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Short Communications (Research Advances)

A potential giant gallium deposit hosted in the tailing dam of the Fankou Zn-Pb deposit in northern Guangdong Province, South China

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1. Objective

The Fankou giant zinc (Zn)-lead (Pb) deposit in Guangdong Province is well-known for its huge reserves of over 10 Mt (million ton) Zn + Pb metals and high ore-grade with Zn + Pb exceeding 15% (Guangdong Fankou Deposit Investigation Group, 1980; Zhu XY et al., 2017). After 60 years of exploration and exploitation, the deposit has accumulated millions of tons of tailings. One interesting question is that what components are hosted in these tailings, and whether some key and critical metals such as gallium and germanium are extremely enriched and worth further comprehensive utilization. This motivated us to conduct an integrated set of field investigation, sampling, major-trace element analyses and reserve assessments about the Fankou tailings. In this contribution, we discover that the tailings contain a variety of metal elements such as zinc, lead and gallium with comprehensive utilization potential. These data can act as a scientific guidance for further exploration and utilization of the Fankou tailings, and aid to enhance the utilization efficiency of the key mineral resource in China. Our study also provide demonstration for future green mine construction in China.

2. Methods

Sampling: Three tailing ponds at Fankou, including the Laoyashan (1#), Huangzitang (2#) and Nuankeng (3#), with the total storage capacity of 1.6×10^7 m^3, are sampled. The tailing samples cover the main planes and depths of the Fankou tailing ponds, and comprise 3 samples from the 1#-, 15 samples of 2#- and 8 samples of 3 # tailing ponds. The detailed sampling positions are marked in Fig. 1.

Major-trace element analysis: The obtained samples are made into standard sheets and 200-mesh powder. Then, the powder samples were dissolved in acid, and then sent to Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) and Inductively Coupled Plasma Mass Spectrometer (ICP-MS) for the measurement of major and trace elements. Among them, the Ga-containing sample was decomposed by mixed acid (hydrofluoric acid, nitric acid and sulfuric acid), and the salt was dissolved with aqua regia to extract the constant volume. Portion of the solution was diluted with nitric acid, and finally the Ga content was determined by ICP-MS. The test standards are carried out in accordance with the DZ/T0130-2006 quality specification, repeated analysis results of the relative deviation are qualified with the relative deviation being less than or equal to the allowable limit, otherwise are unqualified. A total amount of 22 samples in this batch were analyzed repeatedly. The qualified rate of each element is more than 95 %, and all the analyses are qualified.

3. Results

The major and minor elemental contents of samples at the Fankou tailings are displayed in Supplementary Table S1 and Fig. 2a. The measured major elements include Fe, Pb and Zn. Among them, the content of Fe is 2.91%–25.3% (average 13.4%). The contents of Pb and Zn were 0.17%–1.12% and 0.17%–10.1%, with an average of 0.79% and 1.18%,

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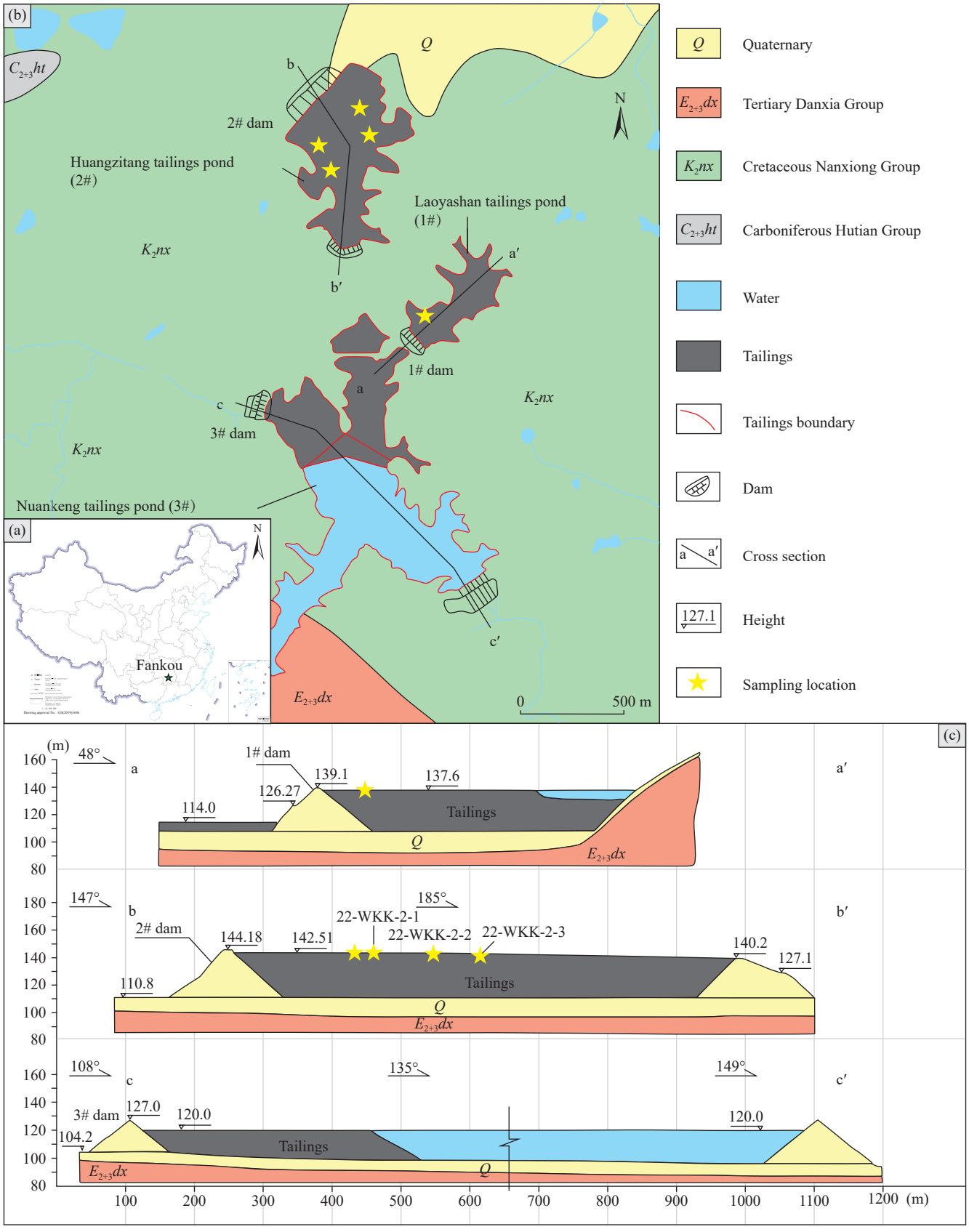

Fig. 1. Location (a), geological map and sampling locations (b), and representative profiles (c) of the Fankou Tailing Dam.

respectively. In terms of trace elements, the contents of As and Cu are variably ranging from 52 × 10^{-6} to 1390 × 10^{-6} (average 745 × 10^{-6}) and from 28 × 10^{-6} to 280 × 10^{-6} (average 165 × 10^{-6}), respectively. The concentrations of Ga and Ge range from 12.5 × 10^{-6} to 97.5 × 10^{-6}, with an average of 49.1 × 10^{-6}, and from 1.3 × 10^{-6} to 24.4 × 10^{-6}, with an

average of 7.3 × 10^{-6}, respectively. The average grade of Ga is much higher than the content of the average crust (18 × 10^{-6}).

It is noteworthy that there is a significant positive correlation between Ga concentrations and sampling depths in the Fankou 2# tailing pond (Fig. 2b). The Ga content increases with increasing depth. Antimony (Sb) and silver (Ag) also show similar correlations. There are correlations between Ga and some elements in the Fankou tailing samples. As shown in Fig. 2, Ga has a highly positive linear relationship with Pb (r^2 = 0.90), and a moderate positive linear relationship with Ag and Zn (r^2 = 0.64 and r^2 = 0.68). There is a high positive correlation between Zn and (As + Cu + Ga + Sb + Ag), and the correlation coefficient is 0.85 (Figs. 2c, d),

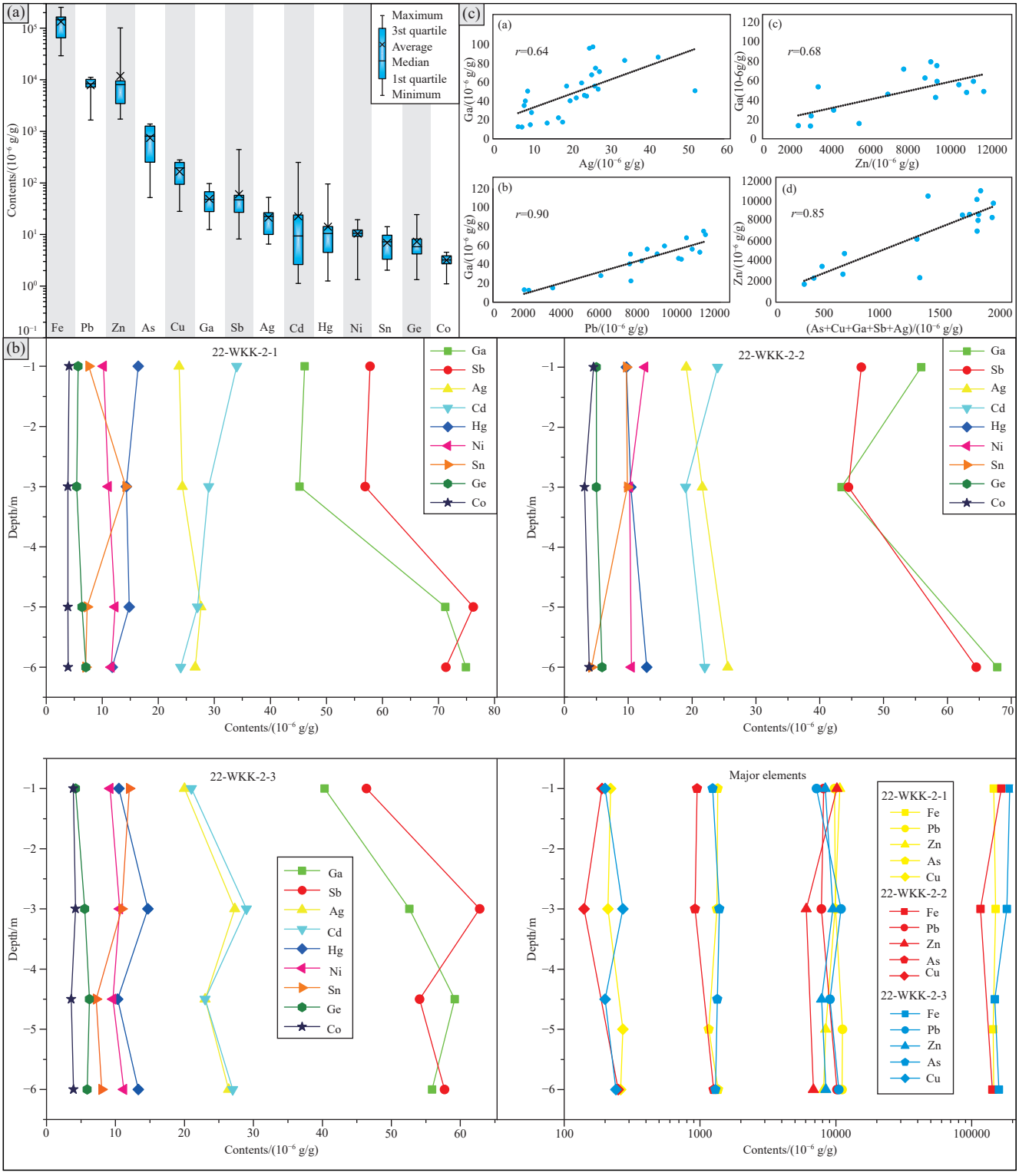

Fig. 2. Statistical diagrams of the major-trace elements at the Fankou tailing pond. A-Box plots of the major-trace elements at Fankou tailing pond; B-Elemental contents variation with depth of samples at the No. 2# tailings pond; C-Correlation between elemental pairs of Ag-Ga, Pb-Ga, Zn-Ga and (As+Cu+Ga+Sb+Ag)-Zn.

which is consistent with the enrichment mechanism of Ga: $2 \times Zn^{2+}=(Cu, Ag)^{+} + (Ga, As, Sb)^{3+}$. Thus, the enrichment of Ga in tailings has significant relationship with Cu, Ag, As, Sb and Zn. In the primary Fankou Pb-Zn ores, Ga and Ge are clarified as stoichiometric substitution to Zn in the host sphalerite, and we therefore infer that Ga and Ge enter into the lattice of host sphalerite via a complex series of coupled substitution.

The Ga (average of 49.1×10^{-6}) in Fankou has relatively high economic value though the concentrations are lower than 100×10^{-6}. The number 100×10^{-6} is a very old reference standard proposed in 1980s for the Ga 's comprehensive utilization. For a long time, it has been considered as a constant for comprehensive utilization. In fact, the value of an ore deposit is determined by the changing market demand and extraction cost, rather than changeless. For key metals Ga and Ge, the extraction cost from sphalerite by-product is becoming very low, and more demands are increasing for their great application potential in green and high-tech fields. These factors will reduce the minimum industrial grades of Ga and Ge for comprehensive utilization. The evaluation of Ga and Ge is a new issue, and a national standard and more case studies are urgently required. Therefore, on the basis of the obtained Pb, Zn and Ga concentrations, we try to estimate the gallium resources for the Fankou tailings. Given the Laoyashan tailing pond has storage capacity of 5.6×10^6 m^3, the Huangzitang tailing pond has 2.6×10^6 m^3, and Nuankeng has 7.9×10^6 m^3, with the average content of Ga are 13.4×10^{-6}, 65.0×10^{-6} and 32.7×10^{-6}, respectively, the Fankou tailings are estimated to preserve 412160 t of Zn + Pb and 803.7 t of Ga metals. Both the reserves of Zn-Pb and Ga meet the standard of large-scale deposits. In consideration of the limited samples in this study, we call for a more comprehensive evaluation on the metal reserves at the Fankou tailings in future.

4. Conclusions

The amount of 803.7 tons of Ga and 412160 tons of Zn+Pb metals are estimated to be hosted in the Fankou tailings, and both Zn-Pb and Ga meet the standard of large-scale deposits with promising economic values. Due to sampling limitation, a more comprehensive evaluation on the Fankou tailings is needed.

CRediT Authorship contribution statement

Peng-peng Yu, Zhao-bin Hu and Yi Zheng conceived of the presented idea. Zhao-bin Hu, Cheng-ming Wang and Xi Chen participated in the field investigation. All the authors discussed the results and contributed to the final manuscript.

Declaration of competing interest

The authors declare no conflicts of interest.

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Supplementary data

Table S1 to this article can be found online at doi: 10.31035/cg2023043.

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