SUMMARY OF THE RESEARCH ACTIVITIES BY THE INSUBRIA UNIVERSITY (PP8) FOR WORK PACKAGES 5 AND 4 OF THE IRON ROUTE –LA VIA DEI METALLI PROJECT

Work Package 5 (Studies and Research)

The WP5 activities developed by the Insubria University regarded two mining areas in Lombardy (central Italian Alps): the Val Seriana-Val di Scalve area and the Val Cavargna area.

The activities comprised: inventory, field work, laboratory work.

Inventory

The following documentary, historical and bibliographical sources regarding Val Seriana - Val di Scalve and Val Cavargna principal mining districts have been considered:

- bibliographic references (historical and geological);
- topographical maps (IGM 1:25000, CTR 1:10000 and CTR 1: 5000 in raster format);
- geological maps in raster format (sheets 32-Como, 17-Chiavenna; sheets 18-Sondrio, 19-Tirano, 33-Bergamo, 34-Breno);
- aerial photographs of the *Comunità Montana Alpi Lepontine*;
- thematic maps in vector format from the official web site of *Provincia di Bergamo* (http://siter.provincia.bergamo.it/sitera/oneteam/home)

Field work

Several old mining galleries and furnaces (with some new discoveries) have been geopositioned by means of GIS analysis, catalogued and visited (if possible) in Val Cavargna and in Val Seriana - Val di Scalve areas.

Geological and mining samples (country rocks, mineralized rocks, slags, furnace remnants) have been collected in Val Cavargna and in Val Seriana - Val di Scalve districts.

Then, a geological-structural survey has been carried out.

In particular, we identified the principal fault systems that control the development of the mineralized layer.

Val Seriana - Val di Scalve

In the Val Seriana-Val di Scalve district the studied mines were Manina and Lizzola.

Manina and Lizzola mines are enclosed in the Servino, Carniola di Bovegno, Angolo and Prezzo Limestone.

Two types of siderite mineralizations occur in the these mines:

- vein orebodies, containing massive siderite with quartz, barite and polymetallic sulphides, present in Permian volcanics, continental sequences (Servino Formation);
- stratifom/strata-bound orebodies, including Mn-rich siderite and haematite, associated with Lower Triassic terrigenous-carbonate rocks (Servino Formation).

Val Cavargna

Val Cavargna is located between Como lake and Switzerland, northward of Porlezza (Lugano lake). It is included in the Southern Alps.

This area is less distorted than other parts of Alpine chain and it preserves almost unaltered its original lithostratigraphic features.

The Fe-mines are enclosed in the Stabiello Gneiss, granitic and migmatitic gneiss.

Near Cusino the Stabiello Gneiss are in contact with Dolomia Principale along the Grona Fault.

The Fe-mine are linked to veins containing ankerite ($CaFe(CO_3)_2$), pyrite (FeS_2), chalcopyrite ($CuFeS_2$), Fe-oxides and Fe-hydroxides.

The veins are associated to NE-SW normal faults, which cross the SE-NW foliation of the Stabiello Gneiss.

<u>Laboratory work</u>

We performed a selection of samples, followed by preparation of polished thin sections of country rocks, mineralized rocks and slags in order to analyse them by:

- reflected- and transmitted-light optical microscope for a brief petrographic characterization;
- scanning electron microscope (SEM) for a detailed petrographic characterization;
- X-ray diffraction (XRD) for mineralogical analyses;
- electron microprobe (EMP) for mineralogical and chemical studies.

The analyses are been carried out in Como (Department of chemistry and environmental sciences, University of Insubria), in Paris (University of Paris 7) and in Padua (Department of mineralogy and petrology, University of Padua).

Obtained results

The activities we carried out led to the following results:

- the identification of the mining and smelting sites through a detailed field work, joined with a critical literature analysis;
- the identification of the ore-forming minerals with their chemical composition;
- the make hypotheses on the ore origin and the geological setting of the mineralization.

The result of this research could be employed to realize new infrastructures, or to develop already existing ones, oriented to cultural and environmental tourism.

Extended abstract of the research carried in Val Cavargna

Val Cavargna iron district

The Val Cavargna iron district is located in the crystalline Lombardian Alps in north Italy (Figure 1). This mining district extends from the N of Lugano (Malcantone region) to the Orobic Alps (Valtellina) with a E-W trending, in the Southalpine domain. The Val Cavargna district is contiguous to that of the Valle Albano (Dongo) to the east, and to that of Val Morobbia to the west (Figure 2. These districts had a similar siderurgic development since XIV century; however the oldest traces of a mining activity have been found only in the Sottoceneri area. The San Jorio Pass and related roads, joining the Valle Albano with Cavargna and Morobbia valleys, had a relevant role in the mining and related commercial activities since the XV century, at the time of the Ducato di Milano. The first iron furnaces were builded in Val Cavargna and Morobbia at the end of the VXIII century, assisted by the expertise of smelters from Bergamo. The Cavargna furnace was the most relevant iron foundry of the Ducato di Milano in that period, and produced 40% of cast iron, a production greater than those of other lombardian furnaces as that of Val Morobbia (Figure 3).

The more famous mines are located at San Nazzaro Val Cavargna, as the Val Caldera, Forni Vecchi and Bubegno mines, at San Bartolomeo (Mezzano, Crivello, Fòo and Piazza della Moranda mines) and in Val di Rezzo (Seghebbia mine), at Grandola in locality Cardano, at Carlazzo in locality Ovvia, at Porlezza in locality Begna (Figure 4.

In some of these places furnaces and foundries were present and still preserved (Figura 5).

Slags from Forni Vecchi furnace display an unusual Ca-rich composition derived from smelting carbonates such as amkerite (Figure 92). In particular they are composed by monticellite (CaMgSiO4).

In Val Cavargna the iron exploitation was followed by a more recent exploitation of antimony.

The mining activity concerned siderite-rich and sulphide-rich veins intruded within the schists and gneisses of variscan age of the Southalpine domain.

The Southalpine domain conmprehends schists and gneisses, Permo-Carboniferous and Mesozoic non-metamorphic cover sequences (Figure 6) It is separated from the Penninic and Austroalpine nappes by the Insubric/Tonale tectonic lineament (Figure 7.

The mineralized gneisses and schists are attributed to the Adriatic (African) passive continental margin that underwent granitic intrusions ("Massicci dei laghi": es. Monte Mottarone near Lake Maggiore) during Permian time and extension in the Early and Middle Mesozoic time. Intrusions and extension preceded the opening of the Jurassic Tethys ocean. The Lugano fault, bounding the Monte Generoso sedimentary basin, was one of the important faults responsible for the extension of the Adriatic margin. On the base of field observations and analyses, we can not exclude that the intrusion of the siderite and sulphide veins occurred during the Adria margin extension, at the end of the Permian intrusion of the "Graniti dei Laghi".

The mineralized veins are decimetric to metric in thickness and always discordant in relation to the schistosity of the gneiss. Veins are generally filling shear planes and faults of uncertain age, likely Carboniferous to Permian in age (Figure 8)

The mineralized veins are intruded along N-S discontinuities and WNW-ESE shear planes dipping to NNE, .in agreement with the Lugano Line and other minor faults.

Often, the siderite veins are cut across by a set of ankerite-bearing veins. Sulphides (pyrite, chalcopyrite, blende, galena, tetraedrite arsenopyrite and gudmundite) are generally associated with this second generation of veins (Figure 9). Minerals have been studied at the electronic microscope (SEM) (Figure 10) and by means X ray diffraction (Figure 11).

The crystalline basement of the Val Cavargna are metapelites (namely Morbegno and Stabiello Gneisses, or “Scisti dei Laghi”) with interlayered amphibolites, quartzites, marbles, calcareous schists, metagranitoids and, in a only case, pegmatites. The protoliths of metapelites have been dated at Early Paleozoic age . Metapelites are characterized by staurolite, cyanite and garnet association which are typical minerals of the Scisti dei Laghi (Figure 12).

Figure 1- Lombardy in the Alps.

Figure 2 - Val Cavargna setting.

Figure 3 – Furnaces in Val Morobbia.

Figure 4 – Structures at Sasso Bianco gallery (Valle di Lana - San Nazzaro Val Cavargna).

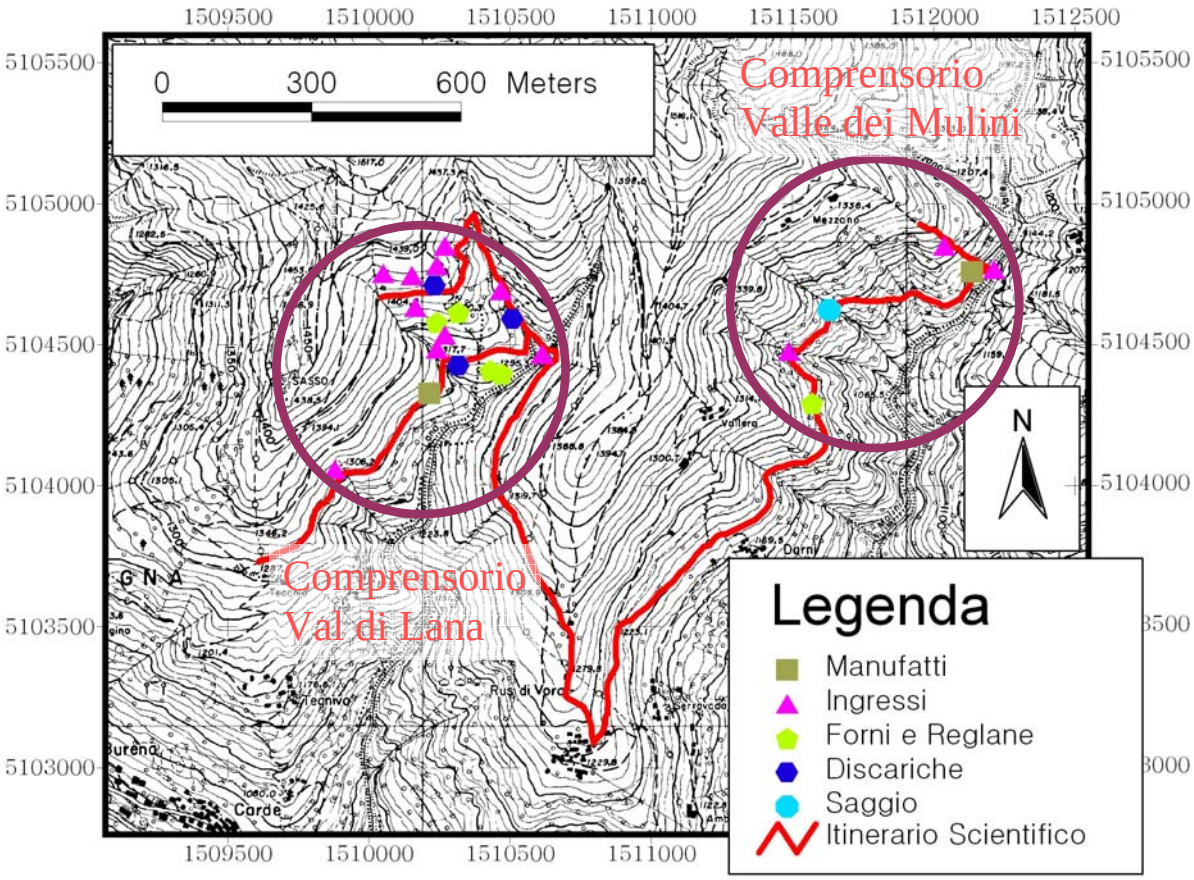

Figure 5 – Mines in Val Cavargna.

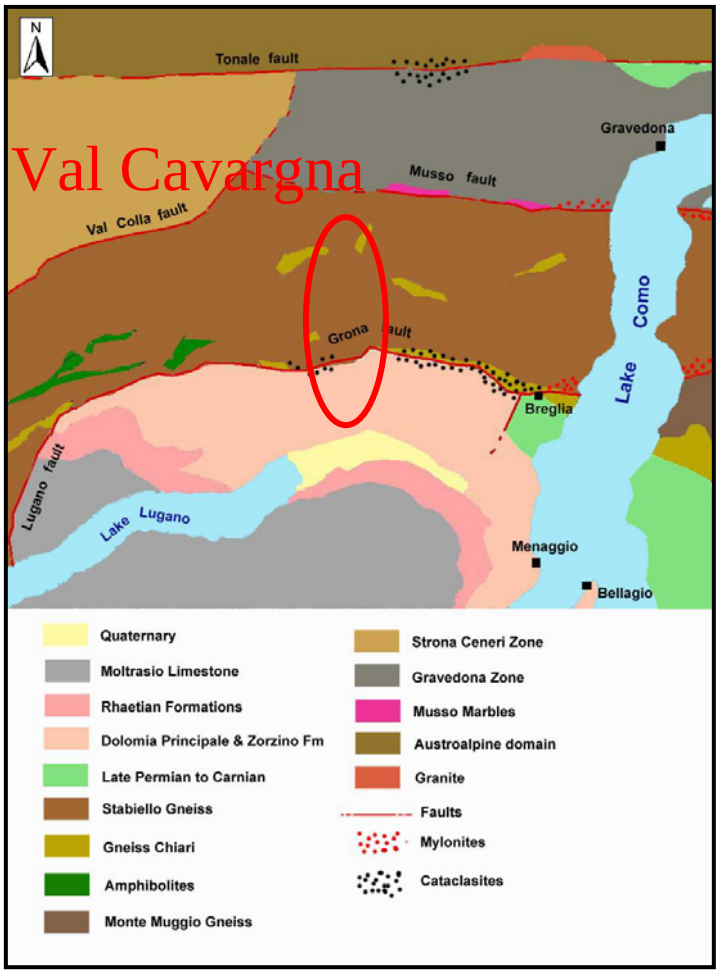

Figure 6 – Geologic map of the studied area.

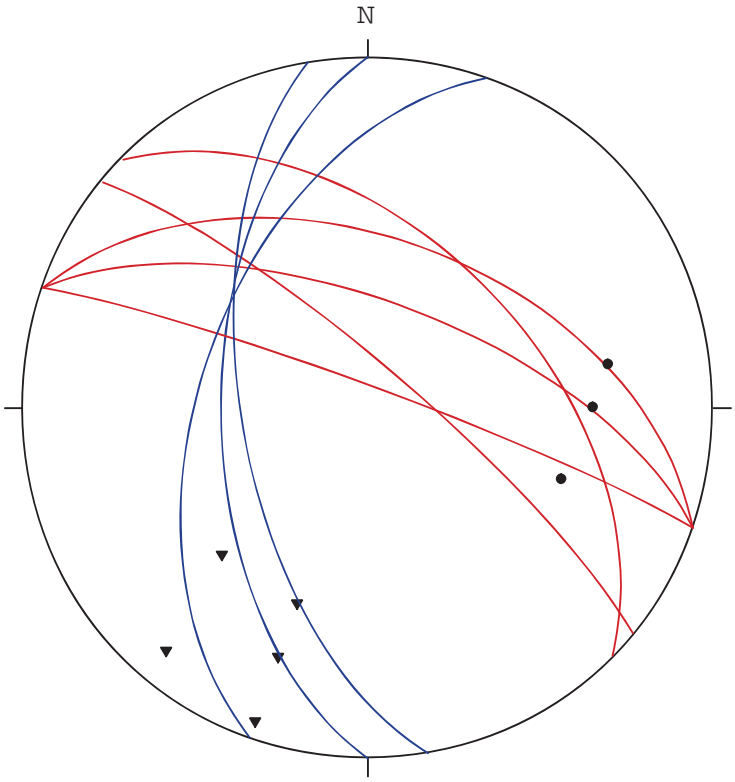

Figure 7– Stereographic projection.

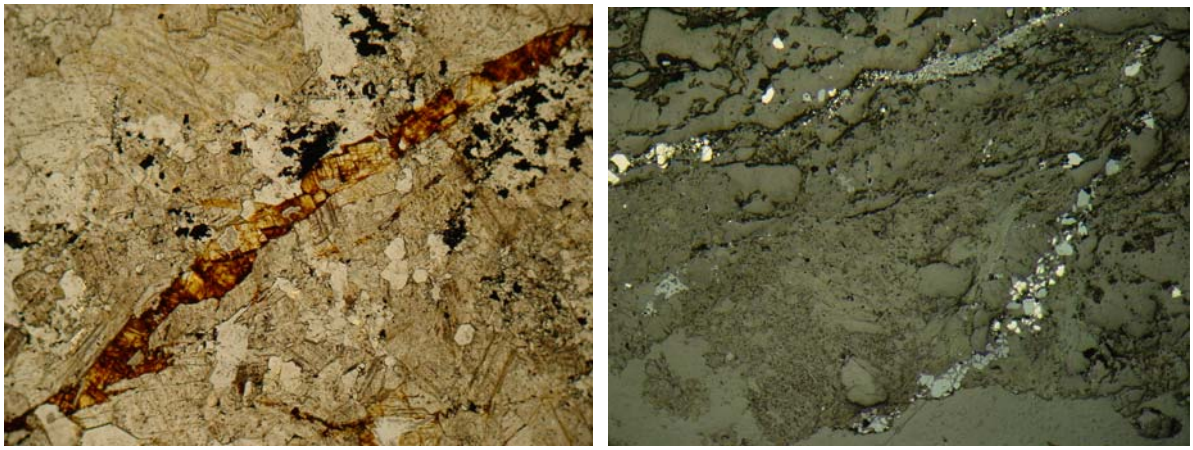

Figure 8 – Carbonate and sulphide veins.

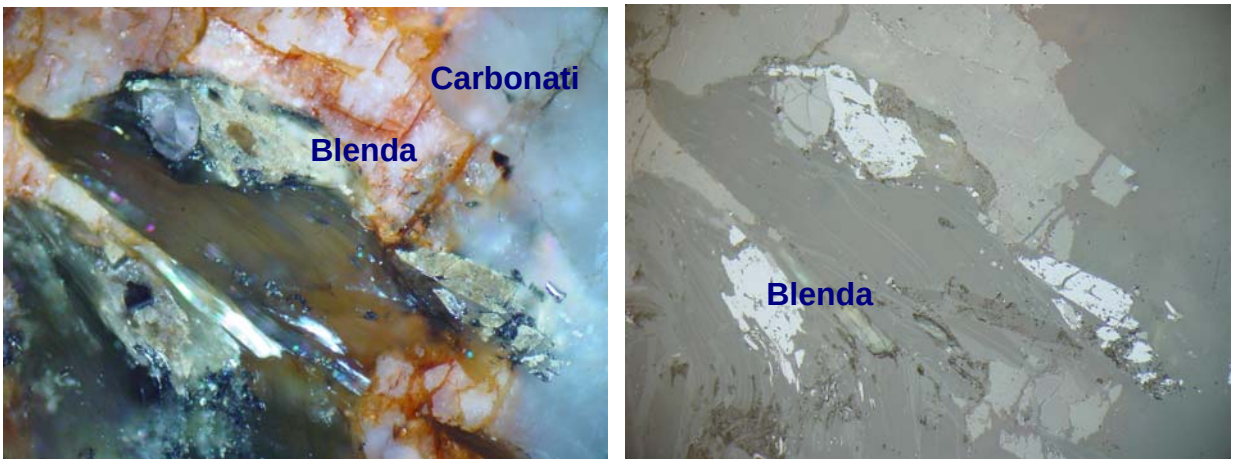

Figure 9 – Sphalerite and carbonates.

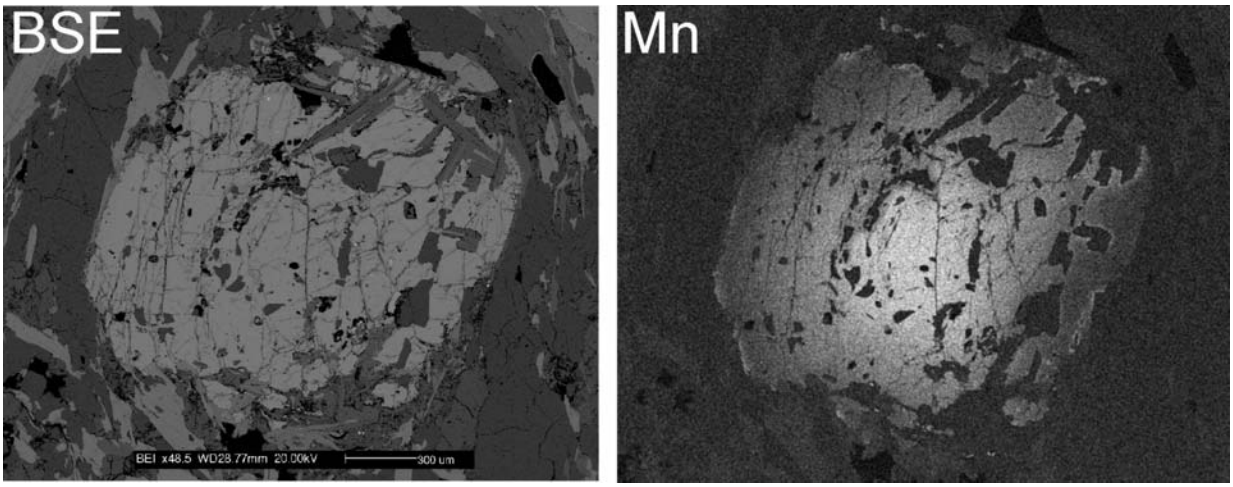

Figure 10 – Garnet under the scannino electron microscope.

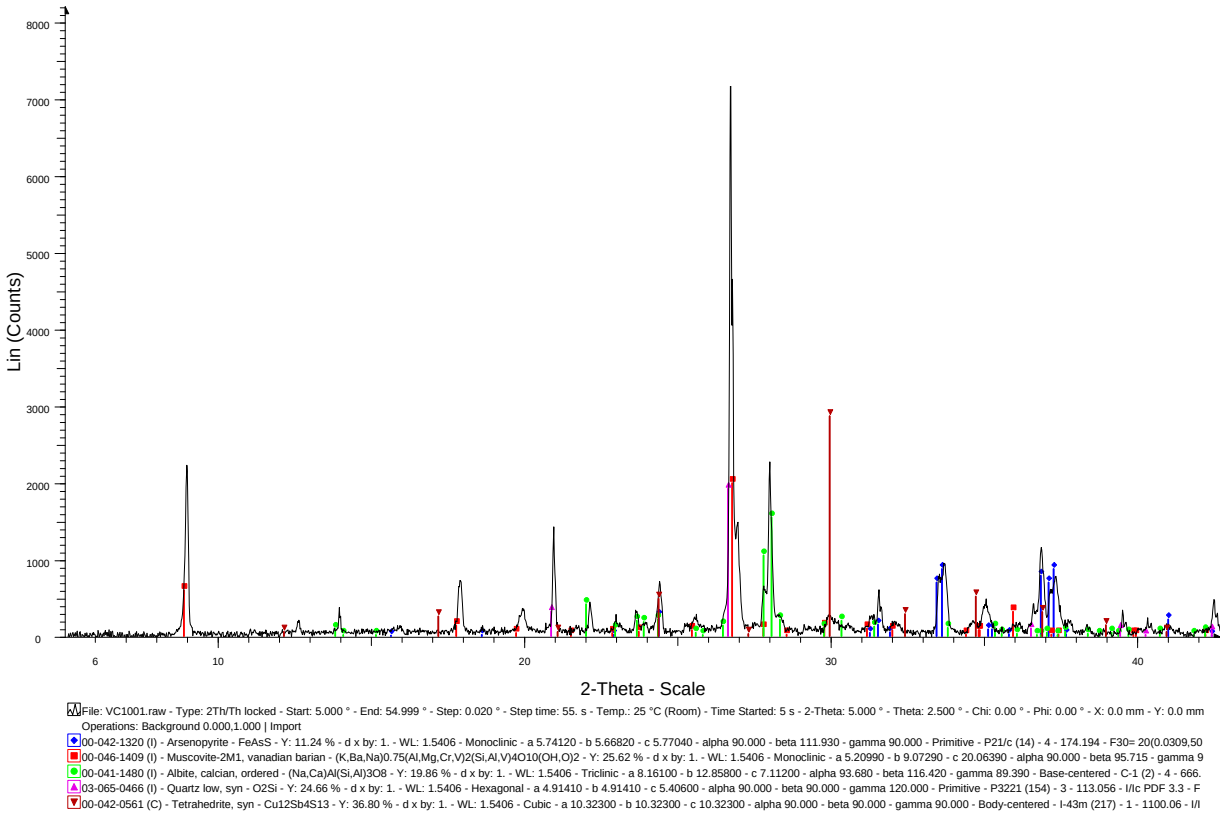

Figure 11 – X ray diffraction analysis of the mineralization.

Figura 12 – Gneiss of Val Cavargna under the optical miscroscope.