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ENVIRONMENTAL LEVELS OF ANTIMONY, ARSENIC AND MERCURY IN THE TAFONE MINING AREA (SOUTHERN TUSCANY, ITALY)

Abstract - A geochemical survey on mine wastes, fresh waters and biota, carried out in the Monti Romani zone, reveals heavy Sb-(As-Hg) pollution in an area between the Tafone and Chiarone fluvial basins. In the Tafone stream, there is a steep increase of the antimony content in water downstream of mine wastes as far as the mouth, with absolutely high peak levels of the dissolved element. The waters of Tafone Lake also exhibit heavy antimony pollution and the ichthyofauna have high levels of both Sb and Hg in muscle tissue. Wild and cultivated species of plants, collected in the neighborhood of mining areas, often present anomalous contents of these heavy elements. The environmental damage turns out to be closely linked to the wastes of mining and smelting activities and can be attributed largely to the cessation of mining works without any appropriate reclamation program.

Key-words - Mine wastes, environmental pollution, antimony, arsenic, mercury, fresh waters, element speciation, element mobility, contaminated biota, southern Tuscany.

Riassunto - *Livelli ambientali di antimonio, arsenico e mercurio nell'area mineraria del Tafone (Toscana meridionale, Italia)*. È stata condotta nella zona dei Monti Romani una campagna geochimica su materiali di risulta dell'attività mineraria, acque superficiali e forme di vita vegetali ed animali. Questa indagine ha messo in luce la presenza di diffusi e marcati fenomeni di inquinamento per Sb-(As-Hg) nell'area compresa tra i bacini del torrente Tafone e del torrente Chiarone. Lungo il corso del torrente Tafone si registra una brusca impennata nei valori di antimonio in acqua subito a valle delle discariche minerarie. Tali livelli di contaminazione persistono fino alla foce del torrente. Anche le acque del Lago del Tafone contengono valori molto elevati di antimonio in soluzione ed il tessuto muscolare della fauna ittica presenta valori decisamente anomali per Sb e Hg. Varie specie di piante, sia spontanee che coltivate, raccolte nei pressi delle aree minerarie, rivelano molto spesso contenuti elevati in elementi pesanti. I danni ambientali rilevati sono indubbiamente legati alle discariche minerarie e possono senza dubbio attribuirsi all'abbandono dei siti minerari in assenza delle opportune opere di bonifica.

Parole chiave – Materiali di risulta dell'attività mineraria, inquinamento ambientale, antimonio, arsenico, mercurio, acque superficiali, speciazione degli elementi, mobilità degli elementi, forme di vita contaminate, Toscana meridionale.

INTRODUCTION

Heavy element pollution is an increasing environmental concern in many developed countries, since significant negative effects of these substances on the biosphere have been well documented (WHO, 1976; WHO, 1981; Fergusson, 1990).
Among the various sources of toxic elements in the surface geochemical systems, the wastes of past and present mining activities certainly play an important role.
The geochemical maps of southern Tuscany available for some toxic heavy elements (Protano *et al.*, 1998) emphasize a number of broad anomalies that are frequently marked and mostly related to abandoned mining works. There is particular concern for the southern part of the region, where a historically important activity of Sb-Hg-(As) mining has produced huge piles of polluted dumps and tailings.
Baroni *et al.* (1996 and 1997) recently pointed out the abnormally high antimony levels registered in stream waters, sediments and biota of various localities of the Monti Romani area, which overlaps, at least in large part, the Sb mining field.
In this paper, we will focus on the area embracing the Tafone and Chiarone drainage basins, in an attempt to outline the expected environmental implications of the recently recognized geochemical anomalies for antimony.

SAMPLING AND ANALYTICAL METHODS

Samples of mine wastes, topsoils, surface waters, cultivated and wild species of plants and ichthyofauna were collected in the Tafone and Chiarone fluvial systems, particularly in the neighborhood of the mining works.
We collected samples of about 3 kg of fine-grained materials from mining wastes by summing several shovelfuls from different points at the foot of dumps, over an area of several square meters. These samples were then dried in a stove at 40°C and the sieved fractions with grains smaller than 75 μm were used for chemical analysis.

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Topsoil samples (up to 10 cm in depth) were homogenized and reduced to very thin powder by a mechanical agate mortar.
Water samples, 500 cc in volume, were filtered through polycarbonate Millipore® filters at 0.45 μm, and supplemented with 2.5 cc of nitric acid.
After an ultrasound bath, plant samples were accurately washed and then dried at 50°C in stove.
The hot digestion of samples was carried out in Pyrex flasks using Friederick's apparatus. Organic samples (0.5 g) were attacked for one hour by a mixture of 5 cc of H_2O_2 and 5 cc of nitric acid. Inorganic samples (0.5 g) were attacked in the same way with a 1:1 $HCl+HNO_3$ mixture to bring the metals into solution.
Extraction of metals in soils was carried out with both deionized water and a slightly acid solution (0.43 mol/l acetic acid) according to the method of Ure *et al.* (1993).
All samples were analyzed for antimony, arsenic and, in part, for mercury by a Perkin Elmer mod. 5000 AAS, equipped with FIAS, employing the hydride method.

Geological outlines

The study area is part of the hills and plains bordering the Tyrrhenian coast in the southernmost corner of Tuscany, where terrains ranging in age from Lower Paleozoic to Quaternary crop out (Giannini *et al.*, 1971; Dessau *et al.*, 1972; Moretti *et al.*, 1990).
A clastic sequence, consisting of black shales, gray to red metasandstones, quartzites and phyllites from Late Cambrian-Early Ordovician to Lower Triassic, is a main geological protagonist and constitutes the relief of Mt. Bellino, pushing as far as the southern slope of Mt. Maggiore, Mt. Capita and Monteti. Upper Triassic evaporites, mainly consisting of a polymictic breccia, known as «Calcare Cavernoso», lie on the Paleozoic metaclastites and, in turn, are overlain by the Tuscan Nappe formations, the allochthonous Ligurian flysches (Cretaceous-Eocene) and the neoautochthonous post-Tortonian terrains.
The «Calcare Cavernoso» formation, and particularly its top zone near the contact with flysches, represents a preferential host for Sb-ores in this area. Stibnite is the main ore mineral and is associated with abundant pyrite and marcasite and subordinate quantities of sphalerite, galena and cinnabar. Little or no gangue is a peculiar feature of these Sb-ores.
Mining works were active at Mt. Capita, Poggio Fuoco-Macchia Casella and, particularly, in the Tafone ore field, where a large open pit constituted the main Sb-exploitation center. Indeed, a Sb-oxide production plant is still active there, employing imported coarse metal.

Analytical results and discussion

As already mentioned, Baroni *et al.* (1996 and 1997) and Protano *et al.* (1998) report that both fresh waters and stream sediments of this zone of southern Tuscany are sometimes heavily polluted for antimony and, to a lesser extent, for arsenic and mercury.
In the study area, the numerous old mining works, and particularly the Tafone orefield, appear to be the obvious sources of the anomalous values in the stream media.
To assess the polluting potential of mining wastes and the environmental effects of such pollution, we

Tab. 1 - Sb, As and Hg contents of mining wastes and soils (expressed in mg/kg).

Tafone basin area

	Sample	Sb	As	Hg
Materials from the Tafone mine dumps				
1	*TS45*	1680.0	485.0	
2	*TS54*	192.8	95.2	
3	*TS55*	920.8	196.7	
4	*TS67*	114.8	39.9	
5	*TS68*	1247.2	312.2	
6	*TS77*	515.7	168.5	
7	*TS78*	650.2	210.8	
8	*TS79*	910.2	219.8	
Soils around the Tafone open pit				
9	*S1*	288.2	142.2	8.7
10	*S2*	79.6	37.9	< 0.01
11	*S3*	2795.5	898.6	13.0
12	*S4*	15112.9	74.1	72.2
13	*S5*	5105.0	267.2	9.2
14	*S6*	54.3	102.0	8.0
15	*S7*	540.4	269.3	24.3
16	*SCA75*	202.8	91.5	9.5
17	*SCA76*	192.4	152.5	13.2
Materials from the Tafone mineral processing tailings				
18	*SCA69*	76233.6	160.4	168.2
19	*SCA70*	3380.7	2343.9	188.5
20	*SCA71*	6529.7	2466.3	162.2
21	*SCA72*	261.4	2.4	3.5
22	*SCA73*	9157.5	89.7	183.2
23	*SCA74*	2769.6	3213.1	277.9
Soils around the Tafone mining area				
24	*S10*	22.0	26.8	
25	*STA1*	25.0	33.6	
26	*STA2*	52.2	39.2	< 0.01
27	*STA3*	26.1	46.3	
28	*STA4*	13.4	47.1	

Chiarone basin area

	Sample	Sb	As	Hg
Soils				
29	*S26*	28.6	5.3	
30	*S27*	204.1	17.9	
31	*S34*	136.8	13.6	
32	*S35*	154.0	15.6	
33	*S48*	119.1	9.5	

collected samples from a varied spectrum of objects and situations.

The antimony, arsenic and mercury contents of the analyzed samples are reported in Tables 1, 2, 3, 4 and 5, while the sample locations are shown in the sketch map of Figure 1.

In Table 1, samples 1-8 refer to the fine sand at the foot of dumps in the Tafone mining area, where runoff collects the eroded particles. The antimony content of these, certainly representative, samples is always very high, in several cases approaching or exceeding 1000 ppm. The arsenic values are also rather high (As=40-485 ppm), albeit to a lesser extent than for Sb. Furthermore, the levels of these two elements appear to be linked by a remarkable geochemical consistency.

Samples 9-17 represent the topsoils collected around the Tafone open pit. The antimony and arsenic contents are both generally high, comprised in the wide ranges of 54-15,113 ppm for Sb and 38-899 ppm for As. Mercury is present in moderate quantities (< 0.01-72 ppm), often exceeding by far the regional background of 0.21 ppm (Baroni *et al.*, 1994).

However, the highest contents of these heavy elements are found in the mineral processing tailings lying in the southernmost part of the Tafone orefield, close to the open pit. For example, a huge pile of flotation wastes with some roasting slags has provided samples (18-23) with impressive contents of antimony (261-76,234 ppm) and arsenic (2-3,213 ppm). Mercury also reaches relatively high levels, up to 278 ppm, in these materials.

Sample 18 (SCA 69) has the highest Sb concentration (76,234 ppm) measured in the study area. It is the top portion of flotation wastes, white stained by a thick film of saline efflorescence, that is widespread over a large surface area of this dump in the Tafone mine site (Figs. 2 and 3). The salt film is composed mostly of sodium sulfate thenardite with minor and variable amounts of the rare mineral mopungite [$NaSb(OH)_6$]. These minerals, and possibly others not yet identified, are probably the products of the interaction of ores with reagents employed in the mineral processing.

Agricultural topsoils collected around the Tafone mining area (samples 24-28) present rather constant and slightly anomalous values of Sb (13-52 ppm) and As (27-47 ppm).

Tab. 2 - Extraction tests on soils and waste materials of the Tafone mine (data expressed in mg/kg).

Antimony test

Sample	Total content	Soluble fraction	Exchangeable fraction
S1	288.2	0.11	1.72
S2	79.6	0.08	1.53
S3	2795.5	1.80	5.20
S5	5105.0	0.76	1.78
S7	540.4	0.27	5.73
SCA69	76233.6	29.10	
SCA75	202.8	0.17	2.90
SCA76	192.3	0.15	3.00

Arsenic test

Sample	Total content	Soluble fraction	Exchangeable fraction
S1	142.2	0.002	0.31
S2	37.9	0.001	0.48
S3	898.6	0.019	1.47
S5	267.2	0.012	1.60
S7	269.3	0.001	0.40
SCA69	160.4	60.000	
SCA75	91.5	0.006	0.11
SCA76	152.5	0.004	0.24

Tab. 3 - Antimony and arsenic concentrations in fresh waters (expressed in μg/l).

Tafone basin area

Sample		Sb	As
Tafone lake waters			
34	*SCA8*	258.0	35.5
Drainage waters of the Tafone mine dumps			
35	*SCA47*	750.0	1500.0
Tafone stream waters			
36	*SCA44*	3.1	1.0
37	*SCA56*	238.8	20.0
38	*SCA46*	258.0	17.9
39	*SCA11*	181.3	20.0
40	*SCA12*	256.0	10.7
41	*SCA6*	133.8	2.6
42	*SCA62*	95.0	1.6
43	*SCA2*	84.5	2.2
44	*SCA58*	3.3	1.4
45	*SCA52*	9.3	3.0

Chiarone basin area

Sample		Sb	As
Chiarone stream waters			
46	*SCA33*	0.5	2.7
47	*SCA49*	1.0	0.4
48	*SCA48*	1.5	0.5
49	*SCA29*	2.3	1.6
50	*SCA34*	5.7	1.4
51	*SCA35*	50.6	1.7
52	*SCA28*	70.8	2.0
53	*SCA27*	68.9	1.6
54	*SCA26*	63.4	1.3
55	*SCA50*	54.5	0.9
56	*SCA1*	58.5	0.2
57	*SCA24*	60.5	1.2
58	*SCA51*	42.5	0.9

Tab. 4 - Antimony, arsenic and mercury concentrations in plant species (expressed in mg/kg dw).

Tafone basin area

	Antimony						*Arsenic*						*Mercury*
Cultivated plants	Bulk	Root	Stem	Leaves	Flower	Fruit	Bulk	Root	Stem	Leaves	Flower	Fruit	Root
59 Celery (*Apium graveiolus*)				1.39						0.53			
60 Turnip (*Brassica napus*)				0.20						0.26			
61Pepper (*Capsicum annum*)				1.81		0.32				0.27		< 0.01	
62Tomato (*Lycopersicum esculentum*)				0.71		0.02				0.07		0.01	
63 Pumpkin (*Cucurbita pepo*)				2.02	1.74					0.23	0.40		
64 Lettuce (*Lactuca sativa*)				0.15						0.13			
65 Eggplant (*Solanum melongena*)				0.37						0.11			
Wild plants													
66 *Cistus salvifolius*			1.06	5.72					0.22	1.29			
67 *Silene vulgaris*		15.49	30.86	56.41				6.68	2.54	5.82			
68 Clover (*Trifolium pratense*)		18.85	0.68	2.11				4.46	0.08	0.50			0.44
69 Alfalfa (*Medicago sativa*)		12.07		8.13				3.34		2.81			0.55
70 Marine green algae	2.05						11.33						

Chiarone basin area

	Antimony						*Arsenic*					
Cultivated plants	Bulk	Root	Stem	Leaves	Flower	Fruit	Bulk	Root	Stem	Leaves	Flower	Fruit
71 Pepper (*Capsicum annum*)				0.35		0.02				0.07		< 0.01
72 Wheat (*Triticum aestivum*)						0.03						< 0.01
73 Sunflower (*Helianthus annuus*)				0.08		< 0.02				0.04		0.03
74 Corn (*Zea mais*)				0.20		< 0.02				0.01		0.03
Wild plants												
75 Horsetail (*Equisetum*) a	31.00						0.15					
76 Horsetail (*Equisetum*) b	105.00						44.7					
77 Alfalfa (*Medicago sativa*)				0.16						0.04		
78 Marine green algae	0.94						8.80					

Reference values (*)	*Antimony*	*Arsenic*	*Mercury*
Terrestrial plants	0.002-0.03	0.02-7.0	0.005-0.02
Cultivated plants	0.0001-0.2	0.01-1.5	0.013-0.17
Grass	0.03		
Forage crops	0.10		
Marine algae	0.02-0.9	1-30	0.03

(*) Data from Bowen (1979) and Fergusson (1990).

Topsoil samples (29-33) from the Chiarone mining area (Mt. Capita mine) have decidedly anomalous antimony contents, although the values, generally in the range 119-204 ppm, are not as high as in the Tafone mine situation. The arsenic levels are normal, ranging from 5 to 18 ppm.

The total concentration of heavy elements is not a good indicator of biological effects, whereas their

Tab. 5 - Heavy element concentrations in muscle of Tafone lake fishes (expressed in mg/kg fw).

Fish species	Sb	As	Hg
79 Capito	0.03	0.03	0.45
80 Goldfish	0.21	0.77	0.56
81 Barbel	0.55	1.20	0.54
82 Little cyprinid (*Rutilus Erythrophtalmus*)	0.99	0.40	0.39
Normal range in sea fishes (*)	0.004-0.2	0.2-10.7	0.4 (**)

(*) Data from Bowen (1979) and Fergusson (1990).
(**) The reported value is a broad, perhaps slightly high, average. As a matter of fact, 0.5 mg/kg is considered unfit for human consumption in several developed countries (i.e. Canada).

speciation is a central topic in pollution studies. Therefore, we carried out a series of metal extraction tests on selected samples, the results of which are reported in Table 2.
The data in Table 2 show that the total contents of antimony and arsenic in the selected samples are evidently unrelated from a geochemical point of view. Moreover, the extent of the soluble and exchangeable fractions demonstrates that these heavy elements are mostly present in poorly soluble phases.
On the other hand, the «bioavailable» fractions obtained are remarkable, especially in view of the toxicity and the poor geochemical diffusion of these elements in nature. As expected, the exchangeable fraction prevails quantitatively over the soluble one, although to a varying degree.

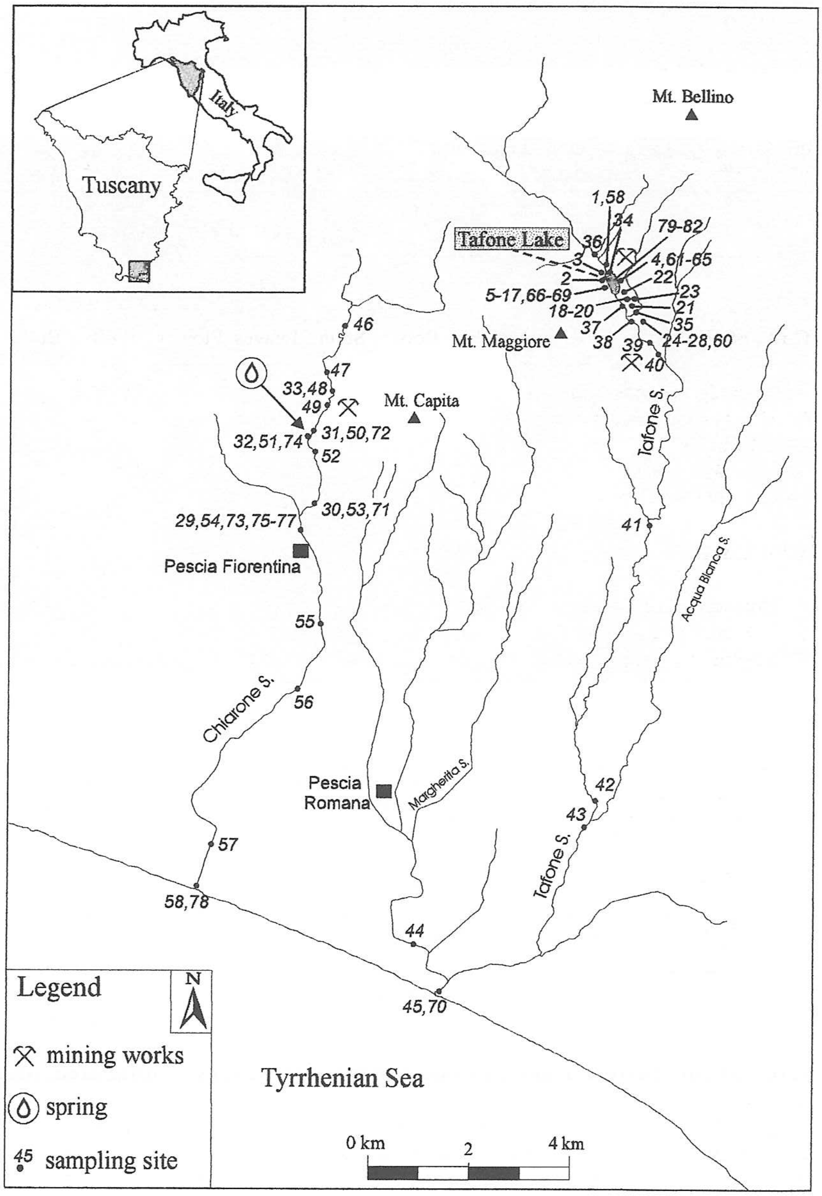

Fig. 1 - Sketch map showing the location of the main mining works and sampling sites in the Tafone and Chiarone basins (Monti Romani area).

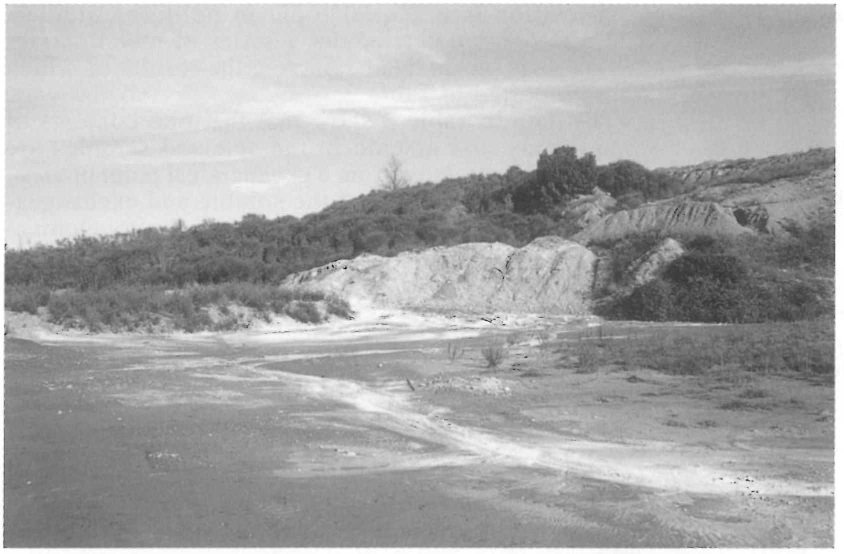

Fig. 2 - A thick white efflorescence covers the mining wastes at the Tafone mine.

Fig. 3 - Felted intergrowth of thenardite crystals (with minor mopungite) on pebbles (detail of Fig. 2).

Particularly meaningful, however, is the soluble fraction of the SCA 69 sample. Indeed, although the high value of 29 ppm of dissolved Sb is certainly justified by the exceptional total content of the element itself, the even higher level of soluble arsenic (60 ppm) in the same sample is frankly surprising. In fact, at least one third of the arsenic in SCA 69 must clearly be present in an easily soluble, still unidentified, phase. Table 3 summarizes the values of antimony and arsenic dissolved in fresh waters of the Tafone and Chiarone basins. The values of Sb and As in sample 34 refer to the Tafone Lake (flooded open pit) waters and represent an average of ten measures performed on samples taken at different times in different places of the stretch of water. All the analyses performed agree very closely with the average values of 258 μg/l Sb and 35.5 μg/l As, which, at least for antimony, should be considered absolutely high.

The waters of Tafone stream are similarly polluted, mostly for antimony. The heavy impact of mine wastes stands out on first glance. The relatively low Sb value (3.1 μg/l) in water upstream of the mining area changes quite abruptly to very high figures (181-258 μg/l) immediately downstream. The same trend, although in different proportions, is shown by arsenic, with concentrations in stream waters ranging from 11 to 20 μg/l near the Tafone mining site. Downstream of the mining area, high Sb values of 100 μg/l, on average, persist in the Tafone stream waters for a long tract. Indeed, the antimony dissolved in waters decreases to values of 9 μg/l only near the mouth, owing to confluence with the cleaner (3.3 μg/l Sb) Margherita stream.

Within this framework, the Sb and As concentrations in sample 35 (SCA 47) deserve particular attention. This sample represents the wash waters of the highly polluted tailings of the Tafone mine dump, collected during a heavy rainfall. However, despite the very high arsenic content (1500 μg/l) of these waters (exactly twice that of antimony), no sign of the expected heavy As pollution is recognizable downstream in the Tafone stream, the natural collector of these waters.

The strong solubility of the yet «undetermined» arsenic compounds, mentioned previously, coupled with the moderate absolute content of the element in the outcropping materials, create a quickly waning «temporary peak» of dissolved As, which is not able to have a strong effect on the chemistry of stream waters. This hypothesis seems to us rather convincing since the Sb/As ratio in the sampled wash waters is identical to that obtained in the same materials (SCA 69) during the laboratory tests of heavy element extraction.

The Chiarone stream waters also show relatively high values of antimony in solution (42-71 μg/l). In this case, however, the main contributor to the pollution seems to be a natural spring (Fig. 1), which is fed by groundwaters percolating through silicized Sb-bearing limestones in the Mt. Capita area (Protano and Riccobono, 1997).

The overall situation, that we have described, is certainly worrying as it is well known that streams heading directly onto mine sites are of crucial importance in the dispersal of heavy elements in the environment, both in solution and in the particulate phase (ore, adsorbed on coatings or particle surfaces, etc.). Once in the river system, the polluting elements can persist at the surface, as stressed by Miller (1997), for hundreds or thousands of years, weighing heavily on the environment and constituting a serious menace (Stigliani, 1991; Konsten *et al.*, 1993).

In an attempt to identify the effects on living organisms of the pollution from mining activities in the area, we collected wild and cultivated species of plants in the neighborhood of the mine sites and some specimens of ichthyofauna from Tafone Lake. The results of the analyses are reported in Tables 4 and 5. It is clear that the metal uptake can be different for various species of plants, since indicators, accumulators and excluders of elements are well known in the plant kingdom. Therefore, the results for antimony (Tab. 4) provide a picture of a generalized anomaly in the Tafone mining area, which stands out clearly when the measured values are compared with data from the literature (e. g. forage crops). Edible plants from the Tafone area also show objectively high antimony contents (0.02-2.02 mg/kg), although the paucity of data in the literature concerning this toxic element makes a sound appraisal for each single value very difficult.

The plant data from the Chiarone basin mostly show lower Sb contents (< 0.02-0.35 mg/kg), except for two horsetail samples. The sharp difference in antimony and arsenic contents between the «a» and «b» horsetails (both sampled within a few centimeters) seems to be related to the stage of growth, the «b» sample being older.

The Chiarone basin plant data also confirm for antimony the often observed difficulty of translocation of many heavy metals towards the caryopsis in cereals.

Table 5 reports the Sb, As and Hg contents in muscle of four fish species living in Tafone Lake. In two cases, the antimony levels are much higher than the range of the metal (0.004-0.2 mg/kg) reported in literature (Bowen, 1979). Mercury, despite its subordinate presence in the area, also exhibits rather high values ranging from 0.39 to 0.56 mg/kg; this is even more significant if we consider that all the fishes analyzed were very small (5-10 cm) young animals.

The overall picture that appears from the results of the analyses is that of a deeply damaged environment. The data demonstrate both the great hazard of lying mining wastes and the notable mobility of antimony in the oxidizing surface conditions.

With reference to this, Vink (1996) has recently stressed the broad field occupied by the ionic species $SbO_{3(aq)}$, in the Eh-pH space, under oxidizing conditions, be it alkaline or acidic. This substantially rectifies earlier Eh-pH diagrams, which suggested that antimony is practically immobile under these same conditions.

Of particular concern is the presence of very soluble arsenic compounds among the wastes. Since erosion processes are particularly active in several parts of the mining area (Fig. 4), further sampling and periodic surveillance of the flowing waters is certainly necessary.

In conclusion, we believe it appropriate to remark on the mercury pollution in this area. Minor quantities of cinnabar are usual in epithermal mineralizations, such as the ores mined in this area, and the Tafone ore deposit is no exception. In fact, the finding of conspicuous concentrations of cinnabar led the mine management to construct a roasting plant for the distillation of mercury, which was active for some years.

It is very likely that the presence of Hg° is in part responsible for the levels of this element found in the biota of this area. Recent studies on the mechanisms of physico-chemical interaction of mercury with river sediments (Malamed *et al.*, 1997) indicate that humic acids drastically enhance the solubility of Hg°. The soluble complex thus formed easily spreads mercury through the aquatic environment, as the affinity for interaction with the mineral surface is greatly reduced.

On the other hand, the enhanced mobility of mercury in the aquatic environment increases the probability that conditions for Hg-methylation will occur, this organic form being the dominant source for the accumulation of mercury in the foodchain.

Various case studies of mercury pollution in Brazil, caused mostly by the use of Hg° for gold extraction by amalgama, show that human exposure is partly attributable to the consumption of contaminated fish

Fig. 4 - Deep erosion channels in the mining wastes at the Tafone mine.

(Lacerda *et al.*, 1990; Nriagu *et al.*, 1992; Cleary *et al*, 1994). As a matter of fact, the average levels of mercury in contaminated fishes from 3 locations in Brazil (Cuiu Cuiu=0.58 mg/kg; Jacareacanga=0.47 mg/kg; Itaituba=0.30 mg/kg; Thornton, 1996) are comparable to the values that we found in the ichthyofauna of Tafone Lake.

Concluding remarks

Summing up the relevant data arising from this survey, we can reliably make the following conclusions:
a) The materials lying in the dumps of the Tafone mine show very high contents of Sb, As and Hg, and, moreover, some toxic phase is very easily leachable.
b) Downstream of the mine area, the waters of the Tafone stream contain high values of dissolved antimony, which persist as far as the mouth in the Tyrrhenian Sea. Lower, but still notable, antimony contents are also present in the Chiarone stream waters. They appear, however, to be related mostly to the influence of a naturally polluted spring.
c) The biota sampled close to the polluted areas, such as edible and wild species of plants and ichthyofauna, exhibit decidedly anomalous values, particularly for antimony.
d) The hazard constituted by the wastes lying in the Tafone mining area is enhanced by the complete neglect of the conditions there. Hence this area of southern Tuscany represents a major environmental concern, which definitely requires much more attention.
e) It is highly recommended that an appropriate reclamation program be established in as short a time as possible.

At the end of this description, it is very hard for us not to be very disturbed, since the environmental injury, that we have observed, exactly mirrors the scanty sensitivity of the competent authorities to identify, and obviously to manage, environmental problems. This appears even more true with respect to such an insidious enemy as heavy element pollution.

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