Where does all the gold come from?

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File photo shows gold nuggets on display in Jamestown, California. Were it not for meteorites striking Earth some four billion years ago, humans would never have laid eyes on the gold that has raised and ruined civilisations, according to a study published Thursday.

Ultra high precision analyses of some of the oldest rock samples on Earth by researchers at the University of Bristol provides clear evidence that the planet's accessible reserves of precious metals are the result of a bombardment of meteorites more than 200 million years after the Earth was formed. The research is published today in *Nature*.

During the formation of the Earth, molten iron sank to its centre to make the core. This took with it the vast majority of the planet's precious metals – such as gold and platinum. In fact, there are enough precious metals in the core to cover the entire surface of the Earth with a four metre thick layer.

The removal of gold to the core should leave the outer portion of the Earth bereft of bling. However, precious metals are tens to thousands of times more abundant in the Earth's silicate mantle than anticipated. It has previously been argued that this serendipitous over-abundance results from a cataclysmic meteorite shower that hit the Earth after the core formed. The full load of meteorite gold was thus added to the mantle alone and not lost to the deep interior.

To test this theory, Dr Matthias Willbold and Professor Tim Elliott of the Bristol Isotope Group in the School of Earth Sciences analysed rocks from Greenland that are nearly four billion years old, collected by Professor Stephen Moorbath of the University of Oxford. These ancient rocks provide a unique window into the composition of our planet shortly after the formation of the core but before the proposed meteorite bombardment.

The researchers determined the tungsten isotopic composition of these rocks. Tungsten (W) is a very rare element (one gram of rock contains only about one ten-millionth of a gram of tungsten) and, like gold and other precious elements, it should have entered the core when it formed. Like most elements, tungsten is comprised of several isotopes, atoms with the same chemical characteristics but slightly different masses. Isotopes provide robust fingerprints of the origin of material and the addition of meteorites to the Earth would leave a diagnostic mark on its W isotope composition.

Dr Willbold observed a 15 parts per million decrease in the relative abundance of the isotope 182W between the Greenland and modern day rocks. This small but significant change is in excellent agreement with that required to explain the excess of accessible gold on Earth as the fortunate by-product of meteorite bombardment.

Dr Willbold said: "Extracting tungsten from the rock samples and

analysing its isotopic composition to the precision required was extremely demanding given the small amount of tungsten available in rocks. In fact, we are the first laboratory world-wide that has successfully made such high-quality measurements."

The impacting meteorites were stirred into the Earth's mantle by gigantic convection processes. A tantalising target for future work is to study how long this process took. Subsequently, geological processes formed the continents and concentrated the precious metals (and tungsten) in ore deposits which are mined today.

Dr Willbold continued: "Our work shows that most of the precious metals on which our economies and many key industrial processes are based have been added to our planet by lucky coincidence when the Earth was hit by about 20 billion billion tonnes of asteroidal material."

More information: 'The tungsten isotopic composition of the Earth's mantle before the terminal bombardment' Matthias Willbold, Tim Elliott and Stephen Moorbath *Nature* (2011).

Provided by University of Bristol