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Platinum Group Element Inclusions in Early Bronze Age Gold Artefacts from the Royal Tombs of Ur, 2600 / 2500 BCE

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The Royal Tombs of Ur (Early Dynastic II/III) were excavated from 1921 to 1934 by Sir Leonard Woolley (Woolley 1934). The grave goods consist of countless artefacts made of gold, silver, copper and bronze, thousands of carnelian beads, jewellery, and vessels made of gold, silver, alabaster, lapis lazuli, and pearls (Zettler & Horn 1998). The artefacts can be ranked with the treasuries from Troy or Alaca Höyük. Among the most famous finds of Ur are golden daggers, from which one was made up of a ternary Au-Ag-Cu alloy, and was treated by depletion gilding (Hauptmann et al. 2010). Four lyres from Ur are the oldest musical instruments of the world, and most famous is the „Ram caught in the thicket" that was produced from gold, silver, malachite, and lapis lazuli. The masterpiece of the golden Meskalamdug helmet is world famous. Finally, most beautiful finds were recovered from the tomb of "Lady" or "Queen" Puabi including earrings, leaves from wreaths, and hundreds of pieces of hair ribbons, all made of gold sheet and foil metal.

Micro textures and the chemical composition of the hair ribbons were investigated in Bochum using a Keyence portable digital microscope and a scanning electron microscope. As for their micro texture, the ribbons mostly lack a homogeneous equiaxed grain texture as known from a cast product. In contrary, we observed a microstructure of single gold grains indicating that the grains were welded together. Chemical analysis of such gold grains reveals variation of the silver concentration that is presumably caused by segregation effects in the micro scale. It could though also be caused by an incomplete melting of the tiny gold grains that were welded by sintering (Raub 1993). This led us to suggest that the ribbons must have been made of very fine flour gold as extracted from a sedimentary ore deposit, and that this flour gold was insufficiently homogenised.

The assumption of the use of sedimentary gold is supported by numerous inclusions of platinum group elements (PGE) that abundantly occur in the objects and range from a few to a few hundred micrometers in diameter. We have observed some 150 of these with the Keyence microscope. The PGE in the gold artefacts comprise almost exclusively Osmium, Iridium, and Ruthenium with only minor concentrations of Platinum. The enrichment of the three PGE Osmium, Iridium, and Ruthenium as inclusions in gold is logical because of their specific thermal stabilities. While Platinum is easily soluble in gold during (s)melting processes at about 1100°C, Osmium, Iridium, and Ruthenium are not. We therefore should not exclude the option that the sedimentary gold ore with its PGE inclusions could have been platinum-richer prior to the ancient metallurgical operations than they finally appear in the objects.

PGE are important indicators for the geological provenance of the gold metal used for producing the archaeological objects. They are indicative for gold placers that primarily originate in ore deposits related to (weathered) ultrabasic rocks. There are two major geological units in which PGE minerals can be found: a) Os-Ir-Ru PGE are associated with chromite in ultrabasic rocks and crystallised as sulphide minerals or native alloys. B) Rh-Pd-Pt PGE are associated with magmatic sulphides of Fe, Ni, Cu in layered gabbros (e.g., Sudbury complex).

PGE were described previously to be characteristic for gold from the Pactalos River, Western Anatolia (Young 1972). The analyses that were gained so far from the gold artefacts from Ur coincide with the chemical composition reported from gold artefacts of Mesopotamian and Egyptian objects from the British Museum. Furthermore, the composition of the objects from the British Museum is identical with jewellery from the 16th century BC Qurneh in Egypt (Troalen et al. 2009), and they also correspond with the range of compositions observed in Proterozoic age Egyptian chromite deposits (Ahmed 2007).

To follow up the discussion it becomes necessary to characterise the PGE inclusions in more detail. As a next step in our project Os isotope analyses by Laser ablation mass spectrometry are in process for a more detailed chemical characterisation and also for tracing the provenance of the gold artefacts from Ur exceedingly.

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