreased; in V. Cherts biochemical precipitation of silica became prominent and in P. Cherts the "normal" pelagic sedimentation prevailed.

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