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# Polymetallic mineralization associated with the leucogranites of M.te Arcosu (SW Sardinia, Italy)

MADDALENA FIORI
Centro Studi Geominerari e Mineralurgici del CNR, Facoltà Ingegneria, Piazza D'Armi, 09100 Cagliari

CARLO GARBARINO, SILVANA MARIA GRILLO, SALVATORE PRETTI, IVO URAS
Istituto Giacimenti Minerari, Facoltà Ingegneria, Piazza D'Armi, 09100 Cagliari

CARLO MARINI
Dipartimento Scienze della Terra, località Sa Duchessa, 09100 Cagliari

ABSTRACT. — In the Monte Arcosu area (SW Sardinia), near Nicola Tingiosu, a few showings of a polymetallic mineralization, poorly described in the past, occur at the contact between Hercynian granite and Palaeozoic weakly metamophic terrains.

The present study concerns these occurrences and, more generally, the above mentioned contact.

It has been observed that the local granitic body (Northern Sulcis granite) includes leucogranitic facies, to wich the ore indications are clearly related; more precisely, most of these indications are located along a thin shell of hydrothermally altered granite, while only a few, thin, quartz-molybdenite veins occur scattered inside the granitic body.

The alteration shell, fairly continuous and commonly accompanied by a stockscheider, is of quartz-mica assemblage type. Moreover, the content in metallic and other minor elements places the leucogranite into the field of specialized Sn-granites, other metallic elements (Mo, Y) also being present in anomalous quantities. The study of all these characteristics shows that the ore-forming phenomena fit a greisen-type process, with the exclusion, unlike other granitic areas studied recently, of porphyry-type mineralizing phenomena.

*Key words:* polymetallic mineralization, alteration, leucogranites, Sardinia.

## Introduction

The occurrence of polymetallic mineralization (Mo, W, Sn, Pb, Zn, Fe, Cu, etc.), related to sardinian Hercynian magmatism, has been well known for a long time.

These ore-bodies, studied since the end of the past century (JERVIS, 1873; LOVISATO, 1886; SALVADORI, 1959; etc.) have been re-examined in the light of present knowledge on porphyry copper system (GHEZZO et al., 1982; FIORI et al., 1984; GUASPARRI et al., 1984).

In Iglesiente-Sulcis (SW Sardinia) several granite-related ore occurrences are known. They are characterized by different paragenetic assemblages: Perda Lada, Perda 'l Pibera, Su Seinargiu and Flumini Binu (Mo); Togoro (W); Canali Serci (Sn); sulphides (sphalerite, galena, pyrite, chalcopyrite, etc.) also occur in all of them.

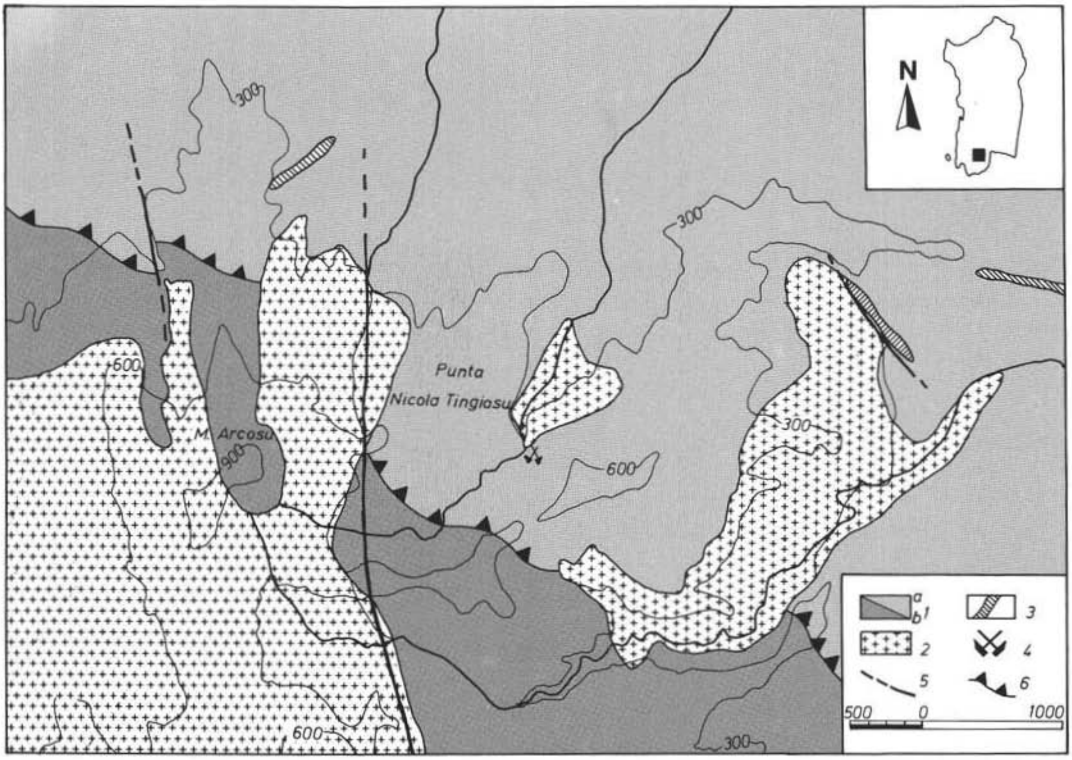


Fig. 1. — Geological sketch map of Monte Arcosu area. 1) Palaeozoic cover: a) Arburese unit; b) San Leone unit; 2) Granites; 3) Hydrotermal veins; 4) Site of old exploration; 5) Fault; 6) Overthrust.

In particular, in the area of Monte Arcosu (Sulcis), close to the contact between granite and the Palaeozoic country rocks, an interesting sulphide-bearing ore-body occurs near Nicola Tingiosu.

Other indications of mineralization related to the contact occur in the surroundings. The present authors believe that a detailed study of these occurrences could supply new data, in order to better characterize both the metallogenic environments and the paragenetic assemblages, as compared to the studies carried out up to now, which were generally on a broader scale.

## Geological setting

The terrains outcropping in the area of Monte Arcosu are only of Palaeozoic age (Fig. 1). The main units are described below.

*Arburese unit* (BARCA *et al. 1981).*

This is an important tectonic unit overthrust to the SW on the autochtonous Palaeozoic formations of Iglesiente-Sulcis. According to BARCA et al. (1986) the overthrusting front extends from Arburese to Eastern Sulcis, through the massifs of Monte Linas and Monte Arcosu, reaching the Rio Lilloni valley near Pula. Its lithological facies include micaceous metasandstones, metasiltites and metaquartzites; total thickness is about 450-500 m; this unit is interpreted as a flysch.

*San Leone unit* (BARCA *et al., 1986).*

This unit is interpreted as a parautochtonous unit, having lithological affinities both with the Ordovician-Silurian formations of SE Sardinia and with the coeval ones of the SW Sardinian foreland (Iglesiente-Sulcis). The above authors distinguish two terms of Silurian age.

*Hercynian intrusive complex of Monte Arcosu*

The intrusive granites of Southern Sardinia, unlike the granitoids of Northern Sardinia (related to an ultrametamorphic basement), are in contact with anchimetamorphosed rocks and originate thermometamorphic aureoles. BISTE (1981) studied in detail the granites of Arburese, Linas and Sarrabus and characterized, on the basis of geochemistry of some minor elements, the first two as specialized granites according to TISCHENDORFF (1974).

The granites of Sulcis massif have been recently re-examined by GUASPARRI et al. (op. cit.) in the southernmost part of the complex (sectors of Flumini Binu and Su Seinargiu). These authors, by means of a careful petrological study, recognized equigranular and porphyric leucogranites (already reported to as belonging to the second phase of the sardinian Hercynian cycle by BRALIA et al., 1982) and classified them from the mineralogical and geochemical points of view among the I-type granites of CHAPPEL & WHITE (1982). These granites were also interpreted as products of high crustal level anatexis of the «minimum melt» type.

The petrological study on the rocks of the investigated area, also carried out by means of electron microanalysis (SEMQ-ARL), also showed that these granites belong to the group of leucogranites and that they are characterized by the paragenetic assemblage: quartz, K-feldspar, minor plagioclase and biotite. Quartz, i.e. the main mineral, shows anhedral to subhedral contours.

Plagioclase, albite-twinned, often appears in tabular form; under the electron microprobe it generally gives albitic composition and only seldom an oligoclase-type composition, up to $Ab_{85}$ $An_{15}$. Biotite, the only micaceous term, is often altered into penninite and chlorites, with Fe oxide exsolutions.

The chemical analyses of major elements, mostly performed by X-ray spectrometric methods (Table 1), shows contents in $SiO_2$ and $K_2O$ higher, and contents in $Fe_2O_3$, CaO and MgO lower, than those of first-cycle monzogranites, in good agreement with the data of GUASPARRI et al. (op. cit.). The DE LA ROCHE diagram (Fig. 2) shows that most of these granites are of alkaline affinity.

## Ore occurrences

In the investigated area, besides the bodies related to hydrothermal alteration phenomena, the object of this study, other bodies also occur: galena, sphalerite, barite-bearing quartz veins and magnetite-bearing skarn lenses, both hosted in the anchimetamorphic country rocks. Some of them were of economic importance and exploited in the past. These occurrences are beyond the aim of the present paper and will be not be taken into consideration here. Instead, the studied mineralization is always placed at the periphery of the intrusion, and is exposed where erosion, always deep, cuts the contact between granite and roof rocks.

The ore-bearing structures consist of swarms of veins carrying molybdenite, pyrite, chalcopyrite and other sulphides and sometimes small lens-shaped mixed-sulphide bodies. All these occurrences are always

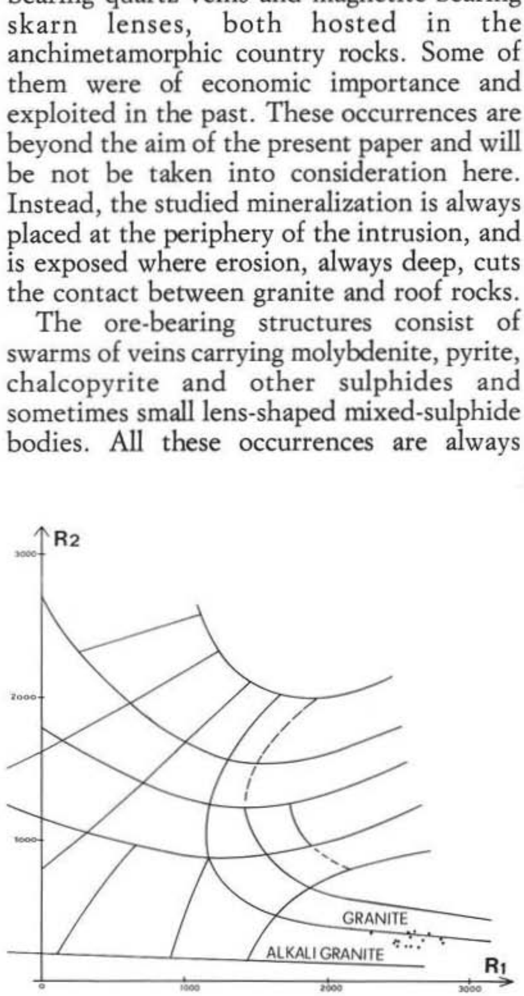


Fig. 2. — DE LA ROCHE diagram for granitic samples from Monte Arcosu area.

TABLE 1

*Major elements in rocks from Monte Arcosu area.*
*Greisens: NT 54 to NT 124; Granites: NT 67 to NT 303. Total iron as $Fe_2O_3$. Values expressed in oxides weight percent*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | L.O.I. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NT 54 | 76.74 | 0.09 | 11.95 | 4.43 | 0.16 | 0.23 | 0.57 | 0.11 | 3.08 | 0.02 | 2.63 |
| NT 59 | 81.56 | 0.11 | 10.31 | 2.64 | 0.03 | 0.18 | 0.02 | 0.10 | 2.91 | 0.01 | 2.14 |
| NT 81 | 75.24 | 0.12 | 14.55 | 1.33 | 0.03 | 0.18 | 0.10 | 0.62 | 5.47 | 0.02 | 2.36 |
| NT 108 | 72.88 | 0.10 | 17.04 | 1.88 | 0.09 | 0.33 | 0.10 | 0.14 | 5.42 | 0.02 | 1.97 |
| NT 123 | 75.48 | 0.06 | 16.80 | 1.64 | 0.04 | 0.16 | 0.07 | 0.64 | 4.28 | 0.04 | 0.80 |
| NT 75 | 78.81 | 0.03 | 13.29 | 0.70 | 0.01 | 0.12 | 0.10 | 0.83 | 4.32 | 0.01 | 1.77 |
| NT 107 | 81.27 | 0.04 | 11.02 | 1.00 | 0.02 | 0.15 | 0.10 | 2.08 | 3.21 | 0.01 | 1.11 |
| NT 112 | 69.15 | 0.09 | 15.96 | 7.37 | 0.31 | 0.32 | 0.06 | 0.20 | 4.37 | 0.02 | 2.15 |
| NT 114 | 74.53 | 0.03 | 15.54 | 2.57 | 0.08 | 0.21 | 0.05 | 0.77 | 4.30 | 0.01 | 1.91 |
| NT 115 | 75.38 | 0.05 | 14.40 | 2.80 | 0.12 | 0.39 | 0.13 | 0.29 | 4.21 | 0.02 | 2.21 |
| NT 116 | 75.10 | 0.04 | 15.48 | 2.19 | 0.10 | 0.24 | 0.09 | 0.26 | 4.47 | 0.01 | 2.01 |
| NT 124 | 76.63 | 0.03 | 13.87 | 2.80 | 0.08 | 0.09 | 0.02 | 0.29 | 4.42 | 0.01 | 1.74 |
| NT 67 | 76.29 | 0.06 | 13.56 | 0.51 | 0.02 | 0.11 | 0.17 | 3.58 | 4.85 | 0.01 | 0.84 |
| NT 76 | 75.32 | 0.09 | 12.32 | 0.76 | 0.02 | 0.55 | 0.97 | 2.92 | 5.04 | 0.03 | 1.99 |
| NT 77 | 76.70 | 0.03 | 13.69 | 0.34 | 0.01 | 0.17 | 0.07 | 2.40 | 5.16 | 0.05 | 1.39 |
| NT 79 | 76.48 | 0.04 | 12.52 | 0.90 | 0.02 | 0.08 | 0.53 | 3.65 | 5.06 | 0.01 | 0.88 |
| NT 84A | 76.77 | 0.04 | 12.69 | 0.93 | 0.01 | 0.04 | 0.30 | 3.76 | 4.76 | 0.01 | 0.68 |
| NT 102 | 76.11 | 0.08 | 12.82 | 0.64 | 0.01 | 0.13 | 0.32 | 0.37 | 5.70 | 0.02 | 0.80 |
| NT 104 | 75.68 | 0.07 | 13.20 | 0.96 | 0.02 | 0.12 | 0.46 | 3.83 | 4.92 | 0.02 | 0.70 |
| NT 105 | 77.19 | 0.03 | 12.93 | 0.25 | 0.01 | 0.06 | 0.29 | 3.89 | 4.81 | 0.01 | 0.53 |
| NT 106 | 74.69 | 0.08 | 12.95 | 1.48 | 0.09 | 0.13 | 0.30 | 3.63 | 5.39 | 0.01 | 1.24 |
| NT 122 | 76.85 | 0.03 | 13.20 | 0.19 | 0.01 | 0.06 | 0.46 | 3.83 | 4.65 | 0.03 | 0.67 |
| NT 100 | 73.29 | 0.11 | 12.87 | 3.81 | 0.04 | 0.15 | 0.38 | 2.84 | 5.22 | 0.03 | 1.26 |
| NT 103 | 76.41 | 0.05 | 13.40 | 0.44 | 0.02 | 0.11 | 0.19 | 3.14 | 5.42 | 0.02 | 0.80 |
| NT 82 | 75.37 | 0.12 | 13.64 | 1.23 | 0.04 | 0.23 | 0.34 | 2.70 | 4.85 | 0.03 | 1.45 |
| NT 97 | 73.20 | 0.23 | 13.38 | 2.25 | 0.08 | 0.67 | 1.06 | 3.13 | 5.08 | 0.06 | 0.86 |
| NT 109 | 75.43 | 0.12 | 13.01 | 1.30 | 0.04 | 0.22 | 0.70 | 3.07 | 5.41 | 0.01 | 0.70 |
| NT 113 | 74.89 | 0.12 | 13.56 | 1.20 | 0.03 | 0.18 | 0.45 | 2.91 | 5.69 | 0.03 | 0.95 |
| NT 117 | 75.91 | 0.04 | 13.54 | 1.31 | 0.02 | 0.20 | 0.18 | 2.88 | 4.97 | 0.01 | 0.94 |
| NT 301 | 75.03 | 0.09 | 14.26 | 0.37 | 0.02 | 0.19 | 0.16 | 2.82 | 6.29 | 0.01 | 0.78 |
| NT 302 | 75.82 | 0.07 | 13.79 | 0.31 | 0.01 | 0.18 | 0.14 | 2.75 | 6.19 | 0.01 | 0.73 |
| NT 303 | 75.63 | 0.07 | 12.82 | 1.24 | 0.03 | 0.06 | 0.40 | 3.30 | 5.68 | 0.02 | 0.76 |

accompanied by intense endogenetic alteration.

Molybdenite also occurs alone in quartz veins, also found inside the fresh granitic body. As in this framework rock alteration phenomena are missing, they will not be treated further.

## Geopetrographical characteristics of the alteration

The endocontact alteration, whose thickness is rather reduced (commonly 1 to 3 metres), is easily detected in the field both because of typical grey colour and for its abundance of glistening mica sheets. This altered strip is often accompanied by silicification phenomena and frequently separated from the country rock by a thin pegmatitic band (stockscheider).

Microscopically, the altered facies commonly appear characterized by strong silicification giving rise to a mosaic texture of quartz, and complete transformation of the other minerals into a clearly neoformed white mica (muscovite) in tufs (Fig. 3).

From a petrological point of view, this alteration must thus be defined as a «quartz-mica assemblage», i.e. greisen-type (the term «greisen» is used here in the broader sense, i.e. «alteration facies of granitic rocks to a quartz-phyllosilicates, mostly micas, assemblage»; it thus corresponds to the «phyllic alteration» or «quartz-sericite assemblage» of other authors; the latter commonly reserve the term «greisen» to

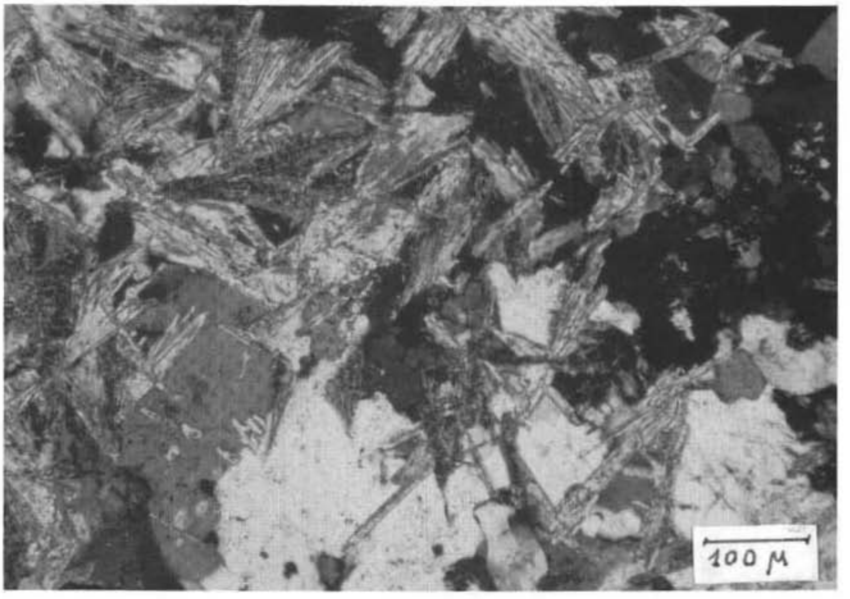


Fig. 3. — Greisen-like alteration of the leucogranite. The rock is composed almost exclusively of tuft-like muscovite and mosaic quartz. Fe-oxides (dark) also occur. Thin section ,n + .

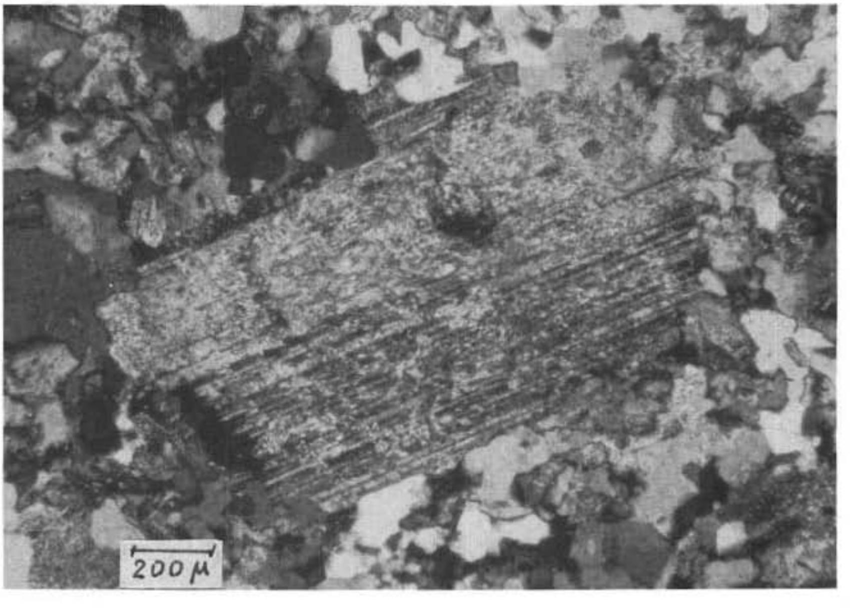


Fig. 4. — Sericitization on plagioclase and silicification. Thin section, n + .

deeper alteration facies including F-Be-Li-bearing minerals).

The chemical analyses also confirm a sharp variation of the altered facies: increase in $SiO_2$, $Al_2O_3$ and $Fe_2O_3$ contents and decrease in $K_2O$ and, particularly, $Na_2O$ with respect to unaltered leucogranite. Another striking characteristic of these alteration facies is the lack of minerals such as tourmaline and topaz, in good agreement with BISTE's (1982) observations in other areas in Sardinia; moreover, this author states that this characteristic is common to all the Sardinian greisens.

Going from the contact inward, the intensity of the alteration decreases, passing gradually to a facies characterized by partially sericitized feldspars (Fig. 4) and then to almost fresh granite.

The exocontact, generally weakly metamorphosed, locally displays intense silicification and, where carbonatic lenses occur, magnetite-bearing skarn formation. The intrusive breccias reported by GUASPARRI et al. (op. cit.) have not been detected in our area.

## Geochemical characteristics of the alteration

The chemical analyses of Table 1 have been utilized in order to define the characteristics of both fresh granites and alterations from the geochemical point of view, according to the current literature.

CREASEY (1959) and MUTSCHLER et al. (1981) proposed a classification of hydrotermal alteration in granites by means of triangular diagrams. CREASEY used the AKF compatibility diagram, while MUTSCHLER et al. also used the normative Ab-Or-Q diagram together with the AKF one; these diagrams define the fields of alteration assemblages (argillic, quartz-sericite and potassic) and that of unaltered granite and help to define alterations better, thus avoiding subjective errors during microscopic study. The use of these diagrams (Figs. 5, 6) showed a sharp separation between greisens (falling into the quartz-sericite facies) and the unaltered granites. The other types of alteration of the classical porphyry systems are thus totally missing in our area.

## Minor and metallic elements

The collected samples were also analyzed for many of the metallic elements already known to occur related to sardinian leucogranites (as quoted in the introduction)

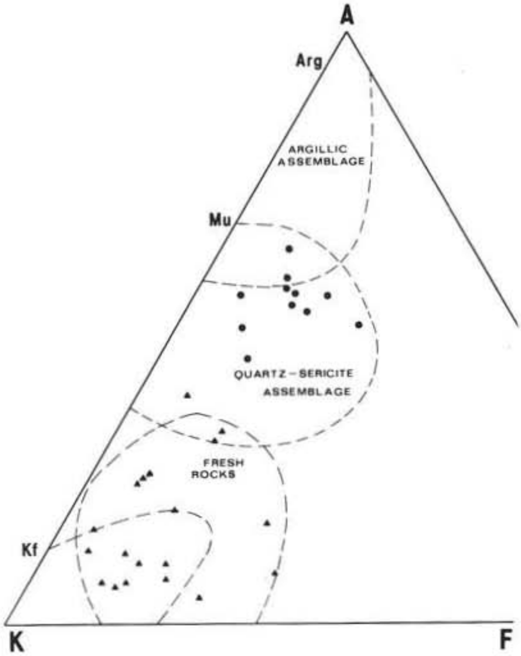


Fig. 5. — A-K-F plot, after CREASEY, 1959.
Arg = Clay minerals; Mu = Muscovite; Kf = K-feldspar.
● Greisens ▲ Granites

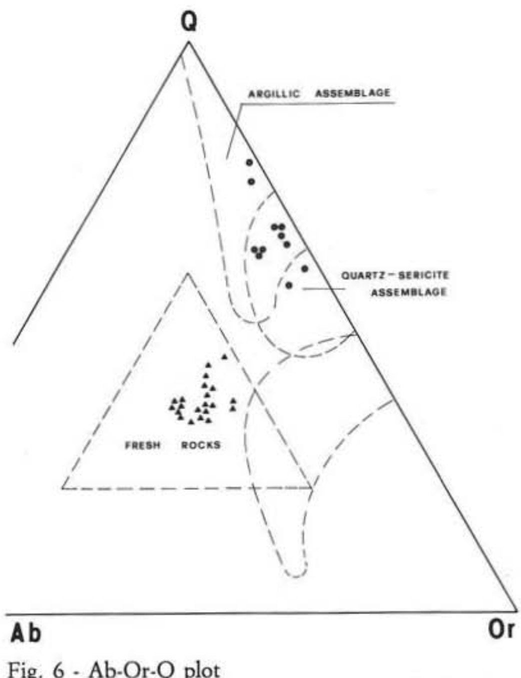


Fig. 6 - Ab-Or-Q plot
● Greisens ▲ Granites

TABLE 2

*Selected minor elements in rocks from Monte Arcosu area.*
*Greisens: NT 54 to NT 124; Granites: NT 67 to NT 303. Values expressed in ppm*

| | Nb | Zr | Y | Sr | Rb | Pb | Zn | Sn | Mo | Ce | Ba | La | F | Li | Be |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NT 54 | 29 | 118 | 73 | 8 | 252 | 45 | 2771 | 70 | 200 | 67 | 418 | 38 | 1450 | 15 | 2 |
| NT 59 | 6 | 92 | 16 | 2 | 163 | 30273 | 670 | 60 | 1400 | 43 | 335 | nd | 1500 | 15 | 2 |
| NT 81 | 17 | 98 | 34 | 26 | 328 | 17 | 22 | 80 | 35 | 14 | 338 | 5 | - | - | - |
| NT 108 | 14 | 84 | 60 | 15 | 363 | 19 | 68 | 55 | 15 | 52 | 379 | 7 | - | - | - |
| NT 123 | 19 | 87 | 86 | 19 | 287 | 17 | 17 | 50 | 10 | 28 | 149 | 19 | - | - | - |
| NT 75 | 19 | 86 | 68 | 13 | 297 | 29 | 16 | 30 | 80 | 8 | 120 | 11 | - | - | - |
| NT 107 | 16 | 78 | 57 | 26 | 233 | 74 | 109 | 105 | 18 | 12 | 153 | nd | 1150 | 12 | 1 |
| NT 112 | 10 | 86 | 31 | 3 | 465 | nd | 147 | 90 | 11 | 39 | 359 | 7 | 1200 | 25 | 3 |
| NT 114 | 16 | 111 | 66 | 14 | 350 | 171 | 246 | 55 | 26 | 31 | 542 | 7 | - | - | - |
| NT 115 | 15 | 85 | 63 | 14 | 287 | 1503 | 159 | 60 | 105 | 16 | 534 | 12 | 1350 | 18 | nd |
| NT 116 | 22 | 104 | 64 | 12 | 334 | 33 | 68 | 65 | 15 | 17 | 600 | 8 | - | - | - |
| NT 124 | 21 | 90 | 92 | 5 | 399 | 3 | 34 | 110 | 10 | 26 | 138 | 9 | 1450 | nd | 1 |
| NT 67 | 15 | 152 | 87 | 37 | 327 | 10 | 12 | 50 | 20 | 18 | 175 | 9 | - | - | - |
| NT 76 | 13 | 98 | 52 | 56 | 320 | 22 | 16 | 30 | 7 | 15 | 316 | 15 | 750 | 5 | 2 |
| NT 77 | 20 | 88 | 61 | 76 | 262 | 5 | 8 | 30 | 6 | nd | 192 | nd | - | - | - |
| NT 79 | 13 | 93 | 60 | 30 | 340 | 42 | 633 | 55 | 80 | 22 | 195 | 13 | - | - | - |
| NT 84A | 27 | 133 | 59 | 19 | 330 | 32 | 14 | 30 | 8 | nd | 139 | nd | 550 | 5 | 4 |
| NT 102 | 16 | 104 | 58 | 28 | 353 | 20 | 13 | 25 | 13 | 35 | 172 | 17 | - | - | - |
| NT 104 | 27 | 92 | 53 | 35 | 331 | 45 | 43 | 35 | 18 | 15 | 78 | 5 | - | - | - |
| NT 105 | 26 | 89 | 60 | 77 | 279 | 24 | 4 | 40 | 6 | 25 | 138 | 9 | 600 | 5 | 4 |
| NT 106 | 33 | 105 | 107 | 26 | 299 | 54 | 34 | 65 | 7 | 63 | 98 | 16 | 600 | nd | 6 |
| NT 122 | 38 | 141 | 199 | 48 | 269 | 37 | 8 | 35 | 5 | 43 | 164 | 35 | 500 | 5 | 3 |
| NT 100 | 13 | 101 | 53 | 40 | 302 | 18 | 12 | 35 | 5 | 59 | 321 | 23 | - | - | - |
| NT 103 | 14 | 79 | 42 | 46 | 298 | 16 | 17 | 30 | 0 | 62 | 103 | 15 | - | - | - |
| NT 82 | 16 | 109 | 41 | 39 | 317 | 25 | 27 | 35 | 0 | 56 | 304 | 15 | - | - | - |
| NT 97 | 12 | 133 | 41 | 94 | 267 | 24 | 46 | 30 | 9 | 76 | 488 | 39 | - | - | - |
| NT 109 | 16 | 106 | 55 | 53 | 341 | 23 | 28 | 35 | 6 | 44 | 389 | 22 | 1550 | 10 | 2 |
| NT 113 | 11 | 87 | 35 | 42 | 315 | 25 | 19 | 30 | 0 | 44 | 394 | 23 | - | - | - |
| NT 117 | 15 | 74 | 41 | 36 | 320 | 21 | 22 | 55 | 12 | 8 | 189 | 9 | - | - | - |
| NT 301 | 16 | 97 | 61 | 19 | 342 | 10 | 2 | 40 | 7 | 62 | 177 | 22 | - | - | - |
| NT 302 | 19 | 98 | 56 | 20 | 345 | 17 | 4 | 35 | 5 | 42 | 176 | 10 | - | - | - |
| NT 303 | 10 | 79 | 33 | 18 | 363 | 36 | 20 | 45 | 14 | 36 | 76 | 13 | - | - | - |

and more in general, known to occur in similar metallogenic conditions. Some other minor elements, commonly used for defining petrological and metallogenic characteristics, were also analyzed (Nb, Zr, Y, Sr, Rb, Zn, Ce, Ba, La by means of XRF spectrometry; Be, Sn, Mo, Au by means of DCP spectrometry; Li by means of emission spectrometry; F by means of potentiometry with specific electrode. The results are reported in Table 2. It is immediately obvious that the Sn, Mo and Y values are quite high and it is thus legitimate to speak of specialized granite in the sense of TISCHENDORFF (op. cit.).

Although the analyses concern samples of all types of rocks previously quoted and the total number of data is rather low, statistical treatment was attempted. The results still seem to be fairly significant (Fig. 7).

Mo displays good lognormal behaviour and both positive and negative anomalous values may be recognized; the main population denotes a fairly high mean value. Sn distribution is sharply bimodal in arithmetic values, the lower population always being characterized by a high mean value and the higher population including only conspicuous Sn contents; some values are anomalous even whit respect to the higher population. Y distribution looks less reliable, although the arithmetic values show a central, weakly symmetric tendency; this population also displays anomalous values, both positive and negative.

As regards REE, the samples were analized only for La and Ce. These elements, especially Ce, showed to be present in normal to low values, as compared to mean contents in granitic rocks. They appear well correlated with each other (correlation coefficient 0.68) and almost totally unrelated with Y. Nor do their contents seem to be related to the nature of the rocks, since their contents in greisens are quite comparable to those in granites.

Anomalous content in Sn, Mo, Y and Rb/Sr, K/Rb ratios are observed, as shown in Fig. 8, mostly in samples coming from greisens. Pb and Zn do not show particular correlations with the rock type, except for the higher values from samples collected in greisens near the ore occurrence of Nicola Tingiosu.

Nb, Zr and Rb contents mostly fall into the

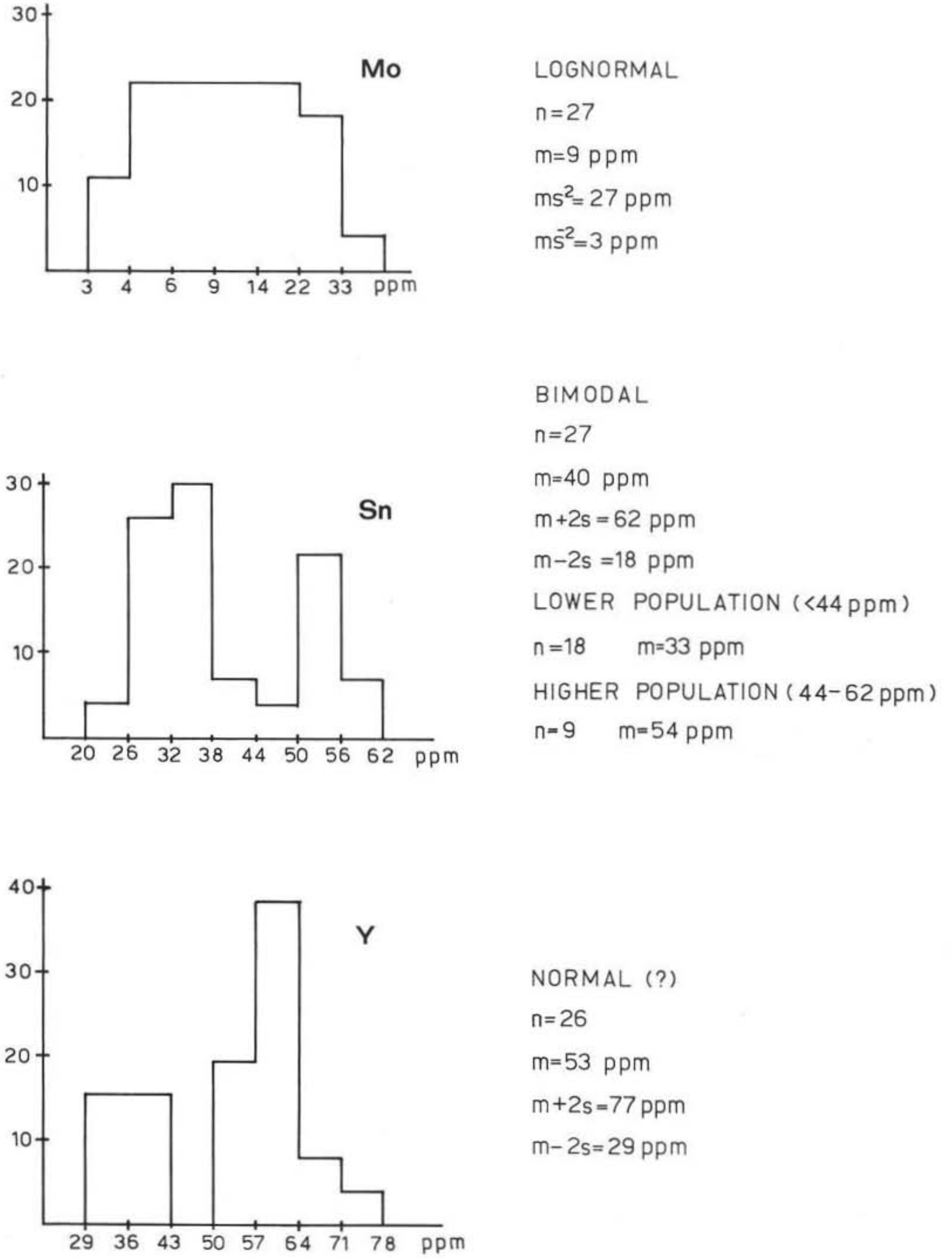


Fig. 7. — Histograms for Mo, Sn and Y; n = number of analyses; m = mean value; s = standard deviation.

normal field of granitic rocks. Sr is clearly depleted in almost all the greisen samples, and less so in a few granites.

Be, Li and F were analyzed only in a dozen selected samples. While Be contents appear at normal levels for granitic rocks, F and Li contents are in the lower part of the fields of normal contents, the higher values belonging to greisen samples.

Au was also clearly detected in a few samples, up to 0.6 ppm in the whole rock. The higher values belong to greisen samples.

As regards the characteristics of the rock itself, the Rb/Sr and K/Rb ratios show a clear differentiation among greisens on one side and granites on the other; actually, although most of the values fall into the same field, the trend for greisens is evidently towards higher values for the Rb/Sr ratio and towards lower values for the K/Rb ratio (Fig. 8).

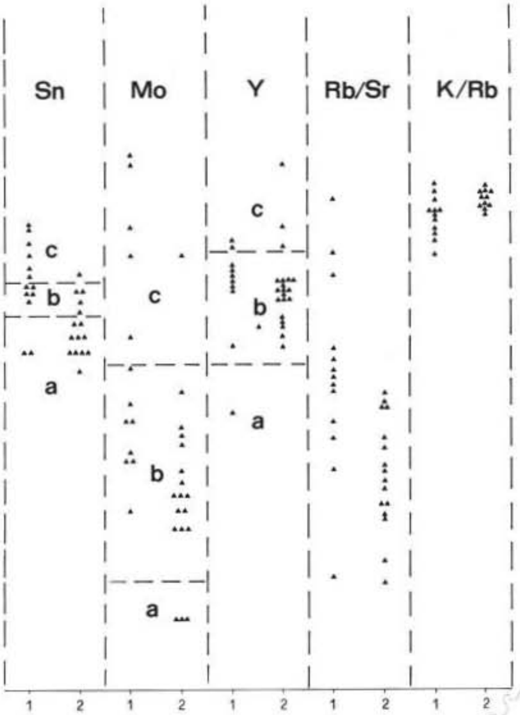


Fig. 8. — Comparative diagrams of contents in Sn, Mo, Y and of Rb/Sr and K/Rb in greisens (1) and granites (2) on logarithmic scale.
For Sn: a) field of lower population; b) field of higher population; c) field of positive anomaly. For Mo and Y: a) field of negative anomaly; b) field of main population; c) field of positive anomaly.

## Nicola Tingiosu occurrence

The Nicola Tingiosu occurrence, that has been previously reported only in an old short paper (LEONE, 1930), was poorly explored in the past by means of two short galleries. It occurs immediately at the endocontact in the form of lenses, decimetric to metric in thickness, formed of large crystals of quartz and ore minerals. The main ore mineral is sphalerite in coarse aggregates. Less abundant are molybdenite in large sheets, pyrite in large well formed crystals, chalcopyrite, also as exsolutions in sphalerite, and galena. Traces of Sn have also been detected by means of chemical analyses.

Microprobe analyses showed that silver contents in galena are quite high (up to 0.61%), while iron contents in sphalerite are rather low (down to 1.45%).

In the Nicola Tingiosu ore-body Mo and Sn minerals (typical of high-temperature deposition) together with high Ag galena and low Fe sphalerite (which denote low-temperature deposition) thus occur, so that the paragenetic assemblage seems to indicate a wide range of temperature for ore mineral deposition.

## Discussion and final remarks

The mineralized showings placed at the endocontact of Monte Arcosu leucogranite display the following characteristics:

i) the previous discussion on the geochemistry of minor and metallic elements shows that the local granitoids are specialized rocks. In particular, the Rb-Sr diagram proposed by SATRAN (1982) places our granites along the trend of Sn-series granites (Fig. 9).
ii) The hydrothermally altered facies hosting the mineralization occurs as a narrow strip formed by a quartz-mica assemblage, which, on the basis of the AKF and normative Ab-Or-Q diagrams, almost always belongs to the quartz-sericite alteration facies.

Both these characters fit the greisen-type mineralization scheme rather than the porphyry-type one.

The lack of some typical structures of porphyry-type occurrences, such as stockworks and intrusive breccias, is also in agreement with this opinion.

It therefore seems that, at least in some areas, greisen-type mineralization occurs unrelated to the porphyry-type, as observed in other sardinian occurrences (GUASPARRI et al., 1984). These greisens seem to be related to more confined and deeper environments. Moreover, the ore bodies are in close proximity to pegmatitic shells, while alteration is weak or absent in the rest of the granitic body (FIORI et al., 1986).

This statement is supported by several recent studies, distinguishing between porphyry-type and greisen-type phenomena.

In 1951 KOHLER & RAAZ established a distinction, by means of differentiation diagrams, between the fields of greisen-type and porphyry-type phenomena.

More recently BURT (1981), by means of studies on the variations of acidity and salinity in fluorine-rich fluids, indicated various greisen types, among wich one, related to low temperatures and lack of boiling, is completely separated in space and time from the porphyry systems.

MUTSCHLER et al. (op. cit.) stated that the greisen assemblage forms during a later phase, often the main one, that produces most of the alterations typical of a porphyry copper system. For these authors too, the level of greisen formation is deeper than that for porphyry-type alterations; thus, a sufficiently deep pluton could suffer only greisen alteration, without other shallower types of alteration.

On the basis of such studies, in his treatise LAZNICKA (1985), discusses ore bodies related to greisens separately from those related to porphyry systems, and clearly defines the different characteristics (shape, paragenesis of minerals in parent rocks and alterated facies, ore mineral paragenesis, etc.) that distinguish these different types of ore occurrences.

Another interesting recent work by KOOIMAN et al. (1986) illustrates the Mount Pleasant ore occurrences, and observes that there are two main mineralization phases: the earlier one, mostly carrying Mo and W in breccias of porphyry-type; and the younger one, mostly carrying Sn and mixed sulphides, related to low-pressure greisen-type phenomena.

We must thus conclude that, in agreement with the above authors, that the ore-forming phenomena related to the emplacement of the latest Hercynian granites may be either of porphyry-type, greisen-type, or both. It is likely that all these possibilities took place; in particular, in the studied area we conclude that the environmental conditions only gave rise to the formation of greisen-type ore occurrences.

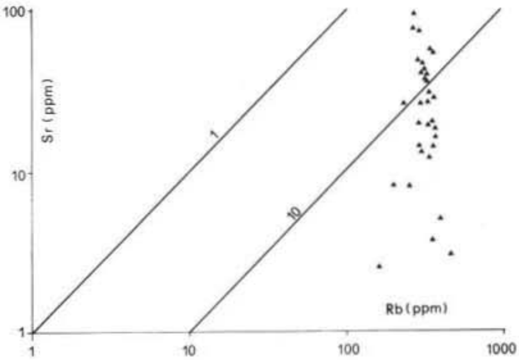


Fig. 9. — Strontium (ppm) vs rubidium (ppm) plot. All the values fall into the Sn series field (see SATRAN'S, 1982, diagram).

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