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MORPHOLOGY AND COMPOSITION OF THE GOLD GRAINS OF THE GALLIKOS–AREA, NORTHERN GREECE AS COMPARED TO SOME RHINE GOLD OF THE RHINE VALLEY, GERMANY

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ABSTRACT

The present study reports results on the morphology and the chemistry of the placer gold in the Gallikos River area, Northern Greece. The content of trace elements in the gold grains of this area is compared with that in gold from the Rhine River. Systematic electron microprobe analyses reveal several differences regarding the Au-, Ag-, Cu- and PGE-group contents. These differences reflect different primary sources of the Gallikos River area and probably still larger contrasts in regard to the source areas of the Rhine River.

ΣΥΝΟΨΗ

Μελετάται η μορφολογία και η χημική σύσταση του προσχωματικού χρυσού στην περιοχή του Γαλλικού ποταμού και γίνεται σύγκριση με αυτόν του ποταμού Ρήνου. Η μικροσκοπική και χημική έρευνα έδειξαν σαφείς διαφορές μεταξύ των δύο περιοχών ιδιαίτερα οτι αφορά τις περιεκτικότητες του χρυσού σε άργυρο, χαλκό και των μετάλλων της ομάδας του λευκοχρύσου. Οι μέσες περιεκτικότητες του χρυσού στο Γαλλικό ποταμό ανερχονται σε 90% χρυσό, 8,7% άργυρο, 0,1% χαλκό, 0,1% λευκόχρυσο, 0,2% όσμιο, 0,1% ιρίδιο. Οι περιεκτικότητες του χρυσού σε σελίνιο, τελούριο, μολυβδαίνιο και αντιμόνιο εύναι σε ορισμένες περιπτώσεις πάνω απο το όριο ανυχνευσιμότητας του μικροαναλυτή. Ο χρυσός του ποταμού Ρήνου αποτελεύται κυρίως απο 92,3% χρυσό, 7,2% άργυρο και 0,2% χαλκό. Διαφορές υπάρχουν επίσης και στη μορφολογία των κόκκων χρυσού. Ο Γαλλικός ποταμός και ο Ρήνος έχουν κυρίως " φυλλώδη χρυσό ", οι αποστάσεις ομως μεταφοράς και απόθεσης του στα υζήματα των περιοχών έρευνας καθώς επίσης οι και οι πηγές προέλευσής του εινaι για τις δύο περιοχές διαφορετικές.

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Μορφολογία και σύσταση του χρυσού στην περιοχή του Γαλλικού ποταμού σε σύγκριση με αυτόν του ποταμού Ρήνου Γερμανίας.

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INTRODUCTION - ΕΙΣΑΓΩΓΗ

Rhine gold was suspected already before the sixteen Century to originate from the north central part of the Swiss Alps. A small share is now assumed to have originated from the Black Forest and the Vosges. Old washes were located all along the younger flood planes of the Rhine valley (Fig. 1). Values of rescered material ranged from 5 mg to 20 mg Au/m³ from individual explorationspits. The gravels in the so-called Low Terraces ("Niederterassenschottern") on the other hand yielded from 2 to 4 mg Au/m³ (KIRCHHEIMER, 1965).

The samples analysed for this study are also from the same gravel pit near Bruchhausen. A first microscopic description was published by RAMDOHR (1965). In this present study an attempt will be made to demonstrate the differences and the similarities between the placer gold of the Gallikos area and the Rhine gold, especially with regard to the composition and the shapes of the grains.

The Gallikos district is situated in Central Macedonia, Northern Greece, 40 km east of Thessaloniki. The occurrence of placer gold in the Gallikos River is known since ancient times. Remnants of antique exploitation can still be found today between the villages of Metaxochorion and Terpillos (LIATSIKAS, 1939). From 1953 to 1960, 1355 kg gold with a fineness of over 900/1000 was mined during this time.

The sampling of placer material was carried out during the summers of 1987 and 1988 by systematic sampling along the Gallikos River and its tributaries.

The Gallikos River, which meanders from the village of Fiska to the Gulf of Thessaloniki covers a distance of more than 60 km. Its tributaries include the Spanos (25 km), the Megalo-Potami (18 km) and the Xiropotamos (15 km) Rivers (Fig.2).

GEOLOGY OF THE GALLIKOS AREA

The Gallikos Riversystem originates from the Kroussia and Vertiskos mountain. These mountains ranges consist of the following rocks: metamorphic rocks of Paleozoic age and older. Paleozoic igneous rocks. Triassic

Fig. 1. The easter part of the upper Rhine valley between Rastatt and Philippsburg. Open circles with numbers designate gold washing gravel pits (after KIRCHHEIMER, 1965).

Σχ. 1. Ανατολικο τμημα του ποταμου Ρηνου με θεσεις εκμεταλλευσης (κυκλοι με αριθμους) κατα KIRCHHEIMER, 1965.

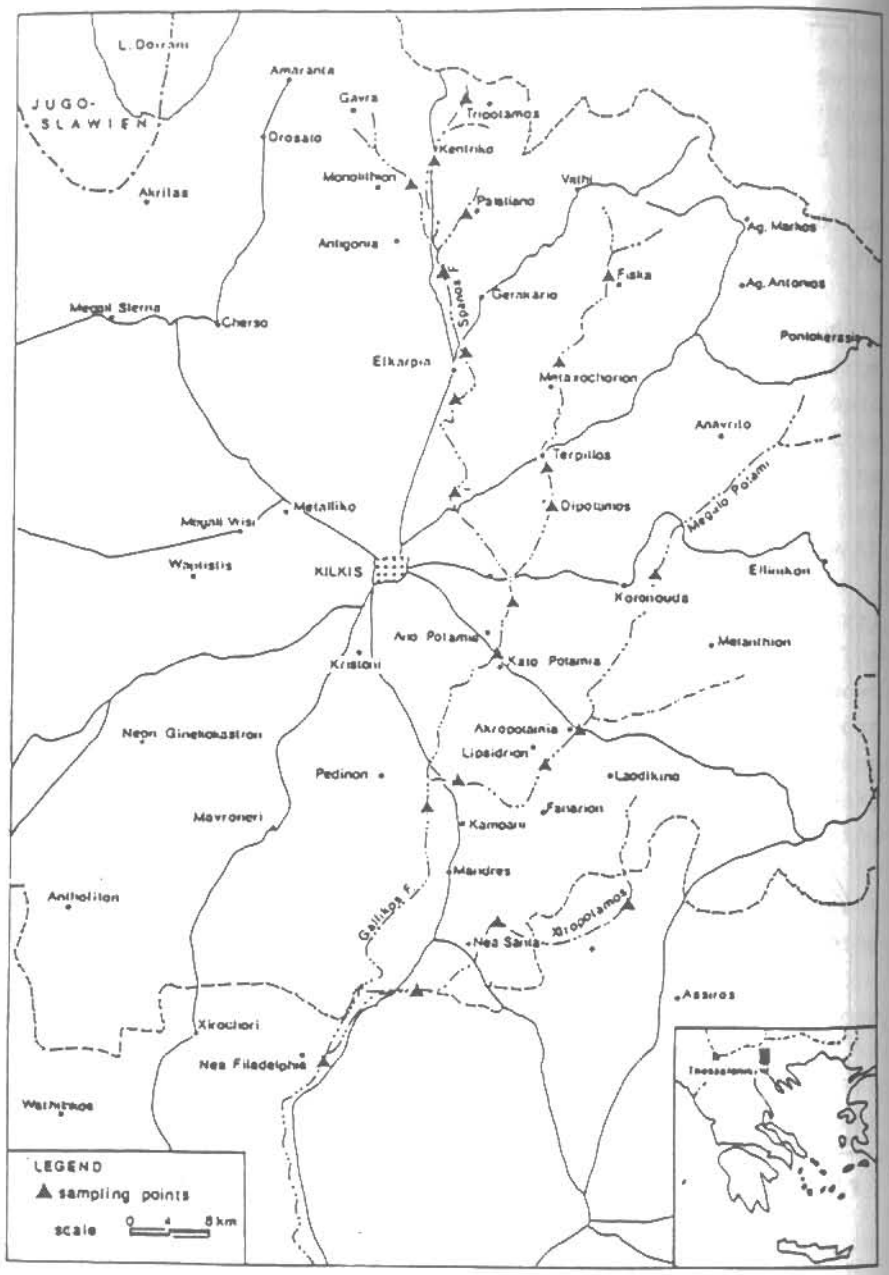


Fig. 2. The placer gold of the Gallikos area- Northern Greece

Σχ. 2 . Εμφανισεις προσχωματικου χρυσου στο Γαλλικο ποταμο.

or Jurassic volcanosedimentary series, volcanic rocks of Eocene age and partly serpentinized ultramafic rocks (KOCKEL et al.,1971): These rocks units are the source areas of the gold which is hosted by Miocene to Pleistocene alluvial sediments and their reworking alluvial. fills.

AURIFEROUS SEDIMENTS - ΧΡΥΣΟΦΟΡΑ ΙΖΗΜΑΤΑ

The auriferous sediments of the Gallikos comprise red clays, marls,sandy marls, sands and gravels. Together, their thickness amounts to 20-25 m, but may exceed 30 m in some places. The main opaque minerals of the heavy fraction of the sediments are magnetite which is partly martitized, ilmenite, intergrowths of ilmenite and hematite, limonite, chrome spinels in different stages of alteration, sulfides and in the most recent deposits remains of slags. Almandin garnet, the green silicate amphiboles, pyroxenes and epidote are the main transparent minerals of the heavy fraction (PE et al., 1978; MICHAILIDIS et al., 1985; KOUGOULIS et al., 1987).

The placer minerals in the Rhine gold concentrate are composed of quartz, garnet, magnetite, martite, ilmenite, hematite, zircone, rutile, monazite, xenotime, cassiterite, kyanite, spinel, staurolite, corundum, anatase, chromite, platinum, cinnabar, columbite-tantalite, galena and tapiolite; framboidal pyrite and artifacts including smeeter iron spheres and alloys of Pb including shot from fire arms are also reported (RAMDOHR, 1965).

MORPHOLOGY OF THE GOLD GRAINS - ΜΟΡΦΟΛΟΓΙΑ ΚΟΚΚΩΝ ΧΡΥΣΟΥ

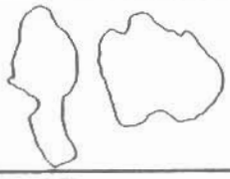
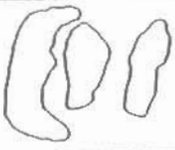
The investigated gold grains show characteristic changes in their morphology due to their mode of transport (Fig.3.4). Important points are given below of the present investigation.

In the concentrate of the Rhine gold the following gold group were observed:

a) lamellar pitted grains, subrounded with yellow cores and dark yellow rims displaying scratches;

Fig. 3. Morphological features of the investigated gold grains.

Σχ. 3. Μορφολογια κοκκων χρυσου στις περιοχες ερευνας.

Locality	Grain form and grain size	Colour and silver-content	Intergrouths
Xiropotamos	 transport: 15 km; the gold grains are rounded or elongated and have a smooth surface; ø 0.3 mm	yellow to dark yellow 5.6 wt.% Ag	quartz, galena limonite
Megalo-Potami	 transport: 18 km; the gold grains are botryoidal to reniform or angular and have a smooth surface; ø 0.6 mm	light-yellow to yellow 12.7 wt.% Ag	chalcopyrite pyrite, quartz limonite
Spanos	 transport: 25 km; the gold grains are elongate or rounded; ø 0.5 mm	whitish-yellow to yellow and dark yellow 14.1 wt.% Ag	quartz, galena limonite
Gallikos	 transport: 45 km; the gold grains occur as flakes, may be rounded, folded, crescent or in bent shapes and have a spongy surface; ø 0.3 mm	yellow to dark yellow 8.7 wt.% Ag	quartz, limonite pyroxene, feldspar
Rhine gold	 transport: 70 km; the gold grains occur as flakes have a sandwich form or folded appearance; ø 0.2 mm	yellow to dark yellow 7.2 wt.% Ag	pyrite, galena quartz, carbonate

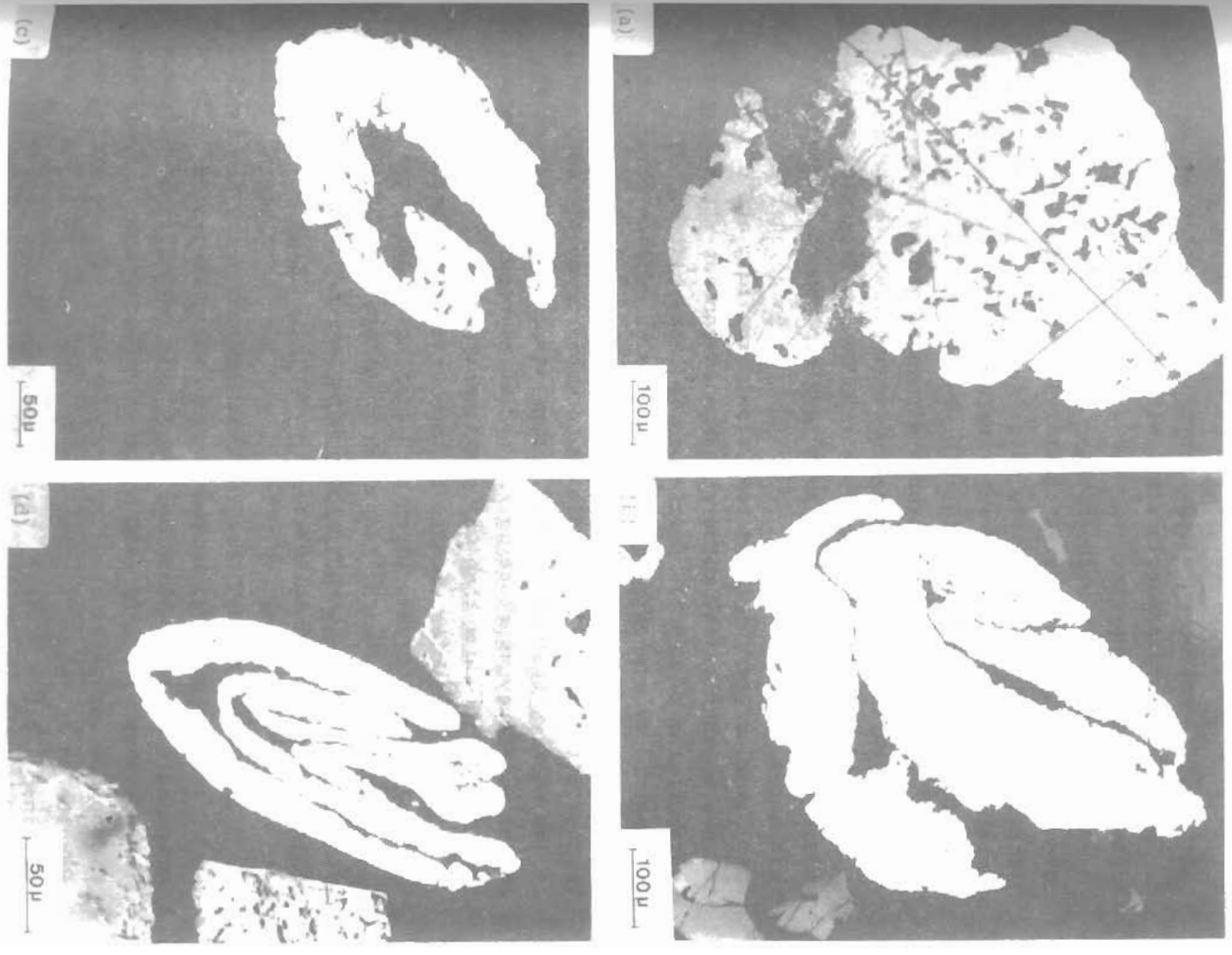


Fig. 4. Typical gold grains from Megalo-Potami(a), Spanos (b), Gallikos (c), Rhine (d).

Τυπικοί κόκκοι χρυσού από Μεγάλο Ποτάμι (a), Σπανός (b), Γαλλικός (c), Ρήνος (d).

b) elongated, folded or bent grains occuring as flakes, with a white-yellow core and high silver content;

c) angular or hooked grains with smooth surfaces and intergrowths with pyrite;

d) "shotty gold" with spongy surfaces, and/or intergrowths with limonite; im part with sandwich structure (Fig. 4d);

e) particles made up of two or more interconnected individual gold flakes;

The following types of gold grains have been observed in the Gallikos area:

a) whitish-yellow grains with 30-40 wt.% Ag (electrum) displaying smooth surfaces as a result of shorter transport distances;

b) angular as well as botryoidal, reniform gold grains with a whitish yellow colour, high Ag-content (20-25) and intergrowths of quartz, pyrite, and galena;

c) round or elongated gold flakes with yellow cores and dark yellow rims;

d) flattened, folded, flexed or bent gold grains, occasionally crescent shaped, consists of pure gold often with a spongy surface scratches as a result of longer transport distances than the previous types;

e) gold particles made up of two or more interconnected individual gold flakes often of differing composition;

f) gold grains with "sandwich structure", only observed in about 7% of the Gallikos grains im contrast to the Rhine gold with 30 to 40%.

CHEMICAL COMPOSITION - ΧΗΜΙΚΗ ΣΥΣΤΑΣΗ

The chemical composition of the gold grains is based on measurements of about 357 individual gold grains (257 from the Gallikos area and 100 from the Rhine) on an ARL-SEMQ microprobe operated at 27 kv accelerating voltage and 30 nA. Results on Au, Ag, Cu, Pt, Os,Ir, Hg, Se, Te And Mo were obtained. Table 1 lists these analyses which represent the mean composition of these grains.

In the Rhine gold 8 of the 100 investigated grains showed Te above the detection limit for Te. 5 of the 100 grains measured contain Hg above the detection limit for Hg. As described by RAMDOHR (1965) Pt is only contained as independed grains in the heavy mineral concentrate from the Rhine River.

The reddish gold in the same material consists of rounded monocrystalline reddish to pink grains, sometimes idiomorphic in contrast to "normal gold". As explained below, reddish gold is auricupride and shows distinctly lower reflectance than normal gold and in oil has a clear lilac tint (RAMDOHR, 1969). According to the microprobe analyses reddish gold contains about 50 wt.% Au, and most of the other 50% consist of Cu.

In the Gallikos River area the following details are worth mentioning

In the concentrate of Megalo-Potami 7 of the investigated gold grains contains Se,Te and Mo above the detection limit for Se, Te, and Mo.

In the concentrate of Spanos sand 30 of the 75 gold grains measured show a different colouring from the interiors to the rims due to the different chemical composition, in contrast to the Xiropotamos (4 of the 40 grains), in contrast to the Megalo-Potami (11 of the 54 grains), and in contrast to the Gallikos (45 of the 93 grains)(BOBOTI-TSITLAKIDOU et al., 1989).

DISCUSSION - ΣΥΖΗΤΗΣΗ

The investigated gold grains of the Gallikos area and of the Rhine River show a very different shape. The chemical composition differs markelly im regard to the silver, copper and PGE contents (Tab. 1, Fig. 5,6).

Several possible sources of the studied placers can be assumed The Gallikos River and its tributaries originate in the following source areas and possible source rocks:

The metamorphic rocks of the Vertiskos-Series;
Hydrothermal quartz veins crosscutting the above rocks;
Polymetallic-sulfide or and iron-manganese deposits;
Porphyry-copper deposits;
Ultrabasic rocks or their chromite-magnetite or sulfide

Table 1. representative microprobe analysis of the investigated gold grains (with averages and ranges over all measurements).

Πιν. 1. Αντιπροσωπευτικες αναλυσεις κοκκων χρυσου απο τις περιοχες ερευνας (με ανωτερες, κατωτερες και μεσες τιμες).

Locality	Au	Ag+	Cu++	Pt	Os	Ir	Hg	Sb	Te	Mn	Total
Xiropotamos	94.1 (88.4-99.6)	5.6 (0.4-11.3)	b.d. (b.d.-0.2)	0.2 (b.d.-0.3)	b.d. -	b.d. -	b.d. -	b.d. -	b.d. -	b.d. -	99.9
Megalo Potami	86.1 (68.6-96.0)	12.7 (3.7-29.0)	0.4 (b.d.-3.0)	0.2 (b.d.-0.3)	0.2 (b.d.-0.3)	0.1 (b.d.-0.2)	b.d. (b.d.-0.1)	0.1 (b.d.-0.3)	0.1 (b.d.-0.2)	0.1 (b.d.-0.3)	100.1
Spanos	85.3 (60.0-99.4)	14.1 (0.3-40.0)	0.3 (b.d.-4.8)	0.1 (b.d.-0.8)	b.d. (b.d.-0.6)	0.3 (0.2-0.9)	b.d. -	b.d. -	b.d. -	b.d. -	100.1
Gallikos	90.8 (70.9-99.6)	8.7 (0.3-28.2)	0.2 (b.d.-0.4)	0.1 (b.d.-0.3)	0.2 (b.d.-0.8)	0.1 (b.d.-0.9)	b.d. -	b.d. -	b.d. -	b.d. -	99.9
Rhine	92.3 (69.8-99.2)	7.2 (0.7-30.0)	0.2 (b.d.-3.2)	b.d. -	b.d. -	b.d. -	b.d. (b.d..0.1)	b.d. -	b.d. (b.d.-0.2)	b.d. -	99.7

b.d. below the detection limit

+ compare fig.5, ++ compare fig. 6

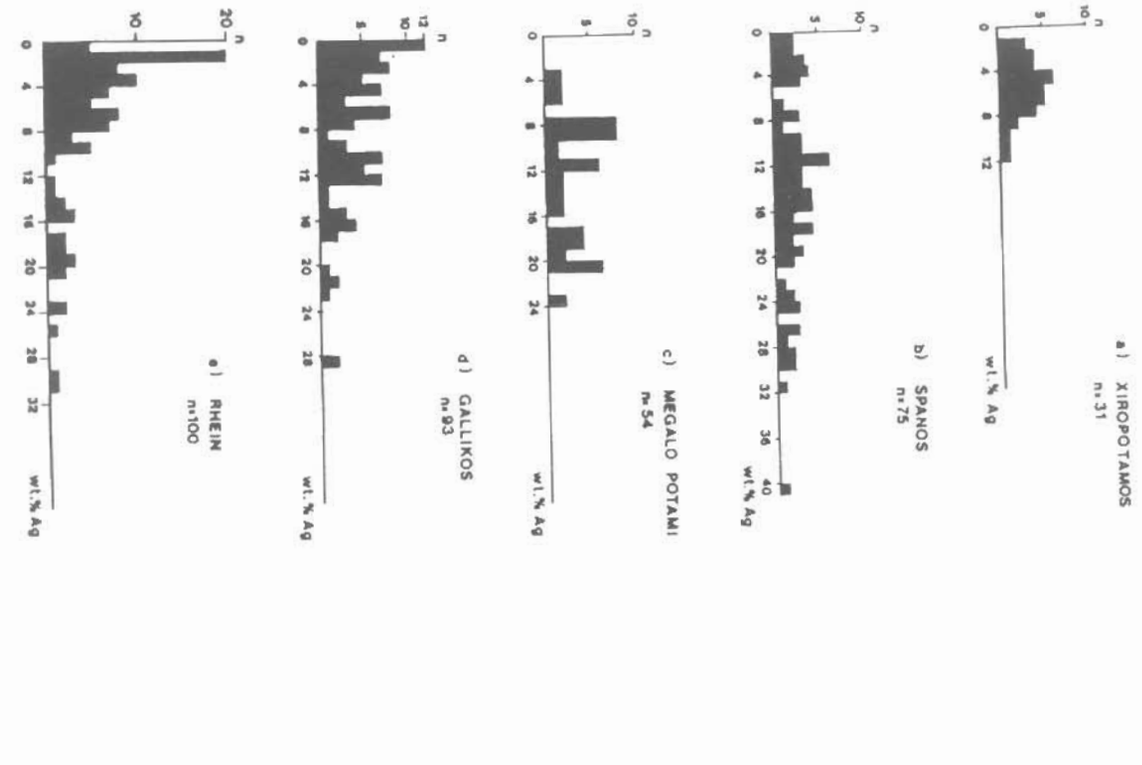


Fig. 5. Histograms of Ag in the placer gold of the investigated areas.

Σχ. 5. Ιστογραμματα αργυρου στις περιοχες ερευνας

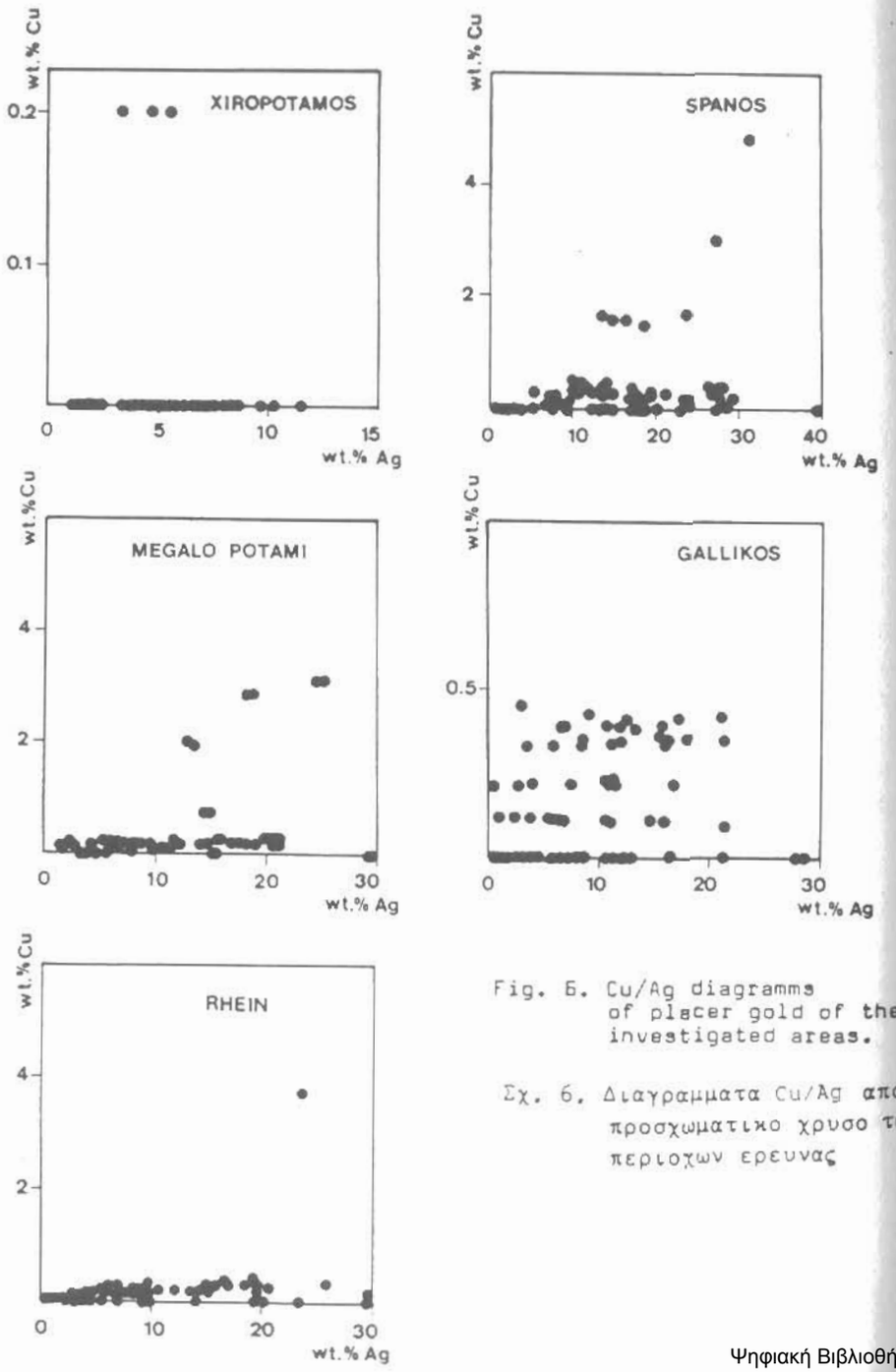


Fig. 6. Cu/Ag diagramms of placer gold of the investigated areas.

Σχ. 6. Διαγραμματα Cu/Ag απο τον προσχωματικο χρυσο των περιοχων ερευνας

ores.

Gold grains with a silver content of 25 wt.% Ag originate probably from the polymetallic sulfide ores, and gold grains with 4 wt.% Cu can stem from the porphyry copper deposits (VAVELIDIS, 1989). The platinum content in the gold grains would normally indicate an origin from an ophiolitic area.

Gold contents of a few g/t (MACK, 1964), and 20 g/t (MPOSKOS, 1986) were proved in quartz veins.

In the gold grains of the polymetallic sulfide ores of Laodikino were detected 0.6 wt.% Cu, 96 wt.% Au and 3.2 wt.% Ag (THIMIATIS, pers. comm.).

According to RAMDOHR (1965) the Rhine gold can stem from many primary sources but most of it had its source probably from hydrothermal quartz veins and gossans.

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