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GEOLOGY AND GENESIS OF THE TALC DEPOSITS IN THE PINEROLESE ([1])

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1 – *Purpose of the note*

The talc extracted from the mines of the Cottian Piedmontaine Alps (the so-called "Pinerolese" [Pinerolo] region)—more precisely: the "white talc" variety that constitutes a good part of the production—presents specific natural characteristics that confer on the commercial product the known and particularly appreciated application requirements.

Such constitution characteristics and mineralogical structure distinguish it from the talcose-chloritic schists of the other Alpine deposits of discrete entities (Lanzo Valleys, Aosta Valley, Malenco Valley, Aurine Alps), from the steatites of the Northern Appennines, from the granular talc texture ("massive") of the Sardinian deposits, etc. But even more clearly the geological characteristics differentiate the deposits.

In this note, using also the results of the site reconnaissance, over decades, and the respective laboratory determinations, the A (Assoc). intends to demonstrate and to coordinate some factual data of a geologic nature *(l.s.),* that appear particularly significant from the sedimentary point of view.

[1] **Text, revised and incorporated, from the communication to the Subalpine Mining association during the visit to the Fontane Mine of Company- VAL CHISONE TALC AND GRAPHITE, performed on June 25 th 1966. At such a time the A (Assoc.), recalling its apprenticeship of student engineers, who completed mining in the mines of the Company some forty years ago, renewed to the President, Ms. A. VILLA PREVER. the Central Manager, Eng. P. SARTORIO, and the Director of Mining, geod. GATTI, their thanks for the traditional, generous donation of hospitality, of information, of study materials to the Mining Section of the Turin Polytechnic.**

2 – *Previous studies*

Known already for about three centuries by the products from the modest extraction activity that provided precise communications on these deposits, found in the statistical and Piedmontaine Montanist literature of the first half of the last century [1], [4], [5], [10] and multiplying thereafter [2]. [7], [21], [23].

The local geognosy, finally masterfully surveyed by V. **Novarese** [24], [25] and entered in the sheets of the Geological Map of Italy [42], has not received further substantial variations, apart from tectonic interpretations in the regional scope of the Alpine structure.

The mineralogical and petrographic characters of the deposits and the rocks that include them were further illustrated by **V. Novarese** [26] and especially, in detail, by **E. Grill** and his students [11], [12], [13], [14], [15], [18], [20], [27], [28] for the central zone of the Chisone Valley; by **A. Roccati** [37], [38] and **L. Peretti** [30] for two deposits of the same group, but outside the Chisone Valley.

Few other data of sedimentary interest *(l.s.)* are contained in the illustrations of technical, chemical, marketing, popular nature, again compiled by **E. Grill** [16], [17], [19], by **A. Roccati** [35], [38], by **E. Ridoni** [31], [32], [33], [34], [35] and by others [6], [8], [9], [22], [29], [40], [41].

3 - *Signs on the geognosy of the Pinerolese Valleys*

The entire talc mineralizations of the Pinerolese—both those of greater size and of extraction interest which are, innumerable, of merely petrographic significance —are, almost without exceptions, *integral elements of a formation of dolomitic phenocrystalline limestones ("crystalline* "), inclusive in the complex lithologic series of the "Dora-Maira massif", an Alpine structural entity considered a marginal salient of the overlap of the Monte Rosa.

As is known, in the central zone of the massif between the biotitic gneisses with glandular texture, orthogenic or at least migmatitic, because of reverse faulting in the direction of the Alpine translation, a vast strip of graphitic paragneiss of Carboniferous age is inserted, injected by a massive intrusion of granodioritic magma. The core of these "lower schists" (according to **V. Novarese [24])** has encased a thick series of fine and micaschist gneisses, *pr.p.* still belonging to the Upper Paleozoic (of the "upper schists" complex), repeatedly and tightly refolded, with interbeddings of orthogneiss and other minor layers of amphibolitic schists and crystalline limestones.

To the West, over a regularly continuous demarcation, traced over a surface of extensive tectonic transverse faulting, outcrops appear of the mesozoic calcareous schists formation with greenstones, of the "Pennidico" (formation) overlap of the Piedmont[42].

4-1 Dolomitic limestones of the upper "Dora-Maira" series

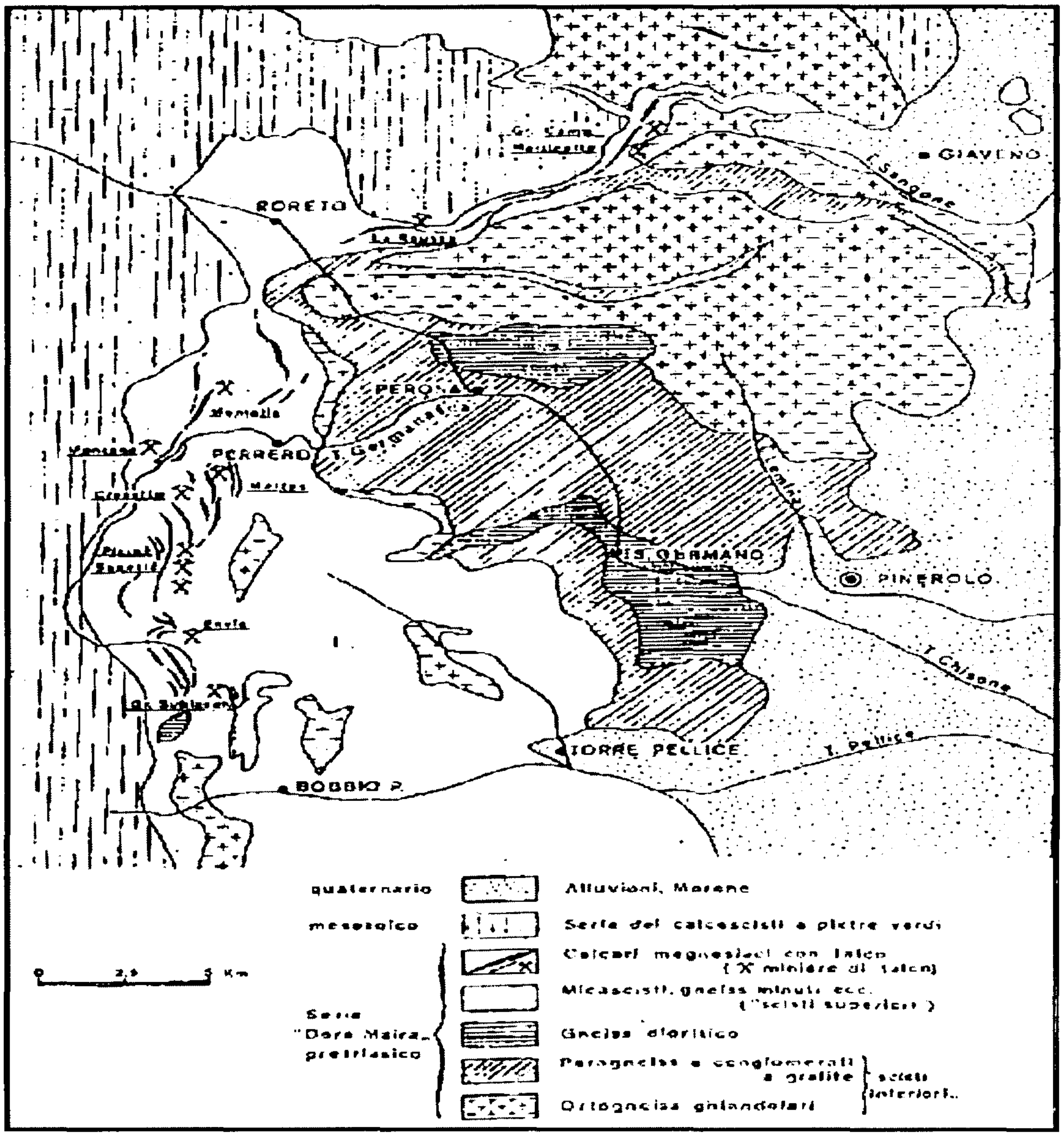
From their above cited, almost constant and exclusive, association with the talc assemblies, the "crystalline limestones" of the upper "Dora-Maira" series presents, a prime sedimentary interest that merits, also in this matter, a rather more detailed illustration.

The outcrops are planimetrically distributed within a narrow band that, from close to the northwestern limit of the gneissic massif, along an arc of around 25 Km., from the high Sangone Valley, through to the middle Chisone Valley, develops largely in the Germanasca Valley, until thinning out on the left slope of the middle Pellice Valley (fig. 1).

They constitute, lithologically and structurally, a limited and clearly identified horizon, that seems to end up in the lateral approaches of numerous coplanar segments of a very broad bank (or, in some case, of two-three neighboring banks), however concordant with the surrounding rocks: in prevalence muscovitic micaschists to albite with garnet or sismondine, or also lenticellular albitic-muscovitic gneiss or glandular gneiss to microclinal and muscovitic-biotitic albite, etc., associated with lenticular masses, dimensionally much more subordinate, of varied greenstones: hornblende amphibolites or actinolitics, to epidote, to garnet); warditic or epidotic prasinite; epidosites to glaucophane; chlorite schist quartz: generally more frequent close to the contact with the limestones.

The limestone bank preserve, sometimes over remarkable extents, almost uniform thickness, of the order from some meters on average to about ten meters. The single segments however as a rule gradually thin out round about, so as to assume a more frequent configuration with extensive and relatively thin flattened lenses. Sometimes the curvature of the lenses is more accentuated, with thickening that also exceeds a hundred meters (for instance: Rocca Bianca, Rocca Corba, etc.). A detailed description of these thicker masses, in which excavations were already opened of famous marbles, is given in the bibliography of **V. Barelli [1].**

Exceptionally, the specific continuity of the limestone horizons



Legend:

Quaternary		Alluvium, moraine
Mesozoic		Series of calcareous schists with greenstones
"Dora Maira" series Pretriassic		Dolomitic limestone with talc (X mining of talc)
		Micaschists, fine gneisses, etc. ("Upper schists")
		Dioritic gneiss
		Paragneiss and graphite conglomerates } Lower Glandular orthogneisses } Schists

Fig. 1 Schematic geologic map of the northern sector of the "Dora-Maira" massif (on the basis of the – "Susa "and "Pinerolo" Sheets of the Geologic Map of Italy).

may be visually noted over lengths of a couple of kilometers. Sometimes, in the subsurface mining development, the bank seems effectively to close itself off entirely. Today, for the most part, the visible continuity of the outcrops is interrupted by the detritic cover (*l*.s.) : but in some case it is reconfirmed by the finding of limited outcrops which have escaped the first geological survey or are not reported cartographically for their small sizes[2].

Similar situations have been shown by the mining works during the present century: the most interesting case from the extraction point of view, besides the geologic one, is represented by the recent discovery of the thick stratum of marble, in view near Fontane to the left of T. Germanasca [42], it also continues extensively on the right of the stream (§ 9).

The lenticular limestone masses are often transversally undulated or folded; the intersections of isoclinal folds with the topographical surface simulate, in places, the existence of more overlapped banks with side by side outcrops. As a rule is clear that it deals with a single bank, at the most accompanied by repeated, thin homologous interbeddings in the surrounding rocks.

The topographical continuity of the limestone horizon is decidedly interrupted either in the NE direction—where large still isolated lenses outcrop on the surface on the right slope of the Susa Valley —or in the SW direction—where the distal outcrops are found on the left slope of the middle Maira Valley.

The lithologic features of the limestone are relatively uniform for the whole formation: isotropic texture, for the more saccharoidal, marmoreal, sometimes finer almost "criptomeric", sometimes more largely granular with separate spathization of the united crystals; with hues more commonly milky-white, or slightly grayish, or compact alternations of white and ash –gray beds according to the original stratification, with locally flat or variously folded joints.

Chemical analyses of **A. Roccati [37]** and of **E. Grill [15]** have shown it involves, according to the places and the different levels in the same stratum, a slightly dolomitic limestone (MgO not > 5%), but more often a calcareous-dolomitic rock, passing to dolomite with very preponderant dolomite over calcite (MgO > 20 %), without that the requisite organoleptics change in a relevant fashion.

[2] Thus, for instance, A. has found in Sangone Valley the outcropping line of a thin marmoreal layer, along quite a few kilometers in the high gorge of T. Sangone, joining together the great lens at Colle della Rossa with those smaller ones of Garida-Ciargiur-Indritto, also connected uninterruptedly to one another.

Next to the contact with the surrounding rocks the dolomitic limestone transforms, to thin beds or to limited lenses, in a microgranular calciphyre with actinolite or to ferriferous epidote or to garnet, with albite and pyrites; or it includes interbeddings lastroids of calcareous schist with quartz, muscovite, chlorite.

The continuity of this dolomitic limestone horizon —still evident, despite the upheavals caused by the Alpine orogenesis, among the terms of the upper "Dora-Maira" series, a few hundred meters underlying the base of the calcareous schists formation —much more regular than appears in the official geologic map, its probable unity, the relative uniformity of lithomineralogical features confer on it an unequivocal stratigraphical significance to the origin, although not yet defined within narrow chronological limits.

5 - *The talc mineralization*

Among the others mineral (quartz, muscovite, amphiboles, etc.) accidentally disseminated in the calcite-dolomite aggregate, without more diffuse and abundant comparison, dispersed or concentrated in homogeneous assemblies of considerable dimensions, the talc characterizes the formation of the dolomitic limestones in the Val Sangone-Val Pellice sector, therefore also designates, correctly, the formation "of limestones with talc"[30].

Only apparently some data in fact seems to contradict to the norm of the local limestone-talc association:

- the absence of the talc mineralization, on a discrete scale, on the edges of the very same bank of dolomitic limestones outcropping outside the Sangone Valley - Pellice Valley sector. *The sharp topographical delimitation of the mineralization is in turn specifically a factual guiding element for the interpretation of the mineralization genesis itself;*

- the sporadic presence of talc in some places surrounding the Cottian Alps, as accessory mineral within other rocks (quarzites, greenstones, etc.) of the "Dora-Maira massif" or of the other Alpine overlaps. This is entirely normal, involving multigenic mineral species and frequent within the epizonal metamorphism. On the other hand the total absence of the talc deserves to be signaled in the numerous, broad dolomitic limestone lenses and interbedded dolomite in the calcareous schists formations, not too far from the deposits in question.

The strict one-to-one interdependence relationship between the dolomitic limestones and the talc mineralization has been for some time the recognized norm, which directed the quarrymen in their mining searches.

Nevertheless the generality and the geologic value of such a relationship was only explicitly affirmed by **E. Grill [20]** in his last monograph study.

The "white" talc it is identified by its chemical composition with the stoichiometrically defined mineral species. The discrete discrepancies found in the analyses of lithologic or mining samples [8], [22] are related in large part to the presence in the rock or in the bulk of small quantities of accessory minerals.

In the same deposit as the most common white-milky variety, with finely felty-flaky aggregate texture, rather anisotropic, without definite rules of distribution, are associated with a variety of creamy-white lamellar texture of large, subparallel crystalline individuals, markedly schistose and with bright pearly luster and a great deal less common variety of greenish–white or ivory-white, with distinct fatty shine, with microgranular texture, isotropic ("massive") steatite type *str.s.*: the chemical composition of this latter would coincide with the theoretical one of talc: in the others the ratios differ somewhat
H_2O MgO: SiO_2. [38].

In the mineralized bodies of the Pinerolese deposits, essentially constituted by the talc in the different structural varieties cited above, are accessory minerals, as isolated crystalline individuals or in aggregated groups, at times diffused over considerable volumes, other times almost completely absent throughout one productive mineralized body, in order of decreasing average frequency:

- calcium and magnesium carbonate: a great deal more frequent in dolomite, in great simple rhombohedric crystals, or in spathic ones joined together with talc, with ill-defined contours and with some individual partially free geodes; less frequently calcite; exceptionally magnesite, sometimes slightly ferriferous, already repeatedly indicated [13], [14], [30] and recently found again by A. at. Fontane in clear isolated crystals (1011), gray, of around 1 cm. on edge;
- chlorites, for the most part nevertheless aggregated in separate edges of chlorite-schists ("grey talc ":see further on);
- pyrites: in crystal disseminations with various guises and characteristic (§ 8), also of large sizes, more abundant in a few zones of some districts (Maniglia Mine; level 1400 in the Fontane Nuova Mine, etc.); on the oxidation of pyrite they are imbued with the rare pigmentations of ochraceous limonite (fig. 2);
- amphiboles of the tremolite-actinolite series, in acicular isolated crystals, but close and iso-oriented or radiating;

Fig. 2 - Pyrite crystals with rounded edges in the talc with dolomite aggregate. (Natural size) *. Nuova Fontane Mine,
level 1400.

— quartz, sometimes in single crystals with strongly corroded surface (101[illegible]

— graphite, as diffused pigment.

Apatite, tourmaline, rutile [11], [15] have no longer been recovered in recent times. Not within the talc, but in "inclusions "(refer to § 7) have been again found: brown idocrase, in large squat crystals at the surface of amphibolite and pyrrhotite lenses, in granular aggregate with calcareous-dolomitic limestone.

The "gray talc", very often irregularly associated with the "white" talc, but in fairly subordinate complex, is quantitatively a talc schist, or more often a chloritic schist, of greenish or grayish or reddish hue, with flat flakey texture, constituted by poorly ferriferous chlorite and richly aluminiferous (clinochlore-prochlorite term) and with talc, with various accessory minerals: amphiboles, epidote, carbonate, graphite, quartz, rutile, etc. [12], [15]; [18], [30].

6 - Morphology of the mineralized bodies

Also present are the lithoclases in the form of long very slender, spreading structures, thinner along the stratification joints of the dolomitic limestone bank; the talc is concentrated to form very thin stratiform masses (“veins “or “strata “)—from some centimeters to a few meters—in comparison to their extent, sometimes found continuous over about ten hectares; 25 cm thickness is considered the lower limit for mining.

The undulations and the folds of the vein are frequent, the lenticular thickening (exceptionally up to fifteen meters), delimited on the perimeter by thinning reduce the mineralization to little more than a simple trace among the salbands.

The talcose beds, clearly delimited always by the salbands, are present interbedded between the limestone bank at only one, or in two-three levels (for instance: in the Maniglia [19],.Malzas and Grand Camp [30] Mines). The partition of the talcose stratum into two is reproduced, at some point, by the interclusion of flattened edges and very distinct from chloritic schist or other greenstones, etc. (see § 7). Otherwise, the vein is developed at the “roof” or the “floor “of the limestone (understood not stratigraphical but in the mining sense) (fig. 3);

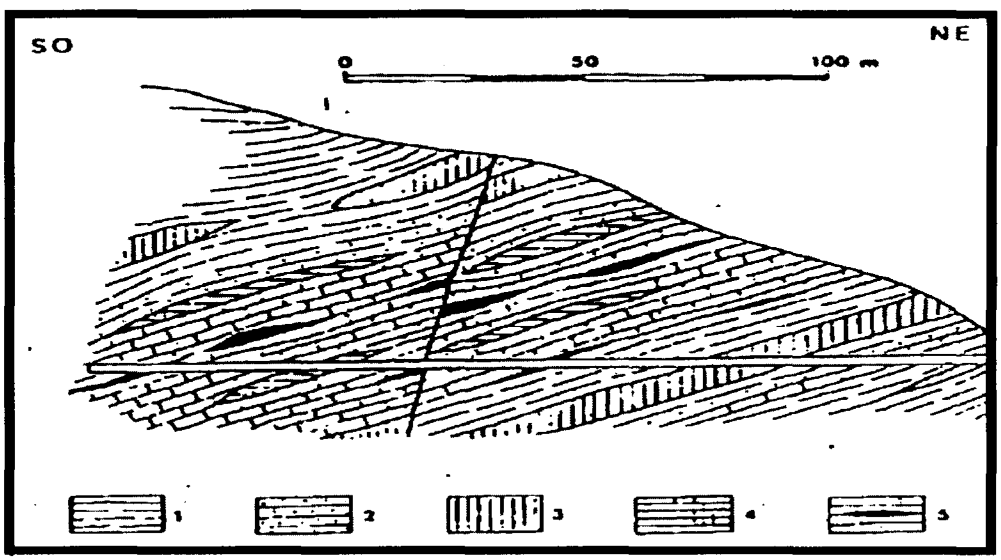


Fig. 3 - Structure of the of dolomitic limestone bank mineralized with talc in the Ribasso Cevrcro from the former Martinetto mine in Sangone Valley.
LEGEND. 1: Muscovitic micaschists with biotite or with sismondine (“Upper schists” of the “Dora-Maira” series).
2: Muscovitic micaschists with garnet. 3: Amphibolite (actinolite) with epidote. 4: Prasinite amphibolic -chloritic or amphibolic -epidotic. 5: Dolomitic limestone streaked with “veins” of talc (dolomitic inclusions).

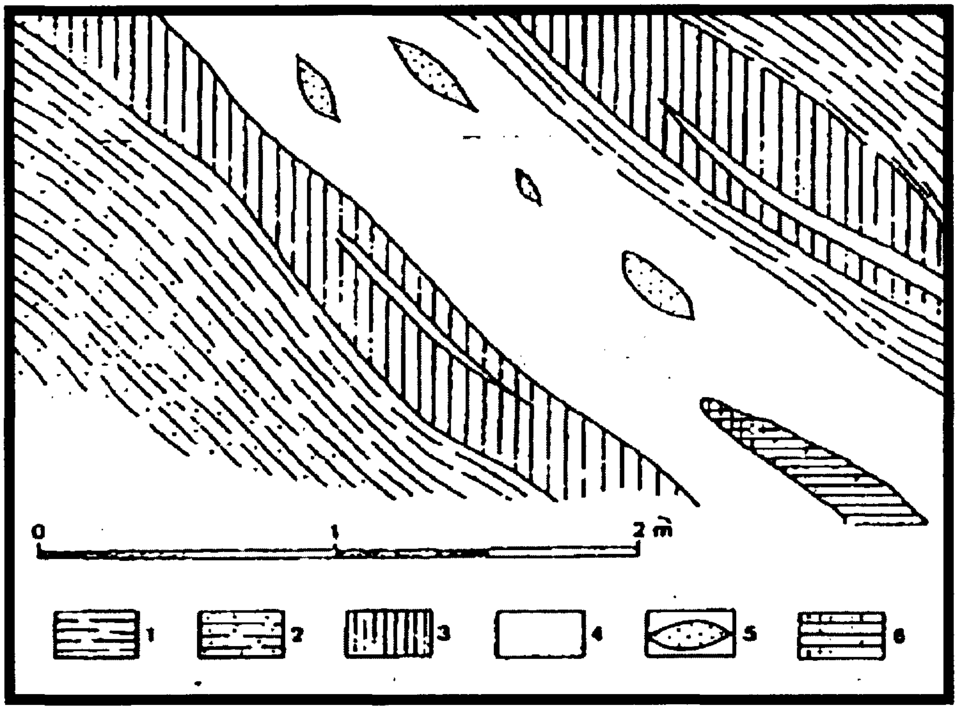


Fig. 4 - Structural particulars of the talc "vein "at the 1500 level of the Nuova Fontane Mine.
LEGEND. 1: Muscovitic micaschist with albite. 2: Muscovitic micaschist with garnet. 3: Talcose chloritic schist - ("gray talc"). 4: talc. 5: Dolomite inclusions with quartz. 6: Interclusion of prasinite, chloritic quartz and calcite.

Rarely, for some sections, the limestone bank and the talcose layer proceed separately, subparallel, from the interposition of layers of other rock, most often thick micaschist, also about ten meters (for instance: in the Fontane Mine) [6], [20]. Also in Fontane in some districts and in some boreholes the limestone is found only at discrete distance (stratimetric) from the talc vein [20].

The thickness of the talcose stratum, or strata, always represents only a modest portion of the local thickness of the limestone bank: from approximately 1/10 to 1/20, in the zones exploited with mining. A broad evaluation of the entire limestone development in the potentially mineralized geographical sector (but where the outcrops for the greater part of the areas are practically unproductive or indeed sterile) it seems—with broad approximation—to reduce the average talc-limestone ratio to around 2%. In conclusion: in the (talcoschists) dolomitic limestones of the Pinerolese, the talc is quantitatively so subordinate, that the concentration of silica and magnesia that this involves is almost insignificant in comparison to the overall chemical composition. The principal talc vein, of whatever thickness, appears as a rule stratigraphically concordant with the stratification joints of the limestone—where it is perceptible—or with the schistose joints of the surrounding rocks (fig. 4). Elsewhere the unconformity contact may be very clearly present and the contact assumes for this a "mechanical" nature: this is after all the rule for secondary veins, that depart from the main one by filling with variously oriented lithoclases.

7 – Inclusions in the talc concentrations

One aspect completely particular to the talc mineralization is the constant and regular presence in the mineralized bodies, of clearly delimited small masses (inclusions or "kidneystones") of various lithological kinds. The phenomenon seems to take on unusual and even fundamental interest from the sedimentological point of view[3].

Consequently it does not seem out of place at this time to list the different lithological types represented in the inclusions.

Always isolated and clearly delimited among the talc that tenaciously takes on smooth surfaces, the inclusion generally have ellipsoidal shape and dimensions varying from a few millimeters to over
1 m of average diameter.

They are constituted from aggregate minerals, not always present locally in the surrounding rocks; in order of frequency:

- Dolomite of phenocrystalline spathic texture, or with smaller saccharoidal structure,. under the microscope: tile structures with large crystals of dolomite (up to 4 cm. in length) not geminate, with clear traces of undeformed cleavage; mineral accessories: calcite and talc;

  - idem, with more hyaline quartz in various proportions, distributed according to distinguished zones; under the microscope the crystals show extinction regions, not undulated. Accessories: pyrites in idiomorphic crystals, talc, actinolite. Sometimes the inclusion nucleus, of quartzose-dolomitic nature has an external shell in which talc and pyrites abound;

—quarzite (probably hydrothermal) with microgranular- texture

[3] **At the end of 1913 the keenest researcher on the matter, A. ROCCATI [38]. mentioning the quartzose inclusions in the talc of the Grange Subiaschi mine, affirmed: "I believe that these masses have to have considerable importance for the topics inherent to the genesis of the talc deposits and I have the intention to return to them in a later work". The intention was not kept and the following Authors, also reporting new data on the matter, neglected to discuss its sedimentological significance.**

with irregular leptoclases. Under the microscope the quartz appears almost exclusively constituted of large individuals of subpolygonal contours, with non undulated extinction regions, free of microinclusions and microfractures. Very scarce interposed accessories: talc in exiled small flakes, granules of dolomite;

- calciphyre of spathic texture, variegated crystalloblastic structure; constituents essentially: dolomite, amphibole (tremolite-actinolite) in acicular idiomorphic crystals; albite, talc, quartz, zoisite accessories;

- calciphyre in elongated and indistinct zones, white and slightly greenish. Structure and composition as above, with sorting into alternate bands of the carbonate mineral crystals and the clear amphibole;

- amphibolite with bacillar-radial texture, with tremolite-actinolite crystals or tremolite; these latter terminating sometimes in clumps of rigid asbestoid fibers, with silky brightness. Sometimes inside the inclusion is a nucleus of spathic dolomite; etc.

In every deposit, topographically defined—and sometimes in the different districts of the same deposit —more frequently appear one (or more) of the lithologic types of inclusions listed above, while others may be completely missing. (Such as, for example missing quarzitic inclusions in the deposits of the Sangone Valley [30]).

In addition to the inclusions it is quite normal (to find), especially where the talc vein reaches the greatest thickness, *interclusions* of isolated edges from the surrounding rocks, still with lenticular configuration, also of discrete or relevant dimensions (from thin to some meters, according to the deposition of the bank). More frequently, in some repeated cases, next to the elements of a tectonic breccia where the talc constitutes the cement, are interclusions of talc-chloritic schists (the "gray talc", already reported); less commons: variety of amphibolites and prasinite, and also chloritic micaschists ("black kidneys stones") or muscovitic.. No occurrence has been found among interclusions of any edges of glandular or lenticular gneiss.

The proportion of inclusions (*l.s.)* in the talcose assemblies is extremely variable from point to point: such nevertheless (may be assessed, in broad measure, at around 30%) as required—after the extraction of the mineral in the subsurface, the largest heterogeneous interclusions have already been discarded from the bulk —the elimination of the inclusions (from a couple to about twenty centimeters of average diameter) through manual selection. The smaller inclusions, milled together with the talc, then determine the slight discrepancy between the market chemical composition and that of pure talc.

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8 - *Impressions of mechanical deformations in the mineralized bodies*

Another intrinsic and peculiar character of the talc assemblies of the Pinerolese also deserves mention, insofar as its significance has gone unnoticed up until now: The complex of *traces of recent mechanical deformations, evident in the talcose masses.* From the scale of the single macrocrystal to lithologic and geologic scale, they are observed with discrete frequency:

— Surface modifications of the idiomorphic monocrystals of pyrites, those of large size, in the form of marked bevels, rounding off and minute scratches, of the edges and the vertices. These deformations are normal for the pyrites crystals encased in talc from other types of deposits, as is usual, are highly disproportional. The complete exception to what is indicated, are the traces of an apparent stress of the pyrites removed by abrasion, interpretable as a recrystallization by redeposition) along the beveled edges of some large crystals (111) recovered in the Maniglia Mine (fig. 5);

Fig. 5 - *Isolated crystal of pyrites in talc. On the edges of the octahedron, beveled and striated by abrasion, irregular protrusions stand out, from apparent stress.* (Natural size). Maniglia Mine.

- the compact, regular parallel ripples of the schistose joints of the macrolamellar talc (fig. 6);

- the frequent mirrors of planar dislocation ("smoothings") in the talc with minutely flattened aggregates. At times the mirrors are scored by parallel grooves ("harnish"), with lamellar epigenetic deposits of pyrites (fig. 7);

- the curved, perfectly smooth, surfaces of the isolated small masses of microgranular talc, rather less deformable than the common flaky talc in which they are included;

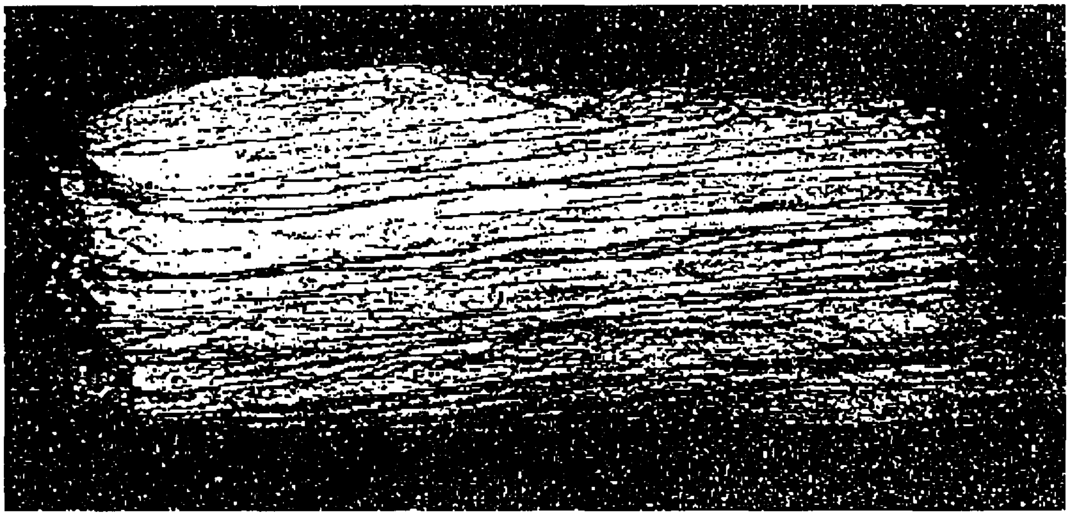
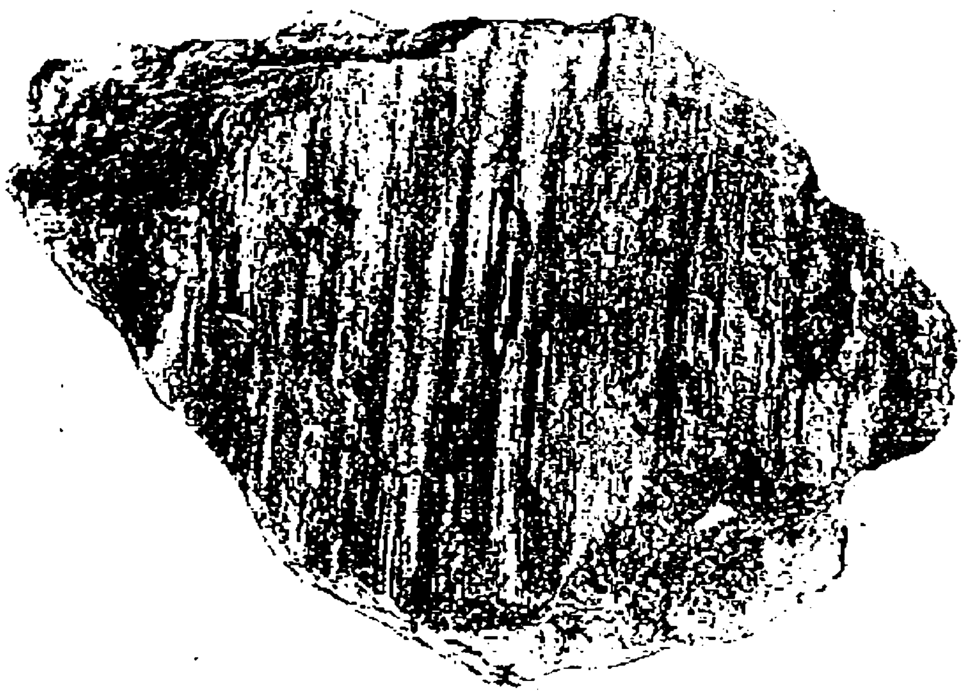


Fig. 6 - *Schistose joint with parallel fluting, in the aggregate of lamellar talc.*
(Photo reduced by 1/2). Nuova Fontane Mine, level 1400.



Fie 7 - *Fault plane striated by the dislocation, in the talc aggregate with chlorite nodules (friction breccia) and laminar epigenetic deposit of pyrites.* (Natural size, white light). Nuova Fontane Mine, level 1500.

- Especially: the geometric configuration, more frequently of great length, of the inclusions, averages sizes: ellipsoidal, of revolution, or of three axes, very flattened, discoidal: the thin talc plates that stick form a small raised crest in the equatorial plane, resulting from the figures with typical "fluid dynamic" shaping (fig. 8 and 9);

- Finally (§ 6), the discordances, at times, between the deposition of the principal stratiform talcose "vein" and, almost always, the smaller "veins" with that of the surrounding rocks: the contact has at times the appearance of a fault mirror.

On the other hand the mechanical deformations of the single constituent crystals do not appear as a rule evident under the petrographic examination of the inclusions, perhaps obliterated by intensive processes of late recrystallization.

Overall these particular phenomena suggest the idea of movement of the, eminently plastic, almost fluid talc ("tectonic lubricant") in fields of intense directional orogenetic forces. It achieves the "placement" of the talcose masses, with a mechanism clearly

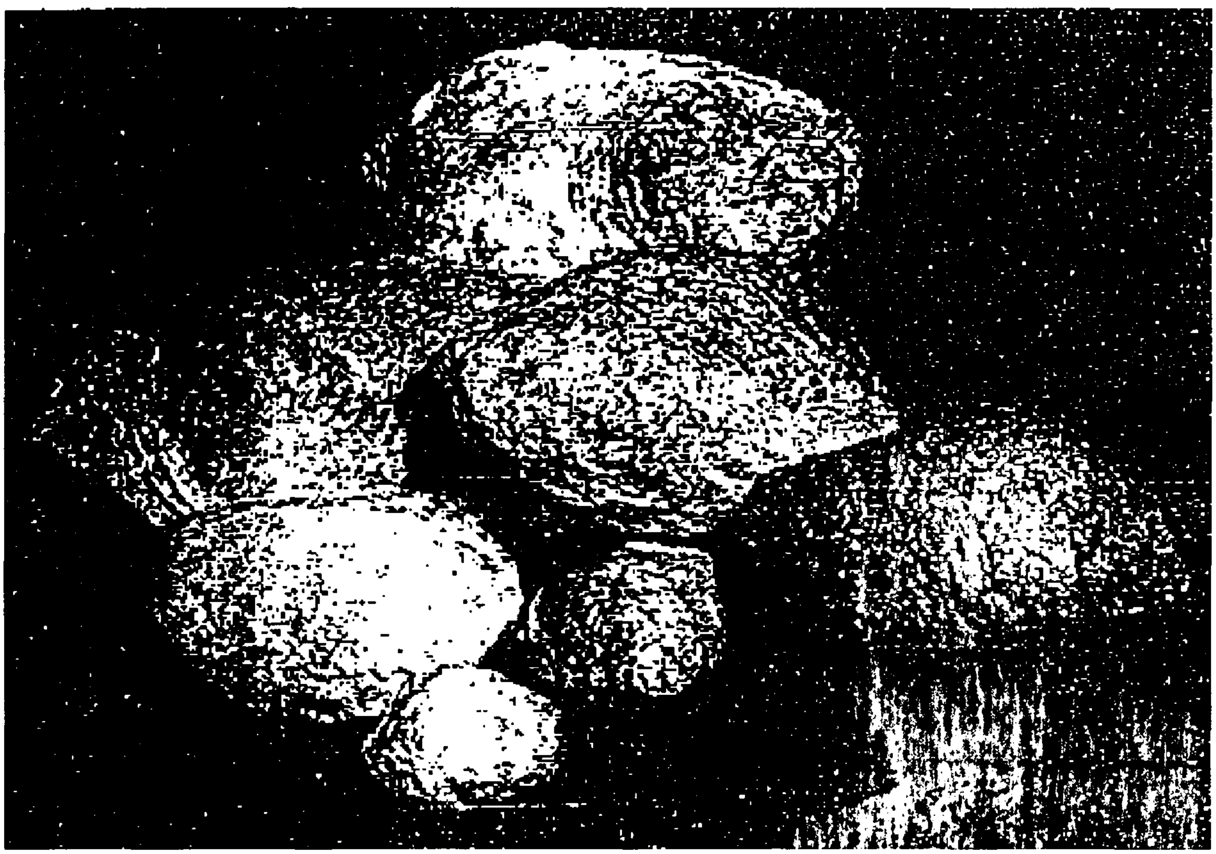


Fig. 8 - ***Inclusion in the talc "vein" of crystalline dolomite and [illegible] coated in talc, in "fluid dynamic" ellipsoidal form*** **(Photo reduced to 1/2). Fontane Mine, Victoria level.**

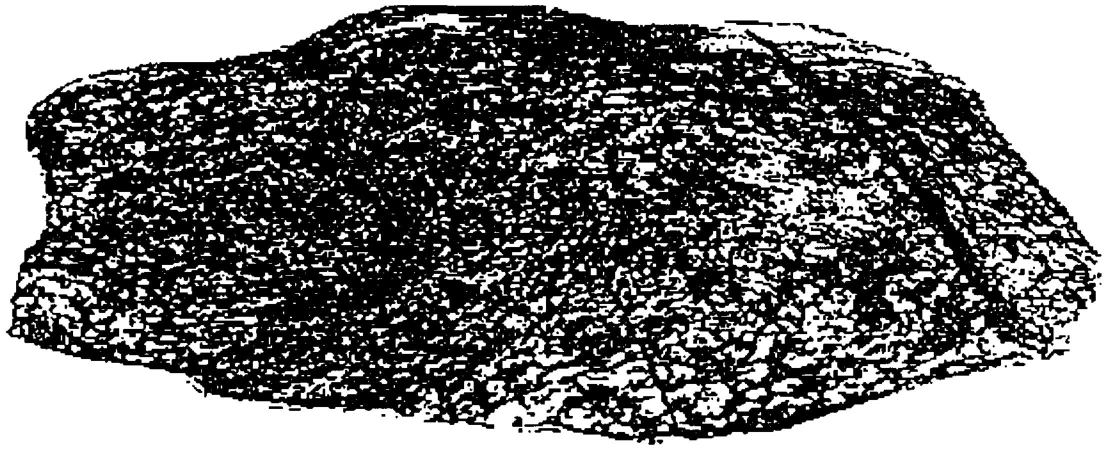


Fig. 9 – *Inclusion in the talc, constituted by biotitic micaschist with muscovite and actinolite, with lenlicellular texture; the schistose joints adjust to the discoidal contour of the inclusion.* (Natural size; polished section; white light); Fontane Mine, Gianna level.

differentiated in comparison to the surrounding rocks, it may have been transported, from the effect of extrusion and dislocation, also at discrete distance from the original position, resulting in such case accidental contiguity relationships with the surrounding rocks. More logically with the hypothesis of a complete transformation of the dolomitic limestone into talc, could be interpreted as the effect of differentiated dislocation as well as the site, anomalous distancing of the calcareous bank from the talcose vein or the absence of limestone within it.[4]

In turn the geomechanical reaction of the relatively rigid dolomitic limestone, to the orogenetic stresses, with formation of lithoclases, faults, breccias — the greater part subsequently completely fused again —

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[4] An analogous geomechanical behavior would seem natural—and consequently analogous structures *(l. s.)* —of the talc masses and the graphite masses (other "tectonic lubricants"), inclusive between more rigid rocks, during the orogenetic displacements.

Between the layers of talc and those of graphite not very distant, in the Pinerolese, subsist nevertheless considerable structural gaps:

- The configuration of the graphitose masses, originally stratiform, but involved completely in the Hercynian orogenesis, is much too irregular and uneven for the talcose masses to be considered therefore of rather more recent origin and subject only to the Alpine orogenesis;
- The abundance of the various heterogeneous inclusions within the talcose assemblies in comparison to the argillitic, syngenetic divisions, in the carbon fossils and in the graphites derived from them, could be explained with a greater "viscosity" of the talc, that would be removed more easily and would transport edges of the salbands, or with the residual autochtonous origin, (unlikely) of a good part of the inclusions: the problem is still unresolved.

would have located and facilitated the percolation and the mineralizing action of the hydrothermal transport.

9 - The Fontane deposit

The greatest concentrations of talc have been subject to mining in many places: Martinetto and Grand Camp in Sangone Valley —then inexplicably ignored in the geomining literature after the indication in 1929 [30]—; Colle della Rosa in Chisone Valley; Maniglia, Malzé, Massello, Fontane, Crosetto, Malzas, La Fracia, Pleiné, Sapetlé, Envie and other smaller ones in Germanasca Valley; Grange Subiaschi in Pellice Valley (fig. 1).

Among the mines already contemporaneously active a few decades ago, the most part are grouped into the concessions of the **Co. TALC & GRAPHITE CHISONE VALLEY,** those with mineralized bodies of modest overall dimensions, or veins on average of very reduced thickness, the most accessible districts have been depleted and were therefore subsequently abandoned, despite the progress of the technical extractions, or perhaps because of them.

Currently the activity tends to centralize the industrial mining (exploration, tracing, connections, production) in the Fontane deposit, the best known also from the petrographic and mineralogical point of view from the studies of **E. GRILL** and his School (already quoted and which are referenced), and of great length and the most significant size. In the part explored and mined for a long time on the left of the Germanasca Valley, the talc "stratum", with average thickness of some few meters, develops continuously between 1000 and 1500 m.a.s.l. for around 1.5 Km in the sense of the stratimetric direction, NNW-SSE, and for around 1 Km in the dip direction, toward WSW, the dip increasing in the lower levels, from 15° to 30°

Limited by the outcrops today toward the SE and sterile rock to the NW, the bank of the old mine extends then, on the right of the deep cutting of the Germanasca Valley, over an area of at least several tens of hectares, systematically verified through boreholes, and in the last years explored with galleries of first tracing, along which the excavation is also begun

The geomining characteristic of this mineralized body, that from the technical point of view may be considered a new large deposit ("Nuova Fontane" or Crosetto Mine), up until now has not been reported in the scientific and technical literature.

It is then news these days of the discovery, through boreholes, of the continuance of the Fontane "bank" also from the SW side, up slope from the Pietra Spaccata narrowing under level 1100, with preliminary indications of relevant thickness and presumably, fruitful yield.

The global cubic content of the mineral still extractable in the districts explored up till now of the entire district of Fontaine-Crosetto varies between 1.5 and 2 million m^3. The huge reserve will be increased considerably with the further development of the exploration work.

10 - *Guideline considerations for the genetic interpretation of the deposits*

The formation of the dolomitic limestones in the upper "Dora-Maira" series is developing in the subsurface much beyond the farthest points reached with the boreholes or with the mine galleries. Consequently it appears obvious that, in the mineralized Sangone Valley - Pellice Valley sector, also the talc concentrations of mining value are distributed as a statistical rule in the still unexplored areas of the formation.

In the past up to today the search for mineralized bodies and their exploration has been conducted on the limestone horizons almost casually based on empirical standards. However, neither would an indicative geophysical prospecting now be effective, from the specific physical characteristics of the mineralization.

An orientation, even though generic, through the exploration could provide the *secure knowledge of the genetic and evolutionary processes of the deposits* instead, until now anything but acquired. The different Authors have avoided taking a position on the matter, or they are restricted to largely inductive affirmations, in some case almost uncontestable, on the basis of particular petrographic-mineralogical observations or abstract chemical-minerogenetic formulations

The natural determining factors in a region so geologically complex in the case in point are so numerous that is not possible to exhaust briefly the casuistry of their mutual influences. An interpretation rather more adherent to reality may be attempted, taking into account the general considerations, especially those of geological nature *str. s.*, time over time emphasized in the preceding paragraph, and that are recalled here, summarizing it:

- the interdependent, one-to-one and exclusive relationship, between dolomitic limestones of upper "Dora-Maira" series and. the talc concentrations;
- the continuity, the (probable) unity, the uniform constitution of the horizon of such limestones, that assigns to it a stratigraphically definite position.

- The uniform talc mineralization of the limestones within a well delimited sector between the Sangone and Pellice Valleys, that suggests the existence of a conclusive mineralization factor placed in proximal geographical position (which could be the Hercynian granodioritic intrusion of the middle Chisone Valley; with outcropping apophyses a few kilometers from the talc deposits; no other similar factors are known);

- The singularity of the talc mineralization, absent in all the other congeneric alpine limestone-dolomitic formations, that confirms the proximal location of an unusual mineralizing factor;

- The absence of talc mineralization, particularly, in the (topographically) contiguous ones and (stratigraphically and tectonically) overlying dolomitic limestones of the calcareous schist formation, that also chronologically limits the time when the mineralization occurred;

- The minimum proportion of talc in comparison to the dolomitic limestones, so that this logically appears the "mother rock" of that, and the consequent minimum quantities of MgO extracted from the dolomite for the synthesis of the talc (under the hypothesis of its epigenetic formation);

The normal presence in the talc assemblies of accessory minerals, some syngenetics (chlorites), others of probable hydrothermal contribution (pyrites, quartz, magnesite) or hypothetically residue from the metasomatism of the dolomitic limestone (calcite, dolomite);

- The constant presence in the talc of clearly individualized inclusion, some allogenics (micaschists, chlorite schists), others autochtonous perhaps (dolomite, quarzite, calciphyres);

- The visible processes of silicification and diffuse silicatization in the preexisting rocks surrounding the calcareous bank, recognizable in the calciphyres, in the epidosites -amphibolites facies of hornfels, in the quarzites and quartz mica-schists, in the migmatitis (the glandular gneisses indicated for the first time by **E. Grill** [20]), etc.: present more frequently next to the contact with the mineralized bodies.

Already as a whole there are sufficient factual data by themselves to reduce beforehand the field of the conceivable genetic hypotheses proposed by the individual Authors, eliminating those that are different from the others:

- The mineralogical transformation, without contribution of substance, of basic pyroclastic material, syngenetic to the limestones and interbedded with them;

- The insertion in place, by intrusion, of the talc as a mineral of late consolidation from a basic magmatic residue;

- The contribution of dolomitic silicates, by the process of hydrothermal transport evinced from basic magmas (Mesozoic);

- The direct massive sorting of the dolomite rather than flint in marble limestone with low magnesium and talc, without external contributions; etc.

Genesis and evolution of the talc deposits under examination should be prospected within the framework of the geologic evolution of the entire Alpine region: But the knowledge in that respect is still uncertain, as to the disputable different general formulations (geochemical, tectonics etc.), assumed by the different geological Schools, being of some use for the different reconstructions of the complex phenomena, in space and time,.

On the basis only of the preceding developments and of the elementary exclusions, deduced from the actual lithogeologic conditions in a relatively narrow scope, a provisional schematization may nevertheless be attempted of the sedimentological process, at times comparing the following phases and the less controversial aspects of the Alpine geology.

The scheme, debatable but sufficiently coherent, is introduced, without other justification or detailed illustrations, in the table.

11 –*Preliminary program for the sedimentological study of the Fontane deposit*

A further considerable progress in the knowledge necessary for a more secure and detailed sedimentological view of the talc assemblies of the Pinerolese may be achieved, in turn, through the systematic compilation of series of particular, quantitative data (the qualitative determinations are already largely sufficient)—as not yet effected, only possible with college team work —over a broad but relatively limited zone, representative of the entire group of deposits.

The zone of the Fontane Mines has been select (old and new), for the facility of access to the subsurface, the observations and the direct samplings, the large number of boreholes already performed, the availability of large scale topographical boreholes, as well as, especially, for its prominent and increasing mining interest,.

With the consent and with the valid collaboration of the **Co. Talc and Graphite Chisone Valley**, using, of course, the numerous partial observations performed by the previous studies, the new cycle of initial investigations is already underway by the Institute of Geology and Mining Deposits—and the Institute of Mining Science of the Polytechnic

Orogenetic cycles		Magmatic Manifestations and their products	Predisposition, formation and evolution of talc deposits
Hercynian	Initial	1. Deep granitic intrusion and migmatization of the preexisting sedimentogenic series ("Dora-Maira" glandular orthogrteiss)	Sedimentation and diagenesis of the neritic deposit of dolomitic limestone (c. from reef)
	Late	2. Granodioritic laccolithic intrusion middle of Chisone Valley (dioritic gneiss of Perosa-Malannaggio).	Formation of. rocks and femic silicates at the contact or within dolomitic limestones.
		(Extrinsically from 1) and 2) of pneumato-lytic-hydrothermal transport and the metasomatizing actions on micaschists, dolomitic limestones, etc.).	Metasomatic mineralization of talc by mobilization of MgO, by work of hydrothermal transport of perimagmatic flint, in environment of meso-epizonal metamorphism.
			Limited tectonic dislocation, of the limestones formation with talc
Preparatory phase of the Alpine cycle		3. Basal Sima injections in the Mesozoic geosynclinal sediments (greenstones of the calcareous schist formation). (Hydrothermal transport and veinous mineralizations with sulfur, etc.).	
Alpine	Initial	(Mobilization of hydrothermal transport because of catazonal metamorphism).	- Accentuated tectonic dislocation of formation of limestones with talc; their dismemberment; morphological evolution of the resulting segments.
	Final		- Differential tectonization and placement of the plastic chloritic schistose and talcose masses; mechanical preparation of the inclusions in the talc: limited structural transformations (recrystallization) in epizonal metamorphism environment.

of Turin, for those matters that involve thoughts on the mining extraction (*l.s.)*.

Sedimentological study chapter foreseen, as a rule which others can augment during the work, on decreasing size scales are:

- the updated analytical geologic survey (for example scale 1: 2000) of the inclusive zone among the bounding watersheds of the Germanasca valley along a section of a couple of kilometers, with classification of the outcropping formations (lithological types and variety, tectonic dates, etc.), on the basis of indicative petrographic determinations (if still necessary);

- The above cited survey (for example at scale 1: 1000) in the subsurface at different levels of the mining extraction and their link with the data taken from boreholes, so that the three-dimensional representation of the mineralized bodies and their surrounding rocks results with the relative structural elements (contact types, disclocations, fractures, etc.);

- Statistical study of the qualitative and geometric distribution of the masses of greenstones, calciphyres, etc. in the limestones; of the edges of intercluded rock in the talc assemblies; of the inclusions *idem* with their orientations; the distribution of some more evident mineral associated with the talc (pyrites, quartz);

- the study of the MgO content distribution in the dolomitic limestone bank;

- the determination (possible) of structural mineralogical data (orientation of the microinclusions in the single crystals); etc.

It is probable that the conclusive results of this broad approach research, pursued on site and in the laboratory, already contributes, at least, to supervise the direct exploration of the unknown part of the deposit through boreholes and galleries, assisting the planning for the purpose of maximum efficiency and the economizing of time and costs.

Turin Polytechnic.
Institute of Geology and Mining Deposits
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AFFIDAVIT

Of Accuracy

This is certify that the attached document, consisting of 22 pages in ITALIAN regarding an Article by Luigi Peretti concerning the Italian Talc Mining Industry, has been translated into ENGLISH by:

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a professional translator of ITALIAN:
with 20 (twenty) years experience, and holding American Translation Association language certification.

To the best of my knowledge this represents a faithful and accurate rendering in English of the original document in Italian.

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