

Geochemical and Mineral Inclusion Analysis of Alluvial Gold as Exploration Tools: Experiences from the Central Iberian Zone, Spain

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Gold occurrences in the Central Iberian Zone have been known since pre-Roman times, principally in placers, where primary sources remain uncertain. This study applies a methodology that includes microgeochemical analyses established by Electron Microprobe Analysis (EMPA) and the mineralogical study of mineral inclusions using Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDS) on two Holocene placer deposits — the Los Ángeles River placer and the Pino del Oro placer — providing a distinctive geochemical 'signature' that aids in tracing their primary sources. In the Río Los Ángeles placer, three gold types were identified: Au₁ (Au-Ag alloy, mean 86.1 wt% Au), Au₂ (high-purity rims, mean 97 wt% Au), and Au₃ (fine-grained gold associated with Fe-oxides and clays). Mineral inclusions, present in 23% of particles, mainly consisted of sulfides (e.g., galena, pyrite, arsenopyrite) and sulfosalts (e.g., boulangerite). The geochemical data indicating a mixture of gold populations, possibly related to vertical zoning in an orogenic source and/or to different hydrothermal mineralization pulses. In the Pino del Oro placer, a similar methodology revealed two gold types: Au₁ (electrum with 16–24 wt% Ag) and Au₂ (high-purity rims). Mineral inclusions, found in 11.8% of particles, included arsenopyrite, galena, sphalerite, and members of the cobaltite group. The compositional data suggest a hydrothermal origin at lower temperatures (<200°C) and indicate complex zonation in the original lode system. The consistent application of combined geochemical and mineral inclusion analyses across both sites demonstrates that both placer deposits originated from distinct stages of orogenic (amagmatic) mineralization. Furthermore, secondary supergene processes, notably silver leaching, significantly altered the gold particle rims during sedimentary transport. These results underline the effectiveness of integrated compositional and mineral inclusion analyses of gold particles in reconstructing the provenance and post-depositional history of alluvial gold.