Gold exploration with 3-D controlled-source electromagnetic method

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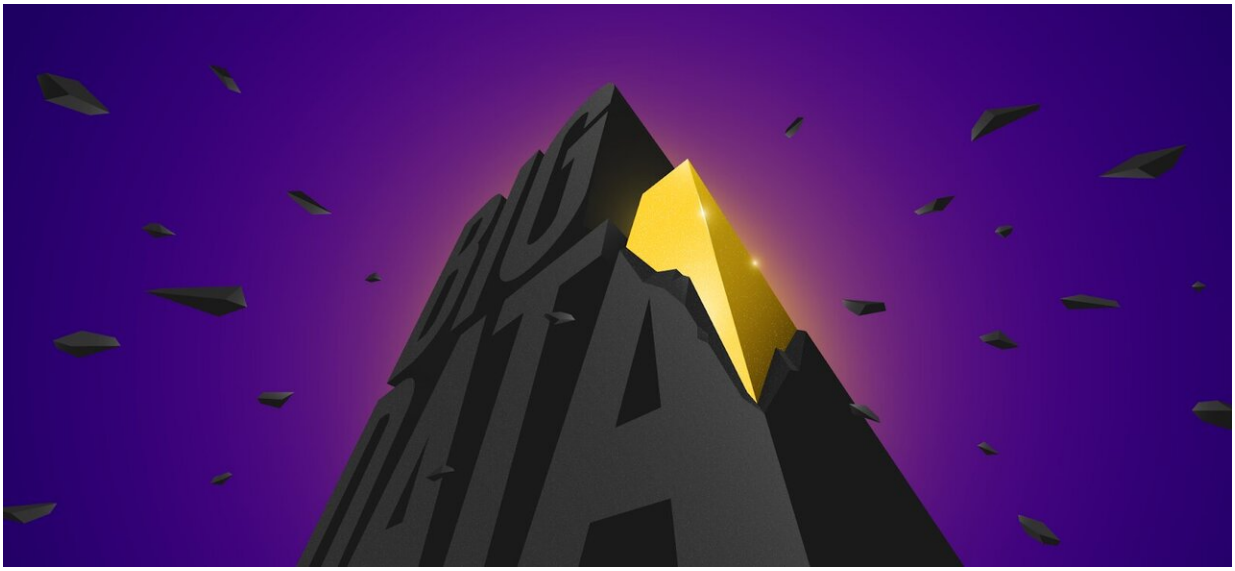

Russian mathematicians and geophysicists have made a standard technique for ore prospecting several times more effective. Credit: @tsarcyanide/MIPT

Russian mathematicians and geophysicists have made a standard technique for ore prospecting several times more effective. Their findings are reported in *Geophysical Journal International*.

The controlled-source electromagnetic method, known as CSEM, dates back to the mid-20th century. It involves deploying grounded electrodes that inject an oscillating electric current into the Earth. The

electromagnetic field is then measured on the surface. The resulting data enable mapping the electrical resistivity of the subsurface rock by solving what is known as an inverse problem. This is useful because a low resistivity suggests the presence of metal ore. A considerable limitation of CSEM, which has restricted its scope of application, is its high demand for computing resources.

Now, a research group led by Michael Zhdanov from the Applied Computational Geophysics Lab at the Moscow Institute of Physics and Technology has created a numerical method that makes the calculations feasible for modern supercomputers.

"Solving the inverse problem involves calculating—thousands of times—the electromagnetic field from a given distribution of electric current," said paper co-author Mikhail Malovichko of Skoltech and the MIPT Applied Computational Geophysics Lab. "We have proposed a new numerical method that speeds up the forward-problem calculation on alternating current severalfold, thus making the inverse problem tractable on modern supercomputers."

However, to use the algorithm for prospecting, it first needs to be verified using precise data on real ore deposits. Highly reliable reference data are supplied by the most expensive geological prospecting technique there is—exploration drilling.

Fortunately, such data turned out to be available on the Sukhoi Log gold deposit, 900 kilometers northeast of Irkutsk, Russia. Discovered in the 1960s, the deposit is one of the largest worldwide. That said, the precious metal concentration in the rock is fairly low. For this reason, Sukhoi Log was thoroughly scrutinized to enable extracting ore only where it is economically viable.

"The Soviet Union spent an immense amount of money to drill more

than 800 boreholes in an endeavor, whose economic feasibility was not subject to any checks anyway," said study co-author Andrei Tarasov, who is an associate professor at the Department of Geophysics, St. Petersburg State University. "This makes Sukhoi Log the ideal place for testing newly developed geological surveying techniques by comparing their predictions with the precise data available from drilling."

By processing the large arrays of available data, the MIPT-Skoltech team created a detailed 3-D map of the area and tested the new algorithm's ability to solve the inverse problem in CSEM. The new model enables prospectors to make do with as few exploratory holes as possible: The drilling is only employed to verify model predictions.

The technique developed by the Russian researchers is applicable for searching for other kinds of ores, including copper-nickel, volcanogenic massive sulfide, and polymetallic deposits.

More information: M Malovichko et al, Mineral exploration with 3-D controlled-source electromagnetic method: a synthetic study of Sukhoi Log gold deposit, *Geophysical Journal International* (2019). DOI: 10.1093/gji/ggz390

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