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# CHANGES OF THE GOLD GRAINS MORPHOLOGY DURING THEIR DOWNSTREAM TRANSPORT: THE GALLIKOS PLACER EXAMPLE (NORTHERN GREECE)

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## Abstract

This study of gold grains sampled in the Gallikos area shows how gold grains evolved in a fluvial placer. The morphology of the grains changes progressively during their downstream transport and is influenced by various factors including character of the original lode grains, distance of transport, chemistry of water, streams energetics and time spent in the stream. In the present work 355 gold particles (26% gold grains and 74% gold flakes) from the Gallikos area have been investigated to identify the morphological features of the gold grains and the relationships between grain morphologies and surface textures.

## Introduction

The Gallikos district is situated in Central Macedonia, Northern Greece, 40 km east of Thessaloniki. The occurrence of placer gold in this area is known since ancient times. From 1953 to 1960 1355 kg gold with a fineness of over 900/1000 was mined during this time (MACK, 1964).

The Gallikos river, which meanders from the village of Fiska to the Golf 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).

The Gallikos river system originates from the Kroussia and Vertiskos mountain. Geotectonically it belongs to the Serbomacedonian Massif (Vertiskos-Series) and consists of the following rocks: metamorphic rocks of Paleozoic age or older, Paleozoic igneous rocks, Triassic or Jurassic volcanosedimentary series, volcanic rocks of Eocene age and partly serpentinized ultramafic rocks (KOCKEL et al., 1971). These rocks units and their ore deposits are the source areas of the gold which is hosted by Miocene to Pleistocene alluvial sediments and their reworking alluvial fills (BOBOTI et al. 1990, VAVELIDIS & BOBOTI, 1989).

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The placer gold material (62 samples, 355 gold particles) have been collected along to the Gallikos river and its tributaries (23 localities) (Fig. 1). The chemical composition of the gold particles in the Gallikos area has been also investigated by BOBOTI et al. (1990). The average content of silver in the individual areas amounts: Gallikos (8.7 wt.%), Spanos (14.1 wt.%), Megalo-Potami (12.7 wt.%) and Xiropotamos (5.6 wt.%).

## Analytical methods

The grains were measured, weighted and their morphology was observed under reflected light and by scanning electron microscopy. The general morphological evolution of the grains goes along with an increase in the flatness, that can be quantified by using one of the different indices calculated to describe the detrital grains. In the present study the Cailleux flatness index (F.I.) has been used. It is defined by the relation (L+b)/(2t), where L is the length, b the breadth and t the thickness. (CALLUEX & TRICART, 1959).

## Results

The results of the investigations represent a wide spectrum and have been classified into the 13 morphological types (Fig. 2-6). Most of the respective surface textures have been also classified neither as smooth-unpitted surface or as spongy surface sometimes with scrathers or rills. Important correlations exist between irregural shaped grain and smooth unpitted surface or between folded grain and spongy surface. Corroded shapes are usually common whereas recrystallization features are rearly distinct. Gold liberated by erosion of the lodes is constituted by xenomorphous grains of highly variable size. Within 12 km of the source, the original crystalline outlines have disappeared. The evolution is then marked by a blunting of the grains and the acquisition of a subrounded or oval bladed morphology. After transport over a distance of about 35km the grains have been flattened so much by hammering that they are easily folded upon themselves (sandwiched grains) or they exist as interconnected individual gold flakes. The mean flatness index of the population of gold grains of primary gold lodes has average value of F.I. between 2 and 3; it reaches 7 after a trasport of about 25 km, 12 after 40 km and 15 after 60 km. The increase in the flatness index with the distance of transportation is a general feature which varies with the size of the grains involved. In the Gallikos river, the increase in flatness is very low in grains with a length less than 0.3 mm but is pronounced in grains with a length over than 0.8 mm (Fig. 7).

## Discussion

The morphology of the gold particles depends on the distance and mode of transport (RAMDOHR, 1965; YEEND, 1975; HERAIL 1984, 1988). The study of the morphology of the gold particles makes it possible to separate, in placers, detrital particles from those that could have been neo-formed (SAAGER, 1969; HALLBAUER & UTTER, 1977; UTTER 1979, HALLBAUER, 1981) or to recognize the sources that provide the detrital gold (HALLBASUER & UTTER 1977).

A detailed examination of the particles collected along the Gallikos river and its tributaries shows chartacteristic changes

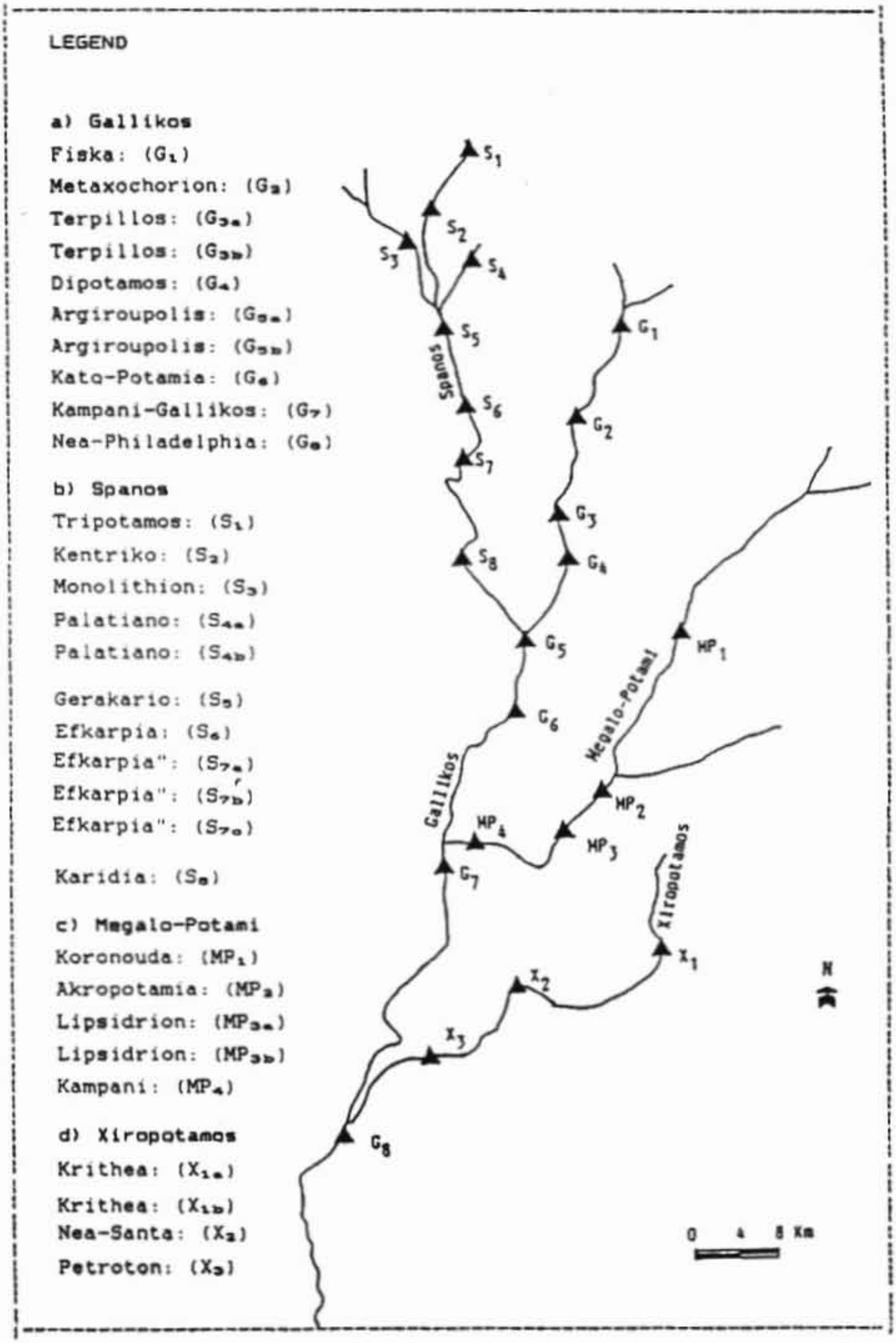


**Fig. 1.** Sample localities of the gold for the present investigation along the Gallikos, the Spanos, the Megalo-Potami and the Xiropotamos.

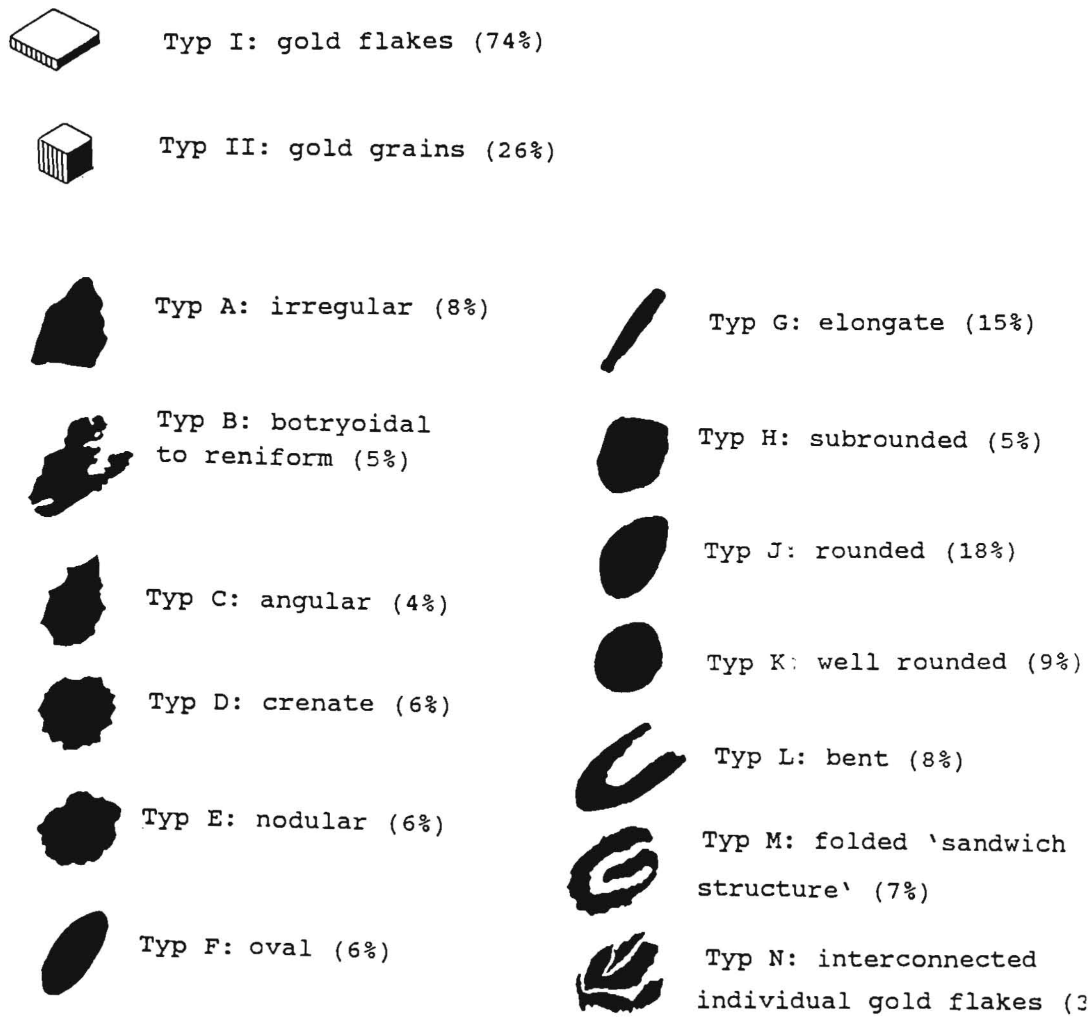


Fig. 2. Classification of the morphological types.

| Locality | Goldtype |
|---|---|
| Fiska ($G_1$) | 1) II,A,C<br>2) I,F,G |
| Metaxochorion ($G_2$) | 1) II,A,E<br>2) I,F,G,H |
| Terpillos ($G_{3a}$) | 1) II,D,E<br>2) I,F,J |
| Terpillos ($G_{3b}$) | 1) II,A,C,D<br>2) I,F,J,M |
| Dipotamos ($G_4$) | 1) II,A,D,H<br>2) I,D,F,G,J |
| Argiroupolis ($G_{5a}$) | 1) II,E,J<br>2) I,F,J,L,M |
| Argiroupolis ($G_{5b}$) | 1) II,G,H,N<br>2) I,L,M |
| Kato-Potamia ($G_6$) | 1) II,K<br>2) I,J,K,L,M |
| Kampani-Gallikos ($G_7$) | 1) II,K<br>2) I,J,K,L |
| Nea-Philadelphia ($G_8$) | 2) I,L,M |

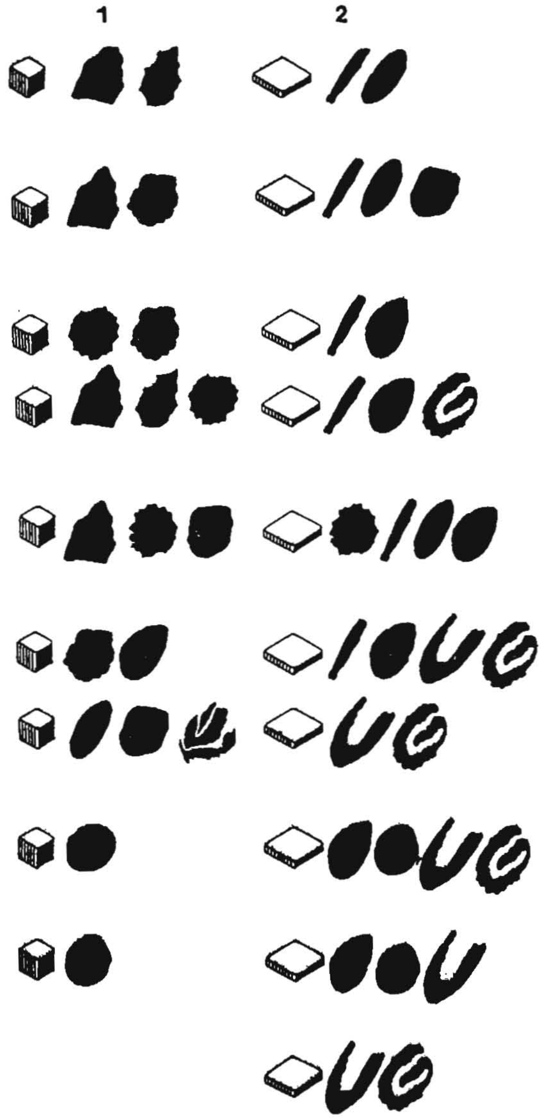


Fig. 3. Morphological types of Gallikos.

| Locality | Goldtype |
|---|---|
| Tripotamos ($S_1$) | 1) II,C<br>2) I,A,F |
| Kentriko ($S_2$) | 1) II,B,E<br>2) I,F,G,H |
| Monolithion ($S_3$) | 1) II,E<br>2) I,F,H |
| Palatiano ($S_{4a}$) | 2) I,F,J |
| Palatiano ($S_{4b}$) | 1) II,A,F<br>2) I,F,J |
| Gerakario ($S_5$) | 1) II,E<br>2) I,F,J,K |
| Efkarpia ($S_6$) | 1) II,J<br>2) I,L |
| Efkarpia ($S_{7a}$) | 1) II,K<br>2) I,M |
| ($S_{7b}$) | 1) II,H,J<br>2) I,H,J,K |
| ($S_{7c}$) | 1) II,A,B,<br>C,D |
| Karidia ($S_8$) | 2) I,J,K |

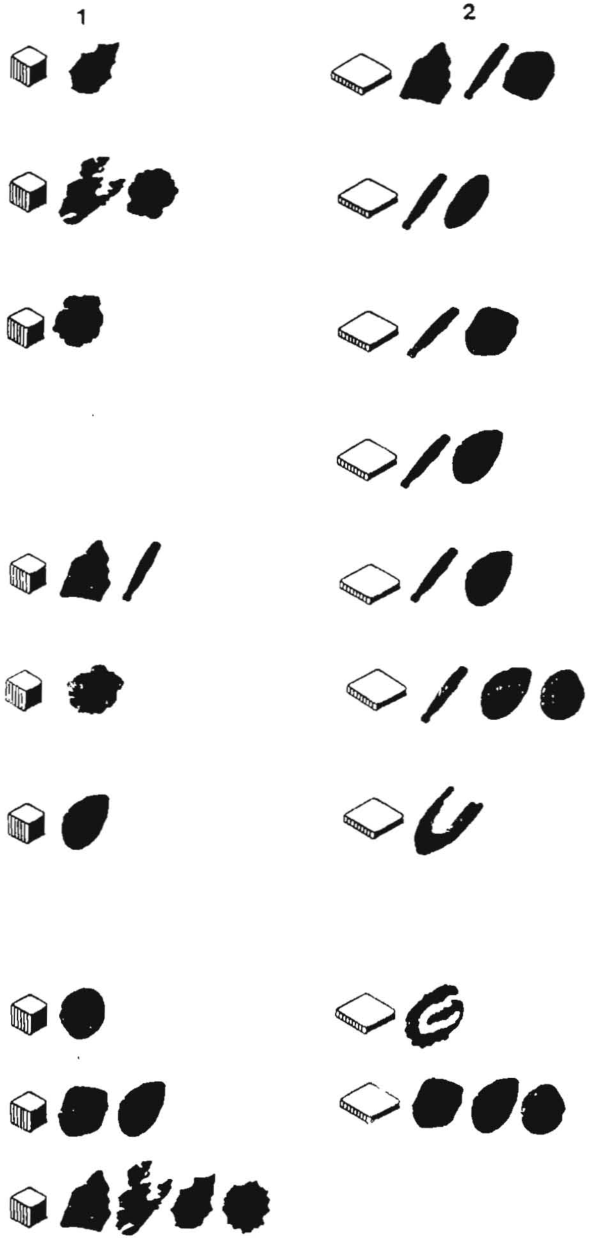


Fig. 4. Morphological types of Spanos

| Locality | Goldtype |
|---|---|
| Koronouda ($MP_1$) | 1) II,E,A,J,G<br>2) I,F,J,D |
| Akropotamia ($MP_2$) | 1) II,A,B,C<br>2) I,H,L |
| Lipsidrion ($MP_{3a}$) | 1) II,A,C,J<br>2) I,D,F,J,K,N |
| Lipsidrion ($MP_{3b}$) | 1) II,F<br>2) I,F,G,J,L,M |
| Kampani ($MP_4$) | 1) II,K<br>2) I,L,M,N |

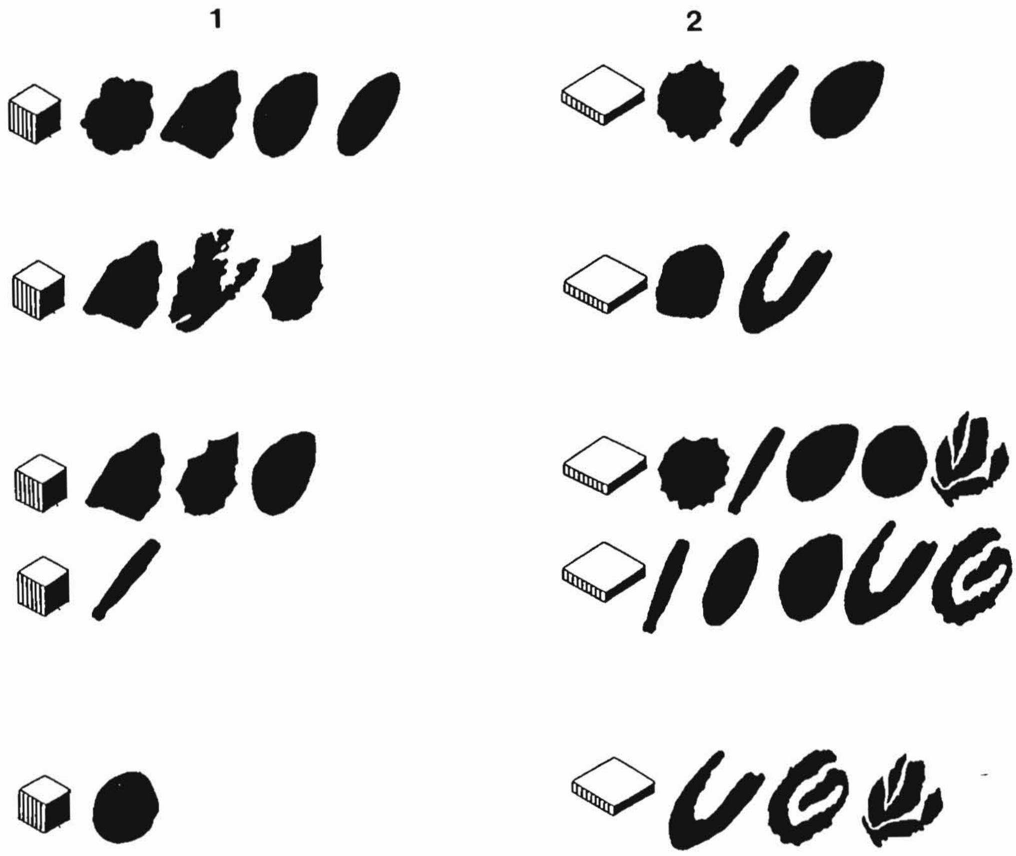


Fig. 5. Morphological types of Megalo-Potami.

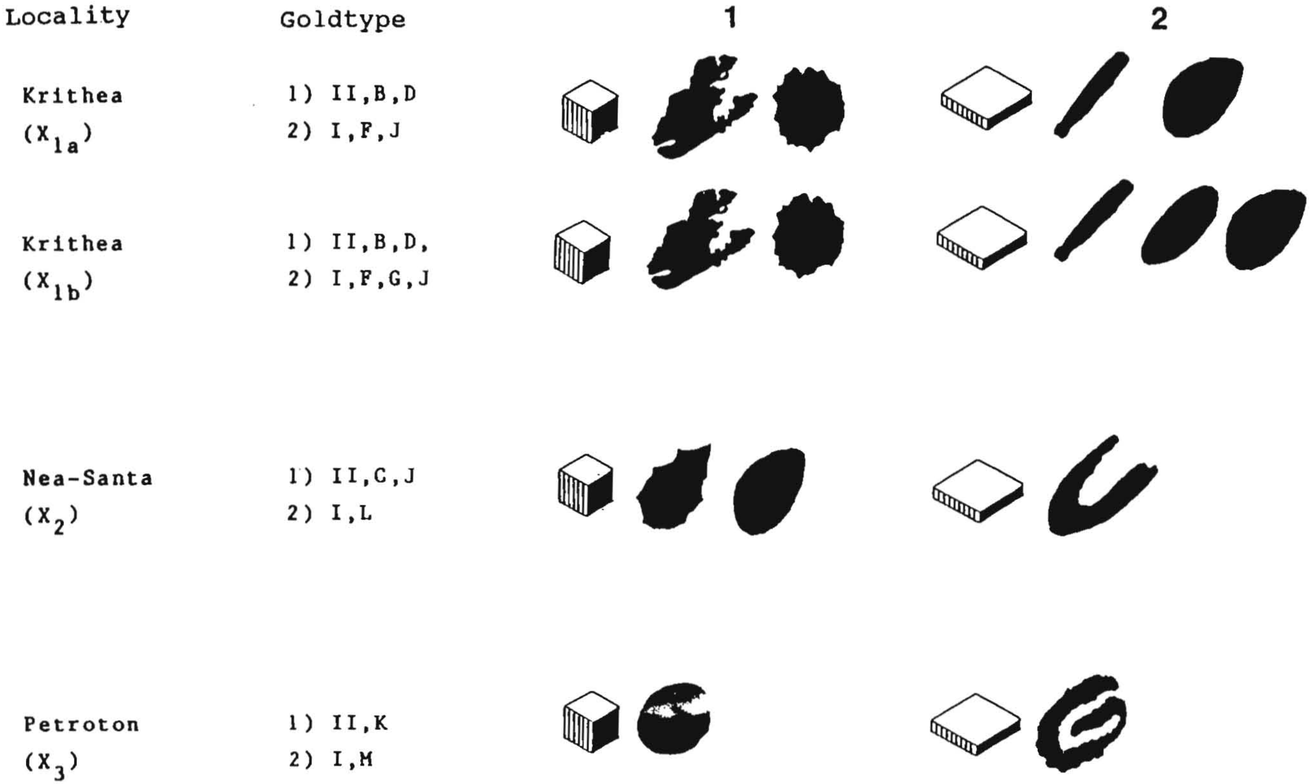


Fig. 6. Morphological types of Xiropotamos.

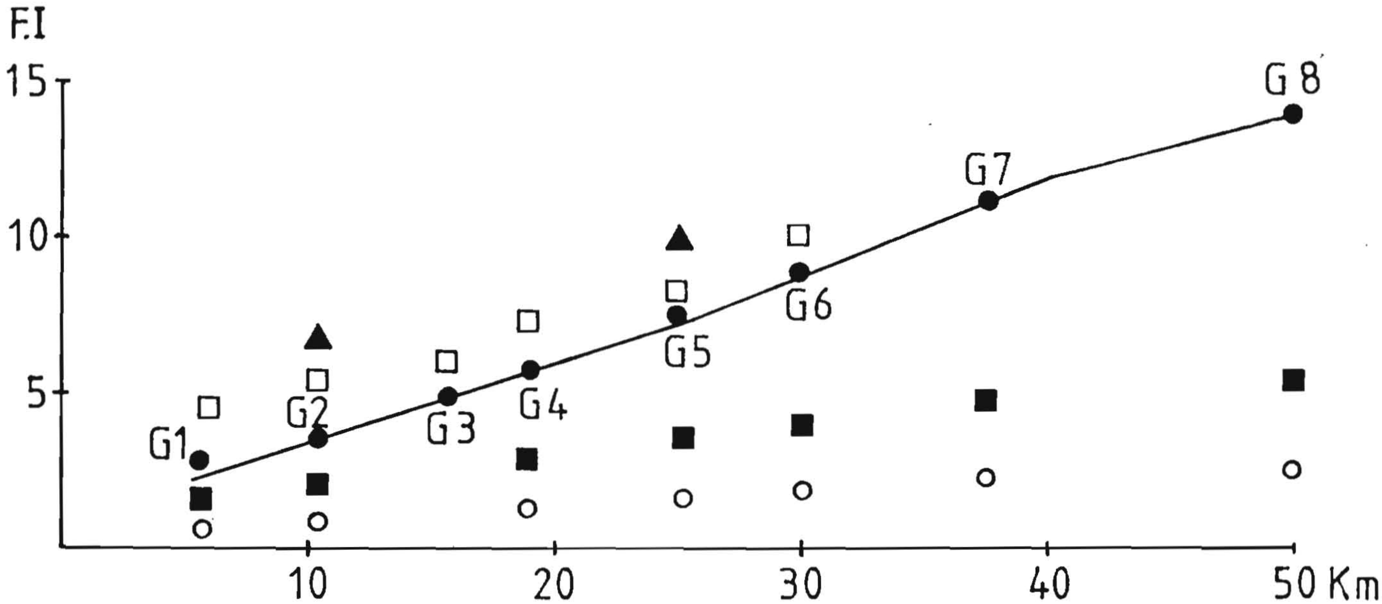


Fig. 7. Variation of the flatness index (F.I.) with the down river transport distance along the Gallikos.

● mean values

○ F.I. value for gold <0.20 mm length

■ F.I. value for gold with a length between 0.20 and 0.40 mm

□ F.I. value for gold with a length between 0.40 and 0.80 mm

▲ F.I. value for gold with a length between 0.80 and 1.2 mm in their morphology and mode of transport. The gold particles are usually irregularly shaped or elongated. As a result of progressive stream transport they become rounded, bent or folded. Their surface texture varies from smooth and clean to pitted hackly and spongy, although variations in the stream's composition, energy and sediment type somewhat modify this general trend. Although the value of the F.I. for particles less than 0.3 mm does not change significantly with transport, the form of these particles is the result of folding.

The same change of morphology and the same variation of the flatness index were also observed by gold particles which come from the tributaries Spanos, Megalo-Potami and Xiropotamos.

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