

Title: Supplementary Data 1

Description: Detailed information of predicted viral genomes identified in the 90 acid mine drainage (AMD) sediment samples.

Title: Supplementary Data 2

Description: Biotic data for the 90 AMD sediment samples across Southern China. OTUs, operational taxonomic units; PCs, protein clusters; MAGs, metagenomic assembled genomes.

Title: Supplementary Data 3

Description: Abundance and taxonomic affiliation of the dereplicated viral populations.

Title: Supplementary Data 4

Description: Virus-host linkages predicted by prophages, shared genomic matches with host genomes, and protospacer-spacer matches.

Title: Supplementary Data 5

Description: Detailed function descriptions and sequence information of the viral genomes containing *phoH* and *phnCDE* genes.

Title: Supplementary Data 6

Description: Homologs of viral *phoH*, *phnC*, *phnD*, and *phnE* genes recruited from eggNOG v5.0.0 database and prokaryotic genomes.

Title: Supplementary Data 7

Description: Abundance and taxonomic affiliation of the dereplicated prokaryotic populations.

Title: Supplementary Data 8

Description: Detailed accession number of metagenomic and amplicon reads for the 90 sediment samples.

Title: Supplementary Data 9

Description: Detailed accession number of metagenome-assembled population genomes reconstructed from the 90 sediment samples.