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The Antimony and Tungsten Deposit of Villasalto in South-Eastern Sardinia and its Relationship to Hercynian Tectonics*)

By L. CARMIGNANI, G. CORTECCI, G. DESSAU, G. DUCHI, G. OGGIANO, P. PERTUSATI and M. SAITTA**)

With 1 figure

Schlüsselwörter

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Sardinien (SW-):
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herzynische Tektonik
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Stibnite
Scheelite
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Abstract

Small veins of stibnite are known within the Silurian black shales of south-eastern Sardinia. At Villasalto these also contain a deposit of stibnite with scheelite, which was of economic importance in the past.

On the basis of their investigations in the field (mapping and structural analysis) as well as in the laboratory (X-ray fluorescence and diffraction, isotopic analyses and ore microscopy), the authors conclude that the Villasalto deposit is located in a black shale tectonic breccia marking an overthrust of regional importance, probably originating from a high-grade deposit reshaped and transported by this tectonic event.

1. Introduction

The Su Suergiu-Martalai mine near Villasalto, situated in the Gerrei region of south-eastern Sardinia, contains stibnite lenses together with some pyrite as well as calcite veins with scheelite, all within a black shale breccia. For nearly a century now it has supplied up to several hundred tons of antimony annually and is presently being reinvestigated.

Since the 1880's opinions have varied between a hydrothermal and a sedimentary origin of the deposit, up to a modern extrusive-sedimentary interpretation in the light of MAUCHER's (1965, 1976) work on the worldwide stratiform Paleozoic Sb-W-Hg formations. Within this framework are also included the investigations by ANGERMAIER (1964) and SCHNEIDER (1972) and his school (HELMCKE, KOCH, LEHMANN).

We believe that the tectonic setting of the Su Suergiu deposit has not been previously taken sufficiently into account.

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**) Author's addresses: All members of the University of Pisa – CARMIGNANI, OGGIANO, PERTUSATI; Institute of Geology and Paleontology, Mapping and Tectonics – CORTECCI; Laboratory of Nuclear Geology, Isotopes – DESSAU; Institute of Geology and Paleontology, Coordination, Ore Deposits, Bibliography, – DUCHI; Institute of Geology and Paleontology, Ore Microscopy – SAITTA; Institute of Mineralogy and Petrography, X-ray fluorescence and Mineralogical analyses.

2. Stratigraphy and Tectonics

Fig. 1 shows in simplified form a part of the geological map. The black ribbon which extends across the map is the outcrop of a tectonic breccia, consisting mainly of black carbonaceous Silurian graptolitic shales, located at the base of an overthrust of regional importance. With the possible exception of PECORINI (1971), the nature of the "Villasalto fault" (TEICHMÜLLER, 1931) does not seem to have been previously recognized.

This outcrop divides the southern area with its nappe of Ordovician "S. Vito sandstones" from the northern area with its series of Ordovician-Silurian porphyroids and arkoses, overlain by Silurian, locally graptolite-bearing black shales, containing intercalations of limestones, black quartzites and sandstones. There are therefore two "levels" of black shales in our area; those of the regular sequence, and those of the overthrust breccia. In the regular sequence above the black shales there follow the marly shales with limestone intercalations of Lower and Middle Devonian age, and then the Upper Devonian-Lower Carboniferous limestones.

A study of a few thin sections of black shales proved rather unsatisfactory, due to the masking effect of the excessive elemental carbon. It was ascertained, however, that these rocks are fine-grained quartzites, with a lot of muscovite and occassionally calcite.

Using X-ray techniques, we have examined 12 samples of black shales, eight come from the Gerrei area and, for comparison purposes, four from south-western Sardinia.

All samples were analyzed for their major constituents by X-ray fluorescence. Arithmetical averages for each constituent were computed disregarding the two extreme values and Fe was computed as Fe_2O_3. The results, in percent, are as follows:

Loss on ignition (water, CO_2, C, etc.): 11.50, Na_2O:0.55, MgO:1.43, Al_2O_3:16.36, SiO_2:56.30, P_2O_5:0.30, K_2O:3.05, CaO:2.43, TiO_2:0.64, MnO:0.05, Fe_2O_3:5.13.

The X-ray diffractometer analyses have yielded approximate results in good agreement with the quoted X-ray fluorescence analyses. Quartz is generally the main mineral. Calcite is abdundant only in several samples. Chlorite and antigorite are rare or occur only in traces. Dolomite is absent. Attempts to estimate the elemental carbon content by calorimetry and by CO_2-analyses (after subtraction of the CO_2 attributed to carbonates) have yielded an average of about 8 percent.

We shall discuss later the content of the trace elements.

In the Paleozoic formations of the Gerrei area three Hercynian compressive tectonic phases have been determined (CARMIGNANI and PERTUSATI, 1977). The first and most impor-

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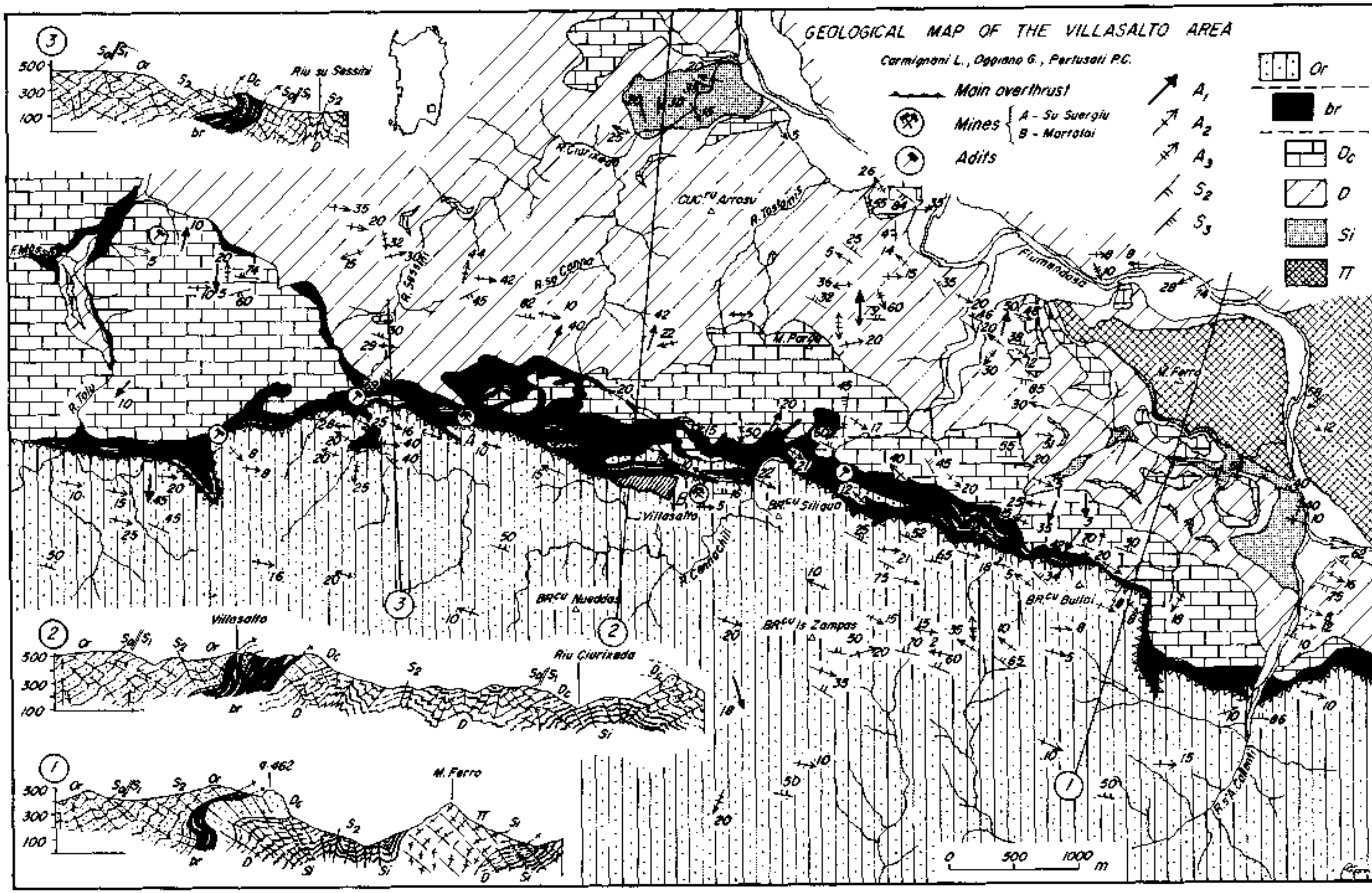
Caption for Fig. 1:

	– Porphyroids and arkoses – Ordovician-Silurian?
Si	– "Black shales", Graptolitic carbonaceous shales, with intercalations of limestones, black quartzites (jaspers, "Lydites") and sandstones – Silurian.
D	– Marly shales, with limestone intercalations – Lower and Middle Devonian.
D_c	– Limestones – Upper Devonian-Lower Carboniferous. This symbol denotes also the biggest limestone lenses included in the Lower and Middle Devonian marly shales.
br	– Polygenic tectonic breccias
Or	– "S. Vito sandstones" – Ordovician?
A_1, A_2, A_3	– Axes of First, Second, Third phase folds.
S_2, S_3	– Schistosities of Second, Third phase.
$S_0//S_1$	– Bedding and First phase schistosity parallel.


GEOLOGICAL MAP OF THE VILLASALTO AREA
Carmignani L., Oggiano G., Pertusati P.C.
Main overthrust
Mines { A - Su Suergiu
B - Martalai
Adits
A1
A2
A3
S2
S3
Or
br
Dc
D
Si
Π
Villasalto
Riu Ciurixeda
Riu su Sessini
M. Ferro
q. 462
Flumendosa
M. Parzu
CUC.ru Arrosu
BR.cu Siliqua
BR.cu Nueddas
BR.cu Is Zampas
BR.cu Bullai
R. Ciurixeda
R. Sessini
R. su Canna
R. Tostainis
R. Canachili
R. Tolu
0 500 1000 m

tant one created isoclinal folds trending N-S, overturned to the west, and was accompanied by an originally sub-horizontal synmetamorphic schistosity, into which bedding is often completely transposed.

The second phase, frequently accompanied by a conjugate schistosity and by a crenulation or fracture cleavage, produces parallel and sometimes very big folds trending N 120° E (see sections in fig. 1). The weak third phase appears only sporadically with kinks and open folds which trend N-S.

The most striking lineament of the area is the E-W trending Villasalto overthrust, always accompanied by a tectonic breccia of up to several hundred metres in thickness and which, as said, contains the antimony deposit near Villasalto. The constituents of the breccia may reach the size of big tectonic slices and in our area consist mainly of black shales. Its matrix is always intensely laminated and may sometimes acquire a cleavage typical of first phase schistosity. The ellipsoidal clasts are strongly flattened parallel to the lamination surface of the matrix, and friction striae as well as tails of fibrous quartz and calcite mark the direction of maximum elongation. One often observes a synmetamorphic schistosity of the phase in the bigger clasts, occurring prior to the brecciation which indicates that the overthrust is late in respect to the first tectonic phase, or at least in respect to its climax.

It has to be stressed that the cleavage of the breccia matrix and the tectonic contact are generally sub-parallel to the first phase schistosity of the underlying and overlying rocks. This suggests that this contact has originally been nearly horizontal. The intense folding (see fig. 1) ist due to the second tectonic phase.

It is difficult to reach definite conclusions in respect to the total amount of overthrusting. But multiple evidence, such as elongation of the clasts, the friction striae as well as the direction of overthrusting of the first phase, suggest a movement from east to west, with a slip which could reach 35 km, – the distance between the Tyrrhenian Sea and the Capidano "Graben".

3. The Ore Deposits

Let us first deal with the trace element content of the black shales, as determined by X-ray fluorescence in the twelve samples already mentioned. The arithmetic averages for each element are, in ppm:

Ni: 76, Cr: 122, V: 598, Co: 13, As: 497, Pb: 42, Ba: 2150, Ci: 76, Nd: 35, Zr: 107, Sr: 135, Rb: 132, Mo: 17, Zn: 131, Cu: 59.

W had not been determined because of instrumental reasons.

With the exception of three samples with 8–17 ppm (of which two come from tectonic contracts), the Sb content, after excluding two obviously contaminated samples from the mine (1745 and 73 ppm), oscillates around 1 ppm, but attains a maximum of 7.

Comparisons with published data in respect to the trace element content of the black shales show that those from Sardinia also fit into the general norm.

The stibnite occurrences of the Gerrei district are of two types. We shall first describe those of the fairly wide-spread first type, but only at Corti Rosas – Ballao, 8 km to the north of Villasalto, is exploitation under way. This type assumes the shape of generally small fissure veins within arkosic Silurian sandstones and porphyroids and is younger than the Hercynian tectonics. They contain tectonically undisturbed stibnite, and very exceptionally some tungsten ore as well. These veins are located a short distance from the black shales in their normal stratigraphic position. The view is generally accepted that the ore originated from the black shales, although is needed an explanation how, with perhaps 1 ppm of Sb (and far more of other metals), these shales might have supplied pure and in one case fairly consistent stibnite veins.

The only example of the other, far more important type, ist the deposit exploited at the mine of Villasalto-Martalai. Here the ore is in the form of almost pure stibnite lenses of all sizes, floating in the black shale breccia, – here of exceptional thickness and with almost vertical dip. These lenses were flattened, parallel with the overthrust, stretched in E-W direction, folded by the late tectonic phases together with the breccia, and were striated with tails of fibrous minerals in the pressure shadows at the ends of the lenses – in short, exhibiting all characteristics of the other clasts within the breccia. Moreover, we have observed that the stibnite is tectonically iso-oriented, with the crystals parallel to the long axis of its ellipsoidal lenses.

On the basis of field evidence alone we can only state that this mineralization, whatever its origin, has undergone a complex tectonic evolution through the greater part of the Hercynian orogenesis. It was already in existence before the end of the first tectonic phase as it has been brecciated at the base of the Villasalto overthrust, and lateron repeatedly folded by the late tectonic phases. The ore lenses are flattened according to the lamination surfaces of the breccia and are not, as it has often been maintained, conformable with the bedding. Therefore any direct evidence of a sedimentary origin of this mineralization is lacking.

Not in genetic connection with stibnite are pyrite grains, nodules and thin layers, which are normal constituents in euxinic sediments. It is interesting that whereas the isotopic composition $\delta\ ^{34}S$ of the sulphur in stibnite oscillates around zero (eleven analyses, $\delta\ ^{34}S$ between -3.5 and $+3.5$), pointing towards a magmatic origin. Three of the four analyzed pyrites show $\delta\ ^{34}S$ between $+14.5$ and $+25.5$, and are therefore biogenic sedimentary. The $\delta\ ^{13}C$ and $\delta\ ^{18}O$ of the calcites associated with stibnite and scheelite are not in disagreement with a hydrothermal origin.

In the light of the foregoing information we have difficulty in accepting an extrusive-sedimentary origin for the antimony deposit of Villasalto. Should this have been the case, we would have expected a much greater distribution of the metal in the Silurian sea. Equally difficult, we believe, would have been a diagenetic concentration or "re-circulation" of the antimony from the black shales, necessarily affecting many cubic kilometres of them, due to their extremely low Sb content. We rather visualize a primary high-grade epigenetic deposit, – it may be left open whether antecedent to the overthrust or pertaining to an early stage of the same – re-shaped and transported by the overthrust itself.

Authors both of the MAUCHER and of the H. J. SCHNEIDER schools have searched for magmatic rocks which could correlate to the deposits, and have had to fall back on the porphyroids, which, however, are generally older, and nowhere in Sardinia directly associated with ores. The latter are in many cases connected with the granite plutons, which are late Hercynian and therefore younger than our deposits.

The acid intrusive rocks, recently described and dated (442± 30 m. y.) by DI SIMPLICIO et al. from other areas of Sardiania, should be somewhat older than the black shales, and most probably older than our deposits. Therefore the association of these deposits with magmatic events remains an open problem.

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The present "abridged version" has space for a few basic references only. In these, and in the "full version", detailed bibliographies may be found.

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