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Study of native gold from the Luopensulo deposit (Kostomuksha area, Karelia, Russia) using a combination of electric pulse disaggregation (EPD) and hydroseparation (HS)

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Abstract

The mineralogy of a gold–sulphide–arsenopyrite ore from the Kostomuksha iron deposit region was studied by scanning electron microscopy (SEM) in hydroseparation (HS) products from various non-magnetic fractions (40–300 μm) after EPD crushing. The computer controlled hydroseparator CNT HS-11 produced a 100× concentration of native gold grains together with other ore minerals. Selection of >150 native gold grains from HS concentrates shows a grain size distribution of 1–154 μm (average 33 μm). Measured, upgraded gold reports as liberated grains (46.0%), as intergrowths with arsenopyrite (14.2%), löllingite (19.7%), native bismuth (17.1%), and in association with pyrrhotite (0.9%) and chlorite/apatite (2.0%). High recoveries of native gold are explained in terms of the combined effects of selective grain-boundary fracture induced by EPD crushing, resulting in preservation of metallic mineral aggregates and grain boundaries, even within large native Au/Bi particles (such soft particles would otherwise show significant changes during normal comminution methods). High gold recoveries should thus be possible using traditional gravity and flotation followed by cyanidation. A combined EPD/HS protocol demonstrates the unique possibilities of this technology for laboratory-scale gravity recoverable gold (GRG) testing.

Keywords: Native gold; Electric pulse disaggregation (EPD); Hydroseparation (HS); Process mineralogy; Gold ores

1. Introduction

Among numerous modern techniques available to gold process mineralogy, hydroseparation (HS) and electric pulse disaggregation (EPD) are relatively new. The combination of both techniques has been applied by the authors in numerous research projects, but, due to confidentiality, these results have never been published. In this respect, this is one of the first mineralogical studies to be reported using EPD + HS as a combined mineral processing technique, which has many advantages over other well known and widely used techniques in the process mineralogy of precious metals and other ore types. For example, besides application of this technology to gravity recoverable gold (GRG) ores, we have also used it with platinum, bauxite, and diamondiferous ores, as well as for investigations requiring concentration of accessory minerals for geochronology such as zircon and baddeleyite.

2. Latest EPD and HS developments

EPD is a mineral separation technique that liberates mineral grains from any rock regardless of lithology or grain size distribution. Normal mechanical crushing of whole-rock samples is replaced in EPD by the rending

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effect of a controlled explosion, which is produced by applying an electric current from a high-voltage power source. A voltage greater than the 100 kV necessary for the breakdown of rock samples is achieved by using capacitors that are charged in parallel but discharged in series. The sample is placed in a water bath on the sieve and the rapid distribution of electric pulses through the sample leads to explosions, the energy of which is transmitted internally and preferentially along zones of weakness, such as grain boundaries and cleavage. As a result, individual, relatively undamaged mineral grains can be recovered (having passed through the sieve out of the explosion area) with virtually intact primary textural attributes.

Further processing and concentration of different grain-size fractions after EPD can be made by gravity (including HS), electromagnetic, flotation or other methods, which can be used to concentrate individual mineral phases or aggregates and provide an opportunity for detailed study of their morphology and shape, crystal structure, physical and textural features, and chemical composition.

The commercially available EPD device CNT Spark-2 (Fig. 1, and see <http://www.cnt-mc.com/>), which was used for this project has a throughput of up to 300 kg/h allows processing large batches of samples including industrial sizes.

The commercially available and fully patented hydroseparators of HS-series – automated CNT HS-02M, computer controlled CNT HS-11 (Fig. 1) and the semi-industrial CNT HS-21, were invented by the authors to process solid water-insoluble powdered samples to produce representative "heavy mineral concentrates" of particles that follow Stokes' law when settling in a carefully controlled, upward pulsating water stream. Ideally, to be applicable for concentration factors (up to 10,000 times) for HS processing/concentration of the heavy particles of mineral accessories do not depend on the throughput which varies on the particular model of the HS device (200 g/h for CNT HS-11, and 50 kg/h for CNT HS-21).

The use of HS has already been well documented (e.g., Cabri, 2004; 2005a,b, 2006, 2007; Lastra et al., 2005; McDonald et al., 2005; Rudashevsky et al., 2002) but the combination of EPD and HS techniques is described here for the first time in an application for mineral processing of gold ores and was also recently reported on a study of platinum ore by Oberthür et al. (2007).

3. Geology

The Luopensulo gold deposit is situated in Kostomuksha iron deposit region (NW Karelia, Russia). It is bound by regional tectonic NW trending fault zones (310°) and early Proterozoic and Proterozoic granites (isochronous age 2.45 b.y.)

Within the deposit, ferruginous quartzites and shales (amphibole–magnetite, biotite–magnetite quartzites), and micaceous shales (biotite–quartz, quartz–biotite and garnet–quartz–biotite) were subjected to intensive hydrothermal alteration (carbonatization, biotitization, chloritization, etc.). These rocks are very rich in base metal sulphides, characterized by early-stage, pyrite–pyrrhotite-, and late-stage, chalcopyrite–pyrrhotite- and pyrite–pyrrhotite–arsenopyrite mineralization. The Luopensulo Au deposit can be attributed to a gold–arsenopyrite genetic ore-type. Concentrations of gold and silver here range from 1.5 to 35.5 g/t, and 0.1–2.5 g/t, respectively.

4. Methodology

A 2 kg sample (assaying 3.62 g/t Au and 0.39 g/t Ag) and several polished sections of gold–sulphide–arsenopyrite ore from quartz–amphibolite metasomatites were used for this investigation. After fragmentation to <1 cm pieces, the sample was crushed using the EPD method with the CNT EPD SPARK-2 (CNT-MC Inc., Canada; Fig. 1) device on a stainless-steel sieve (<1 mm). The crushed product (1050 g) was wet sieved through a standard screen series, resulting in the size distributions given in Table 1.

All fractions were passed through a primary wet magnetic separation and concentrated by means of the computer controlled device CNT HS-11 (CNT-MC Inc., Canada) (Rudashevsky and Rudashevsky, 2001, 2006, 2007) in two stages: (1) production of a preliminary HS concentrate followed by secondary wet magnetic separation; (2) production of final HS concentrate. Five monolayer polished sections were produced from 20–30 mg of the heavy mineral HS concentrates of each fraction. These polished sections were investigated by

Fig. 1. CNT EPD Spark-2 (left) and CNT HS-11 (right) devices (CNT-MC Inc., Ottawa).