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GEOLOGICAL SETTING OF THE PLEISTOCENE PLACERS AND ROMAN GOLD MINES OF THE IVREA MORAINIC AMPHITHEATRE (PIEDMONT, NW ITALY).

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ABSTRACT: Gianotti F., *Geological setting of the Pleistocene placers and roman gold mines of the Ivrea Morainic Amphitheatre (Piedmont, NW Italy)*. (IT ISSN, 039-3356, 2011).
Various alluvial gold placers are distributed along the outer edge of the Ivrea Morainic Amphitheatre (AMI). They were exploited in pre-roman epoch and mainly under the Roman Republic rule, as Strabo and Pliny the Elder reported. The Bessa "*aurifodinae*", dated to II-I century B.C., are the widest mine dumps (10 km^2) constituted of rounded cobbles and boulders accumulations and anthropic stratified sandy-gravel fans. All the AMI placers are proglacials, but they differ in stratigraphic unit, geomorphologic setting, age and genetic evolution. The mines are differentiable into exploitations with or without water channels, depending on water disponibility and placer wealth.

RIASSUNTO: Gianotti F., Contesto geologico dei *placer* pleistocenici e delle miniere d'oro romane dell'Anfiteatro Morenico d'Ivrea (Piemonte, Italia NW). (IT ISSN, 039-3356, 2011).
Sul margine esterno dell'Anfiteatro Morenico d'Ivrea si distribuiscono numerosi giacimenti alluvionali auriferi (placer) sfruttati in epoca pre-romana e romana repubblicana, attività citata da Plinio il Vecchio e da Strabone. Le "aurifodine" della Bessa sono la miniera principale, unica ad essere datata (fase principale II-I sec. a.C.), con discariche di miniera di estensione plurichilometrica (10 km^2) a cumuli di ciottoli e conoidi antropici di ghiaie sabbiose stratificate. I vari placers sono suddivisibili per unità stratigrafica di provenienza (alloformazioni dell'anfiteatro di età medio-pleistocenica), per contesto geomorfologico (legati a scaricatore, come la Bessa, oppure a sfioratore fluvioglaciale) e per età ed evoluzione genetica (placers monofasici e polifasici, in relazione al numero di cicli di risedimentazione a cui sono stati soggetti). Come miniere si differenziano in sfruttamenti tramite canali d'acqua corrente, ulteriormente distinte in aurifodine a cantieri separati (Bessa, Mazzè) o aurifodine a cantiere unico ed omogeneo con canali paralleli e ravvicinati (Baraccone di Villareggia), e quelle coltivate con semplici scavi, senza utilizzo di canalizzazioni evidenti (Villareggia, Areglio, Ronchi presso Torre Canavese ed altre minori), in dipendenza della disponibilità di acqua e del tenore in oro del singolo placer.

Key words: Ivrea Morainic Amphitheatre, gold placer, Pleistocene, Roman mines, Piedmont.

Parole chiave: Anfiteatro Morenico d'Ivrea, placer aurifero, Pleistocene, miniere romane, Piemonte.

Excavation evidences and mine dumps are quite regularly distribuited over the outer (distal) margin of the Ivrea Morainic Amphitheatre (AMI), between the external moraines and the proglacial sandur (Fig. 1). They are the result of *proto*-historical and historical exploitation of gold fluvioglacial placers, ranging from traces of decametric extension to the 10 km^2 wide Roman "Bessa *aurifodinae*". These activities were first cited by some classic authors such as the greek historian Strabo, who named the Dora Baltea River used by the *Salassi* people to gold washing (*Geografia*, IV, 6.7). They were later recognized in modern age (DURANDI, 1767; DE ROBILANT, 1784) and described by a lot of historians, archaeologists and geologists (among these SACCO, 1888; MARCO, 1932; CARRARO in BORTOLAMI *et al*, 1967; GIANOTTI, 1992, 1996; BAIO & GIANOTTI, 1996, PIPINO, 1998). Since 1985 a regional park protects the Bessa *aurifodinae*.
Only the Bessa mine was dated on archeological basis. Previous exploitations kept by the local Ligurian-Celtic populations (*Salassi* and the mysterious *Ictimuli*) are suggested by the pottery stratigraphy (GAMBARI, 1999). After the Roman occupation of the territory (140 B.C.) a intensive phase of exploitation lasted less than 100 years between the second and the first century B.C., according to the roman coins found into the cobble dumps (CALLERI, 1995). Pliny the Elder informs that the roman managers "publicans" were interdicted by law (nearly 70 B.C.; DOMERGUE, 1998) to employ more than 5.000 workman in *Ictumulorum aurifodinae* (*N.H.*, XXXIII, 4). The exhausted mine probably was already abandoned at the beginning of the first century A.D., when more remunerative iberian placers were being exploited (Strabo, *Geogr*. V, 1.12).
The mine dumps take up the place of former alluvial gold placers strictly connected to the Pleistocene glacialism of the Dora Baltea basin. Indeed the petrographic composition of the dump cobbles indicates the auriferous deposits supply from the Aosta Valley. In this mountain catchment some primary ores outcrop, consisting mainly of Tertiary hydrotermal quartz veins, as near Brusson in the Monte Rosa gold district. Most of the primary gold forms microscopic particles into the quartz and pyrite, but pedogenetic alterationof gold-bearing rocks and their derived colluvial deposits aggregates gold invisible micrograins to form macro-agglomerates ("nuggets"). The reject deposits features (particularly the roundness of clasts and the sandy matrix good selection) suggests a fluvial origin of the former placer deposits. But the coarse granulometry of gold (mm) into placer deposits, located several tens of

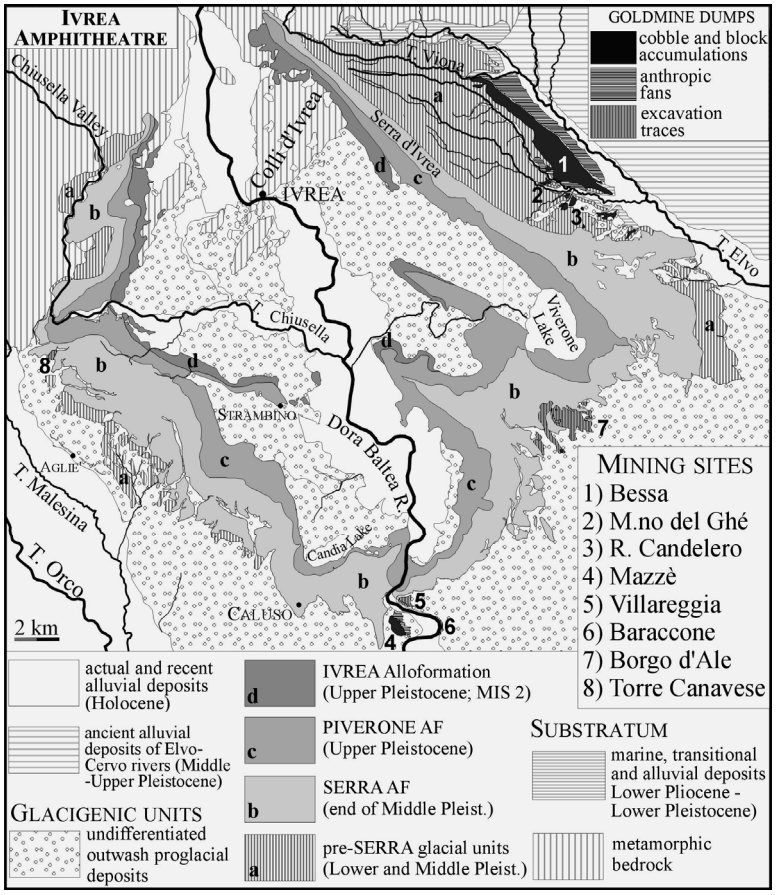

Fig 1. Geologic sketch map of Ivrea Amphitheatre with main gold mines position.
Mappa geologica schematica dell'Anfiteatro di Ivrea con l'ubicazione delle principali miniere d'oro.

km downstream the primary ores, indicates glacial (not fluvial) transport from the mountain catchment to the AMI. Here fluvioglacial deposits locally sedimented in proglacial fans to constitute monophasic placers (Middle Pleistocene). Glacigenic deposits were subsequently reworked by glacial melting watercourses and by streams connected to the local drainage. The resedimentation of glacigenic deposits into stream channels produced further heavy minerals concentration with formation of richer polyphasic placers (Middle and Upper Pleistocene). This process is part of the general razing of the amphitheatre and continues until at the present time.

Placer genesis was constrained and favoured by morainic morphology. Two placer positions are identifiable according to the morainic relief.

Bessa placer (and its neighbouring Mulino del Ghé placer) is located in the left lateral sector of the amphitheatre and was genetically connected to outwash channels along morainic valley parallel to the morainic ridges ("*scaricatori*"). Placers like this were at the beginning enclosed by the lateral moraines that supplied them in sediments. They correspond now to the top of flat high terraces, taking up areas formerly covered by glacigenic deposits that were later more or less completely reworked by fluvioglacial and fluvial erosion.

The other placers are mostly distribuited in the frontal sector of the amphitheatre (Mazzè, Villareggia, Baraccone, Torre Canavese, Borgo d'Ale) and correspond to the apical sector of proglacial fans that lie downstream to fluvioglacial cuts transversal to a morainic ridge ("*sfioratori*").

As regard to the placers stratigraphic setting, Bessa placer has the oldest age and the longest evolution. It is located in an area formerly covered by tills, fluvioglacial and glaciolacustrine deposits related to the first three glaciations known in the AMI dated from the end of the Early Pleistocene and the early Middle Pleistocene. This wide placer (5 km^2) experimented more reworking cycles by glacial streams during some of the Middle Pleistocene glaciations. The main and last of them were linked to a meltwater stream of the Dora Baltea and Viona glaciers during the Magnano and Serra Glaciations, at the end of the Middle Pleistocene. Quite all the little placers were formed during the Middle Pleistocene last glacial expansion (in AMI named Serra Glaciation, correlable to MIS 6; GIANOTTI *et al*., 2008), because they are monophasic proglacial fan placers produced by fluvioglacial deposition of drift and prompt resedimentation of Serra Alloformation tills (Fig.1).

Exceptions are some little placers to the south of Bessa (3 in Fig. 1) referable to a precedent glacial expansion (Magnano Glaciation) and partially reworked until Present by local streams.

Mazzè placer is connected to the main fluvioglacial stream of the second-last glaciation (Piverone Glaciation; MIS 4?). It is placed on a high terrace, suspended 30 m above the right side of Dora Baltea River, 1 km downstream the deep gorge through which the river leaves the amphitheatre. Unlike the other little placers Mazzè is a polyphasic one, because the Mazzé gorge worked as AMI main draining channel during the last three glaciations and the interposed interglacials and interstadials until present.

On the opposite side of the Dora gorge the Villareggia placer is composed of different terraced fluvioglacial bodies ranging from Serra to Piverone glaciations. Finally only one placer (Baraccone at the south of Villareggia) is probably connected to the "Ivrea" Glaciation, correlable to the global LGM (MIS 2). It forms the top of a low terrace (5 m high) on the left side of the Dora Baltea River.

The main polyphasic placers (Bessa and Mazzè) are now terraced 20-50 m above the stream to which they are derived from (Viona and Olobbia streams for Bessa; Dora Baltea R. for Mazzè). A Dora Baltea paleochannel is preserved along the

western edge of the Mazzè placer. On the contrary the monophasic placers are not terraced and they lie in areas lacking of watercourses, because of their position downstream of morainic passes hanging tens of meters on the AMI internal alluvial plain (215 m).
All the placer exploitations were open-air quarrying works. Some tunnels into glacial deposits are reported in the Bessa area, but they can be interpreted as research workings. Three mine typology and related exploitation methods are discernable according to distribution and facies of reject deposits and overall derived morphology.

Fig. 2. Rounded cobbles and boulders accumulations on the Bessa *aurifodinae* upper terrace.
Cumuli di ciottoli e di blocchi arrotondati sul terrazzo superiore delle Aurifodinae della Bessa.

Exploitations by artificial water-channel wascarried out in contiguous but separate mining yards, everyone with a main deep evacuation channel (Bessa, Mazzè). This method produced two tipology of reject deposits. Open-worked deposits of quite rounded cobbles and boulders (also erratic blocks), methodically accumulated in handmade piles 1-10 m thick on the terrace top in the site of the former placer (Fig. 2). Anthropic alluvial fans of clino-stratified clast-supported sandy-gravel with rounded pebble and cobbles, deposited downstream of the channel outlets on the lower alluvial plains surrounding the placer.

Fig. 3. Buried channel sidewalls outcrop at the top of a low terrace on the Dora Baltea River left scarp (Baraccone site, Villareggia). This anthropic horizon lies on Middle Pleistocene fluvial sandy gravel.
Una successione di fianchi di canale sepolti affiora alla sommità di un basso terrazzo sulla scarpata sinistra del Fiume Dora Baltea (sito del Baraccone, Villareggia). Tale orizzonte antropico poggia su ghiaie sabbiose fluviali del Pleistocene medio.

A second exploitation type was carried out with many adjoining parallel superficial water channels (Fig. 3) and was adopted for a complete exploitation of thin alluvial bodies forming extensive flat low terraces (Baraccone).
These two water-based methods could have been the model for the “gorge yard” and the “comb yard” (DOMERGUE *et al*., 1989) utilized a century later in the Roman goldmines in Spain.
The minor placers corresponding to monophasic proglacial fans were exploited by simple excavations without water channels, owing to their distance from any water resource. This mining activity, partially explainable as research workings, is testified by the presence of hectometric wide areas only partially covered with cobble small piles and riddled with some meters deep cone-shaped pits (Frascheia near Villareggia and Moncrivello, Areglio-Bose and Madonna della Cella near Borgo d’Ale, Ronchi between Baldissero and Torre Canavese and other minor sites). Only for the Bessa and Mazzè sites running water was employed, probably because the aqueduct building cost (2 km long for Bessa and at least 10 km for Mazzè) was remunerative according to the placer extension and its higher gold grade.

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