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The gold of the Fersina river (Province of Trento, Northern Italy). A study of the behaviour of gold grains during river transport

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ABSTRACT - PREINFALK C., FUGANTI A., MORTEANI G., 1998 - The gold of the Fersina river (Province of Trento, Northern Italy). A study of the behaviour of gold grains during river transport. [L'oro del torrente Fersina (Provincia di Trento, Italia settentrionale). Uno studio sul comportamento delle particelle d'oro trasportate dal torrente]. *Studi Trent. Sci. Nat., Acta Geol., vol. 73, pp. 99-105.*

The gold contents of the lead-zinc ores of the now closed mines of Viarago, Prementil and of the area of Palù in the Val Fersina (Province of Trento, Northern Italy) are on average around 0.25 ppm with sporadic values up to 20 ppm. The silver contents are between 2 and 57 ppm. The first information on mining activities in the given area is from 1330, the most intense mining was between 1400 and 1500 and the mining activity ended definitely in 1940. These gold contents lead to gold contents in the sediments of the Fersina river. Due to the rapid erosion and quick river transport in the mountaineous area most of the gold grains show no signs of deformation or leaching of the silver contents. The erosion and transport rate is so high, that in the river sediments also euhedral sulphide grains, originating form the primary mineralizations are present.

PAROLE CHIAVE: *oro, argento, torrente Fersina, Val dei Mocheni, Italia.*
KEY WORDS: *gold, silver, Fersina river, Val dei Mocheni, Italy.*

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1. INTRODUCTION AND PROBLEM

In the sediments of the Fersina river draining the omonimous valley in the Province of Trento (N Italy) traces of gold can be found by panning. The Val Fersina, also known as Val dei Mocheni, joins the Valsugana near the town of Pergine. In Fig. 1 a geological sketch map showing also the topography is given.

The gold found in the Fersina river comes from the many small gold-bearing lead-zinc mineralizations which are found in the mountains along the Fersina river. Many of them have been mined for lead and zinc in former times. The first historical record of mining in the Val Fersina area is from 1330.

The mines were most active from 1400 to 1500. Mining for sulphides went on until about 1940 with varying, but in general decreasing success (DESSAU & PERNA, 1966; OMENETTO & DETOMASO, 1970).

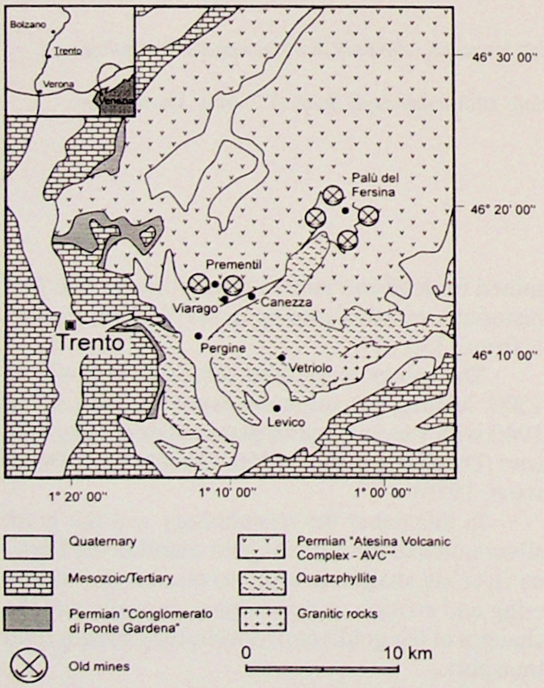
In this paper the morphology and the gold/silver ratios of the alluvial gold found in the Fersina river are studied in order to discuss the weathering and erosion of the primary deposits and the changes of the gold grain morphology during river transport.

2. GEOLOGY

Fig. 1 gives in a simplified geological sketch map as redrawn from the Carta Geologica d'Italia, 1:100.000, Sheet 21 (Servizio Geologico d'Italia, 1968) and the location of the most important mining areas of the Fersina river valley. Those mineralizations are found at Viarago and Prementil near Canezza and in the area of Palù del Fersina (Erdemolo, Laner, Knappenwald and Frotten). The map shows that the mineralizations are located along the outcrop of the basal levels of the Permian pile of lava flows forming the volcanic complex currently called in the regional literature "Tavolato Porfirico Atesino" (TPA) or Atesina Volcanic Complex (AVC) (Barth *et al.*, 1993). According to an idealized stratigraphic succession in its southern part the AVC consists of a lower group composed mainly of andesitic, trachyrhyolitc, rhyodacitic, dacitic and again andesitic lavas and an upper group consisting of rhyodacitic, rhyodacitic-rhyolitic and rhyolitic lavas and ignimbrites (Di Battistini *et al.*, 1989; D'Amico & Venturelli, 1968; Barth *et al.*, 1993). The sulphide mineralizations are related to a late magmatic intense propylitization of the andesitic and dacitic to rhyodacitic rock sequences of the lower horizon as described e.g. by Morteani (1966) and Burtet Fabris *et al.* (1974). Rejuvenated radiometric ages speak in favour of an additional, but low temperature overprint (<300 °C, more likely 130 to 190 °C) during Middle to Late Triassic times (Barth *et al.*, 1993).

Fig. 1 - Mining areas of Viarago and Prementil near St. Orsola and in the area of Palù del Fersina (Erdemolo, Laner, Knappenwald and Frotten) in a simplified geological sketch map as redrawn from the Carta Geologica d'Italia, Sheet 21, Trento (Servizio Geologico d'Italia, 1968).

Fig. 1 - Schizzo geologico raffigurante l'ubicazione delle miniere di Viarago e Prementil nei pressi di S. Orsola e nella zona di Palù del Fersina (Erdemolo, Laner, Knappenwald e Frotten) rielaborato dalla Carta Geologica d'Italia, Foglio 21, Trento (Servizio Geologico d'Italia, 1968).



The Permian volcanic rocks cover the Permian basal conglomerates called "Conglomerato di Ponte Gardena". The conglomerates are underlain in turn by the crystalline basement consisting of quartz phyllites, the so called "phyllites of the Valsugana" of supposed pre-Paleozoic and/or Paleozoic age.

The mineralization of Viarago was worked intermittently until 1940 on the veins Fontanelle and Paolo. The thickness of these main veins is reported to be about 1 meter and the mineralization is described as chalcopyrite, galena, pyrite and sphalerite in a quartz gangue. The copper content of the ore is around 6% and the silver content is reported as 0.06% (Omenetto & Detomaso, 1970).

The mine of Prementil consists only of some small adits opened around 1928 (Burtet Fabris *et al.*, 1974). The mineralization consists of berthierite, stibnite, galena, marcasite, arsenopyrite, and kermesite.

In both mining areas no native gold was detected by ore microscopy.

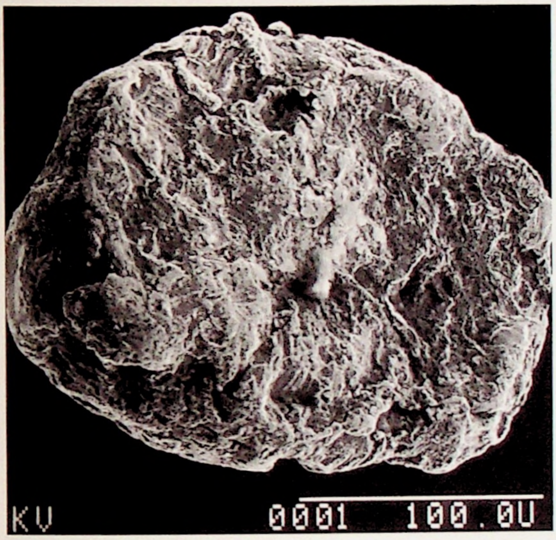
In the area of Palù del Fersina the relics of many small mines can be found still now at Erdemolo, Frotten, Knappenwald and Laner. The mineralization occurs as small veins and disseminated within strongly altered dacites. Pyrite is the most important ore mineral, followed by galena, pyrrhotite, sphalerite, chalcopyrite, rare arsenopyrite, tetrahedrite, polybasite, fluorite, and barite. Omenetto & Detomaso (1970) describe in the ores of the area of Palù native gold included in pyrite. Such parageneses are typical of base and precious metal mineralizations connected with propylitic alteration and late to postmagmatic hydrothermal activity (Maucher, 1959; Morteani, 1966; Murara, 1966).

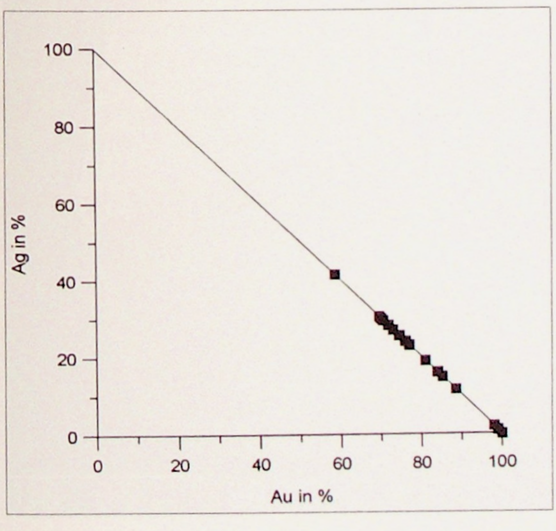
In order to assess the gold potential of the ores of the Val Fersina some typical ores collected from the dumps have been analysed for gold and silver. From Tab. 1 it can be seen that the gold contents are on average 0.25 ppm, only in one case 20 ppm are found.

Tab. 1 - Gold and silver contents in typical ores from the different lead and zinc mineralizations of the Valle dei Mocheni.

Tab. 1 - Contenuto d'oro e d'argento in differenti mineralizzazioni di piombo e zinco della Valle dei Mocheni.

sample no.	Au (ppm)	Ag (ppm)	locality
1001	0.50	57	Viarago
1002	0.45	4	Viarago
1003	0.27	40	Viarago
1004	0.13	1	Erdemolo/Palù
1005	0.10	24	Erdemolo/Palù
1006	20.05	2	Laner/Palù
1007	0.31	18	Laner/Palù
1008	0.12	4	Knappenwald/Palù
1009	0.12	4	Knappenwald/Palù
1010	0.07	2	Frotten/Palù
1011	0.47	4	Frotten/Palù





The silver contents show a large scatter and are not correlated with the gold content of the ores. Most of the silver is therefore probably contained in the sulphides, such as galena.

It should be mentioned that it is not known whether those silver and gold contents were recovered from the ores in ancient times, but the presence of mercury drops in the sediments could be taken as a hint for that (see below).

3. ALLUVIAL GOLD

In order to determine the quantity, shape and chemical composition of the alluvial gold in the Fersina river about 20 kg of the grain fraction below 2 mm, obtained by sieving of the river sediments, were panned. The sampling points were at about 1 km downstreams of the two villages of Palù del Fersina and Canezza. The heavy mineral fraction obtained by panning consisted predominantly of iron oxides and sulphides. Only 2 to 5 gold grains in each sample could be detected.

Fig. 2 shows a gold grain with a rather irregular surface panned at Canezza. No signs of flattening or smoothing of the surface of the grain can be seen.

The EDX analysis showed in this grain a high silver content of 30 wt.-% which is typical for primary gold of the given propylitic type of mineralization. An EDX analysis of some other grains characterized by a rough surface, too, showed again high silver contents inbetween 11 and 40 wt.-% (Fig. 3). The irregular surface and the high silver contents are typical for gold grains transported quickly only for very short distances. No copper or other elements were detected by routine EDX analysis.

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Fig. 2 - SEM picture of a gold grain from the sediments of the Fersina river near Canezza. Notice the rough surface.

Fig. 3 - EDX analysis of the alluvial gold found in the Fersina river. There are two populations. The one is characterized by remarkable silver contents, the other shows practically no silver contents.

Fig. 2 - Immagine SEM di un granello d'oro proveniente dai sedimenti del torrente Fersina nei pressi di Canezza. Si noti la superficie rugosa.

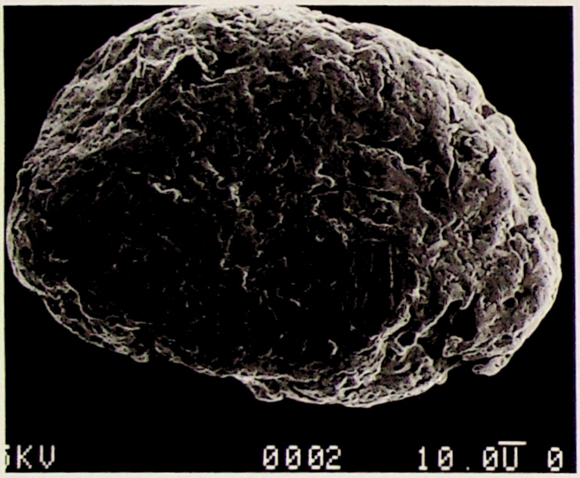
Fig. 3 - Analisi EDX dell'oro alluvionale ritrovato nel torrente Fersina. Si distinguono due popolazioni: una caratterizzata da un notevole contenuto d'argento, l'altra quasi senza argento.

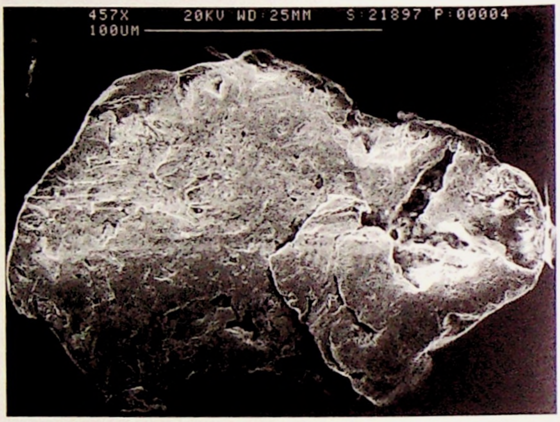
Fig. 4 gives the very rare case of a gold grain from the sediments of the Fersina river near Canezza showing a surface suggesting a smoothing and "glazing" of a preexisting rough surface similar to that shown in Fig. 2. Such a smoothing of the surface and the scratches are typical for gold grains transported for a longer distance and consequently intense hammering by the river pebbles. If the observations of Schmid (1973) on the gold in the Swiss Molasse sediments and the criteria given by Hallbauer & Utter (1977) on the morphology of alluvial gold from the Barberton greenstone belt (South Africa) are taken into consideration this type of grain was subjected to a transport of not more than 30 kilometres. This transport distance points out to an origin of this gold grain from the mines at Palù del Fersina found at about 15 km distance from Canezza.

The long transport of this grain is also supported by the EDX analysis which gives practically pure gold (see Fig. 3). During a long transport the original silver content is leached (Desborough, 1970; Hallbauer & Utter, 1977; Lehrberger, 1997). Fisher (1945) considers that the fineness of gold increases from 0.3 to 7.5 units with each km from the source.

For comparison also a gold grain as obtained by panning of the sediments of the Niger river at Bamako (Mali) is shown in Fig. 5 (Fuganti *et al.*, in prep.). This grain is very flat and shows also towards the grain border no surface structure. The lower right part of the grain shows that the already flattened grain was bent and then flattened again by the hammering of the river pebbles. The morphology of this grain is therefore very different from that shown by the gold grains found in the Fersina river and suggests a transport of at least 80 km (Hallbauer & Utter, 1977).

The fact that the predominant amount of the gold grains found in the Fersina river shows no deformation or silver leaching indicates that the primary mineralizations of the Val Fersina are under





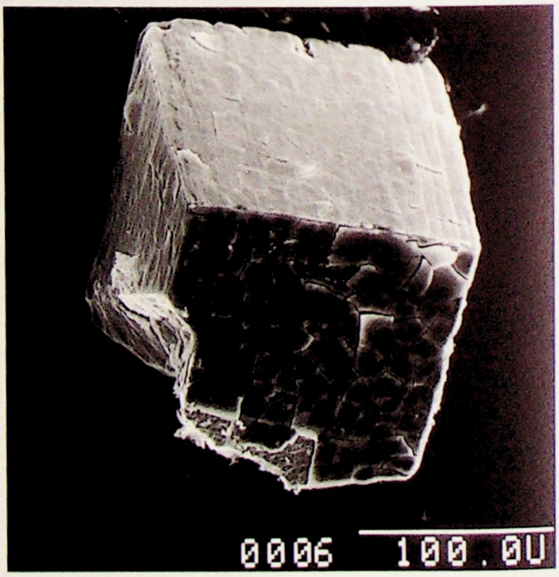


Fig. 4 - SEM picture of a gold grain from the sediments of the Fersina river near Canezza. Notice the smooth surface.

Fig. 5 - SEM picture of a gold grain from the sediments of the Niger river at Bamako (Mali). The grain is extremely flattened, bent and shows no more surface structure.

Fig. 6 - SEM picture of an undeformed euhedral pyrite cube from the sediments of the Fersina river still displaying on the surface typical striations. The just starting oxidation produces the faint mosaic structure on the crystal surfaces.

Fig. 4 - Immagine SEM di un granello d'oro proveniente dai sedimenti del torrente Fersina nei pressi di Canezza. Si noti la superficie liscia.

Fig. 5 - Immagine SEM di un granello d'oro proveniente dai sedimenti del fiume Niger a Bamako (Mali). Il granello è molto appiattito, piegato e non evidenzia più la struttura originaria.

Fig. 6 - Immagine SEM di un cubo di pirite idiomorfico non deformato proveniente dai sedimenti del torrente Fersina, con evidenti striature tipiche sulla superficie.

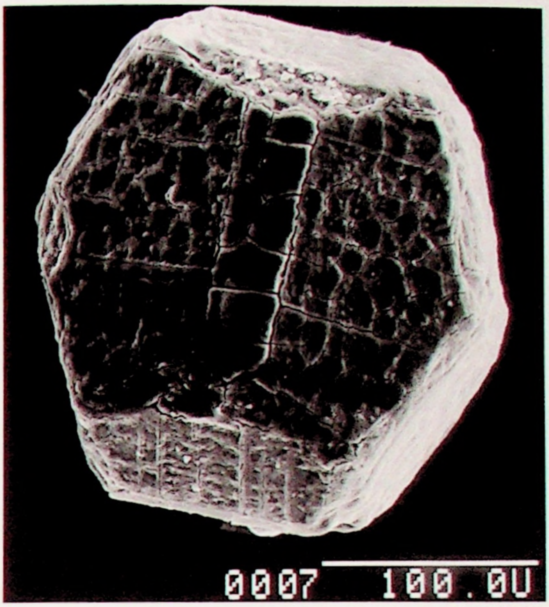
rapid erosion. The erosion products are carried away quickly by the river waters. This is confirmed also by the presence of practically undeformed euhedral and unweathered, or only slightly oxidized pyrite grains in the heavy mineral fraction of all samples. On the crystal faces of the pyrite grain as shown in Fig. 6, the striation typical for pyrite crystals can still be seen. The oxidation is just beginning as indicated by the slight mosaic structure present on the crystal faces.

One of the most oxidized pyrrhotite crystals as found in the river sediments is shown in Fig. 7. In this case the mosaic structure is more developed than in the pyrite crystal shown in Fig. 6. But still in this case the oxidation is at the beginning because the EDX analysis of the crystal faces still reveals the presence of sulphur.

Remarkable is the fact that in one of the heavy mineral concentrates separated from the river Fersina sediments at Canezza a small spherical droplet of mercury could be found (Fig. 8).

From the experience in the gold prospection of the authors e.g. in northeastern Bavaria (Germany) (LEHRBERGER *et al.*, 1988) and in Africa (FUGANTI *et al.*, in prep.) traces of mercury are typically found in the river sediments where upstreams in former times there was either a gold mining with subsequent separation of the gold from the ores by amalgamation or a production of glass mirrors with the connected use of mercury for the silver plating of the glass. The contamination with mercury is very persistent in time and is still found in the river sediments many decades after the closing down of the mercury consuming activities. From the fact that in the Fersina valley no former production of mirrors is known the presence of mercury in the river sediments may suggest that the recovery of gold was tried by amalgamation, at least sporadically, in former times from the primary ores or from the river sediments. Another explanation for the presence of the mercury in the sediments of the Fersina river obviously would be the purely accidental introduction of small quantities of mercury into the river without any relation to the gold recovery.

Attached to the spherical mercury droplet there is a sphere composed of a silicatic iron slag and a crystal which, according to EDX analysis, is composed only of iron. Such small iron slag spheres are, according to the experience of the authors (LEHRBERGER *et al.*, 1988), rather common in stream sediments of northern and central Europe and are introduced into the rivers by the modern iron soldering techniques, e.g. with the electric arc. The spheres show on the surface a typical mosaic structure produced by crystal faces (Fig. 8). The



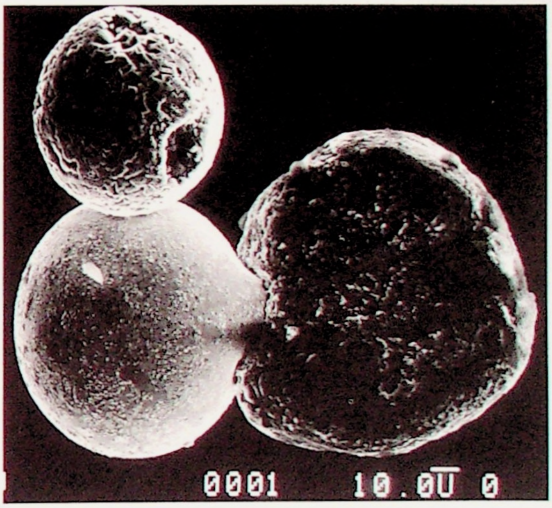


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Fig. 7 - SEM picture of an undeformed pyrrhotite crystal showing a marked polygonal structure on the surface due to an oxidation which is stronger than that shown by the pyrite given in Fig. 6.

Fig. 8 - Small spherical droplet of mercury separated by panning from the sediments of the river Fersina at Canezza. Attached to the mercury droplet is a sphere composed by an anthropogenic iron slag and a crystal probably of hematite.

Fig. 7 - Immagine SEM di un cristallo di pirrotite non deformato con struttura superficiale marcatamente poligonale dovuta ad una ossidazione più marcata di quella subita dalla pirite di Fig. 6.

Fig. 8 - Gocciolina sferica di mercurio separata con la batea dai sedimenti del torrente Fersina a Canezza. Accanto alla goccia di mercurio c'è una sfera composta da una lamella di ferro antropogenico ed un cristallo probabilmente di ematite.

hematite or magnetite crystal, attached to the mercury droplet, originates probably from one of the mineralizations. The form demonstrates that also this crystal, like the gold grains, was transported by the river over a short distance, only.

The rapid sediment transport by the Fersina river which produces immature sediments is also observed by VENZO & PRINCIVALLE (1997).

4. CONCLUSION

From the study results that:

1) the gold contents of the lead-zinc mineralizations of Viarago, Prementil and Palù del Fersina found within the propylitized dacitic to rhyodacitic rocks of the Atesina Volcanic Complex are in most cases rather low but sufficient to produce very low gold contents in the sediments of the Fersina river.

2) Most of the gold grains panned from the sediments of the Fersina river show high silver contents similar to those one can expect in the gold of subvolcanic mineralizations connected with intense propylitization. This demonstrates that no silver was leached during the weathering, erosion and transport of the gold in the river waters.

3) The high silver contents in practically undeformed gold grains and their association with nearly unoxidized euhedral sulphides, like pyrite, pyrrhotite and galena, in the stream sediments indicate that the flanks of the Fersina valley with the mineralizations are subject to a rapid erosion and connected with a quick transport by the rivers.

4) The rapid erosion gives no chance to the formation of consistent gold placers, also if the gold contents in the primary mineralizations are potentially sufficient for such a process.

5) The presence of mercury droplets in the heavy mineral fraction of the river sediments could lead to the supposition that there have been attempts in former times to win the gold by amalgamation.

SUMMARY - The gold contents in the sediments of the Fersina river (Valle dei Mocheni, Trento, Northern Italy) are due to the erosion of the gold-bearing lead-zinc ores found on the flanks of the Fersina valley. The deposits were mined in former times at the mines of Viarago, Prementil and Palù del Fersina. The gold contents in the ores produced by those mines are around 0.25 ppm with sporadic values up to 20 ppm. The first information on the mining of the primary ores for lead and zinc is from 1330, the most intense mining was inbetween 1400 and 1500 and ended around 1940. No information exists about a gold production from the primary ores or from the river sediments, but rare droplets of mercury found in the panning concentrate of the sediments of the Fersina river could suggest an attempt to produce gold from the sediments or the primary ores by amalgamation in former times. The gold grains found in the sediments of the Fersina river have mostly silver contents around 30%.

RIASSUNTO - I minerali di piombo e zinco delle miniere abbandonate di Viarago, Prementil e della zona di Palù in Val Fersina (Valle dei Mocheni, Trento, Italia settentrionale) in generale presentano un contenuto d'oro pari a circa 0,25 ppm, solo sporadicamente si registrano 20 ppm. Il contenuto d'argento varia fra 2 e 57 ppm. Le prime informazioni sull'attività mineraria datano al 1330. La massima attività si ebbe fra il 1400 ed il 1500 e l'ultima miniera fu chiusa nel 1940. Il contenuto d'oro nelle mineralizzazioni primarie comporta la presenza di granellini d'oro nei sedimenti del fiume Fersina. Quale conseguenza della rapida erosione e dell'alta velocità della corrente questi granelli d'oro generalmente non riportano segni di deformazione ed hanno un notevole contenuto d'argento, pari al 30% circa. Solo sporadicamente si trovano granellini deformati che hanno anche basso tenore d'argento. L'alta velocità d'erosione e di trasporto spiega anche come nei sedimenti del Fersina siano presenti sulfuri idiomorfici provenienti dalle mineralizzazioni primarie.

REFERENCES

BARTH S., OBERLI F., MAIER M., BLATTNER P., BARGOSSI G.M. & DI BATTISTINI G., 1993 - The evolution of a calc-alcaline basic to silicic magma system: Geochemical and Rb-Sr, Sm-Nd and $^{18}O/^{16}O$ isotopic evidence from Late Hercynian Atesina-Cima d'Asta volcano-plutonic complex, Northern Italy. *Geochim. Cosmochim. Acta*, 57, pp. 4285-4300.

BURTET FABRIS B., DETOMASO G. & OMENETTO P., 1974 - Sulla mineralizzazione a berthierite ($FeSb_2S_4$) di Prementil presso Viarago (Trentino). *Studi Trent. Sci. Nat.*, 51, 1A, pp. 30-38.

D'AMICO C. & VENTURELLI G., 1968 - Riodaciti e rioliti Atesine in cupole e colate di Pinè (Trento). *Miner. Petrogr. Acta*, 14, pp. 143-170.

DESBOROUGH G.A., 1970 - Silver depletion indicated by microanalysis of gold from placer occurrences, Western United States. *Econ. Geol.*, 65, pp. 304-311.

DESSAU G. & PERNA G., 1966 - Le mineralizzazioni a galena e blenda del Trentino-Alto Adige e loro contenuto in elementi accessori. Atti del Symposium Internazionale sui Giacimenti Minerari delle Alpi, 3, pp. 587-687, Trento.

DI BATTISTINI G., GALLO F., GIAMMETTI F. & VERNIA L., 1989 - Permian andesites fom Val d'Isarco and Val Funes volcanic sequence (Bolzano, North Italy). *Miner. Petrogr. Acta*, 32, pp. 123-137.

FISHER N.H., 1945 - The fineness of gold, with special reference to the Morobe goldfield in New Guinea. *Econ. Geol.*, 49, p. 8.

FUGANTI A., MORTEANI G. & PREINFALK C., (in prep.) - Gold of the Niger, Mali.

HALLBAUER D.K. & UTTER T., 1977 - Geochemical and morphological characteristics of gold particles from recent river deposits and the fossil placers of the Witwatersrand. *Mineral. Deposita*, 112, pp. 293-306.

LEHRBERGER G., PREINFALK C. & MORTEANI G., 1988 - Historischer Goldbergbau im Oberpfälzer Wald im Licht neuer geologisch-mineralogischer Untersuchungen. *Acta Albertina Ratisbonensia*, 45, pp. 95-128.

LEHRBERGER G., 1997 - Methodik der Schwermineraluntersuchung von primären und sekundären Goldvorkommen im nordostbayerischen Grundgebirge. In: Gold in Bayern. Vorkommen am Westrand der Bömischen Masse, *Geol. Bavarica*, 102, pp. 33-43.

MAUCHER A., 1959 - Erzlagerstättenbildung und permischer Vulkanismus im Raume von Trient (Norditalien). *Geol. Rundsch.*, 48, pp. 131-140.

MORTEANI G., 1966 - Die Propylitisierung und die P-, T-Bedingungen der Vererzung der "grünen Porphyrite" der Valle del Fersina (Provinz Trento, Norditalien). Atti del Symposium Internazionale sui Giacimenti Minerari delle Alpi, 2, pp. 495-503, Trento.

MURARA G., 1966 - Le mineralizzazioni a solfuri misti nelle vulcaniti atesine, formazione andesitica, dell'alta Val Fersina (Trentino). Atti del Symposium Internazionale sui Giacimenti Minerari delle Alpi, 2, pp. 471-494, Trento.

OMENETTO P. & DETOMASO G., 1970 - Le mineralizzazioni filoniane a solfuri misti della zona di Pinè (Trento). L'industria Mineraria nel Trentino-Alto Adige, 3, pp. 143-163, Trento.

SCHMID W., 1973 - Über den Goldgehalt der Flüße und Sedimente der miozänen Molasse des NE-Napfgebietes (Kt. Luzern). *Schweiz. Mineral. Petrogr. Mitt.*, 53, pp. 125-156.

SERVIZIO GEOLOGICO D'ITALIA, 1968 - Carta Geologica d'Italia, 1:100 000, Foglio 21, Trento. Roma.

VENZO G.A. & PRINCIVALLE F., 1997 - Le sabbie del torrente Fersina (Trentino, Italia). *Studi Trent. Sci. Nat., Acta Geol.*, 71, pp. 5-19.

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