

The Potential Impacts of Gold Mining in Virginia

Gold mining in Virginia dates back to the 1800s, but today, Western states dominate U.S. gold production, and there are no active commercial gold mines in Virginia. However, as current deposits become depleted and gold prices rise, mining companies are increasingly exploring for lower-grade gold deposits or those that are deeper in the Earth. This has brought renewed attention to the potential for gold mining in Virginia.

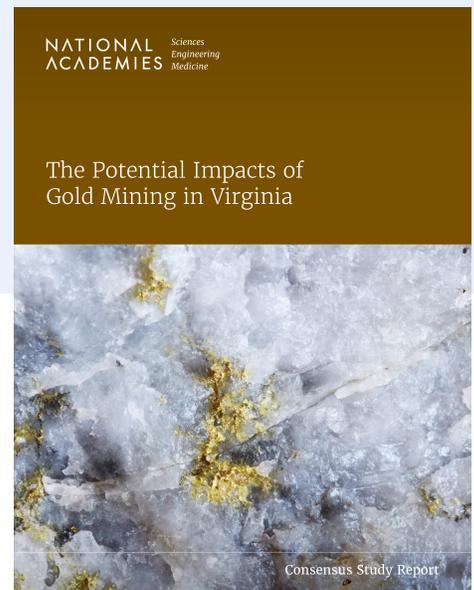
This report provides an evaluation of the main gold deposits in Virginia, the probable modern mining techniques that could be used for such deposits, and the potential impacts of those activities. The report also assesses the sufficiency of existing regulations in the Commonwealth to protect air and water quality and human health from the potential impacts of commercial gold mining.

Overall, the report concludes that the regulatory framework of Virginia appears to have been designed for operations like sand and gravel operations, not gold mining. As such, Virginia's current regulatory framework is not adequate to address the potential impacts of commercial gold mining.¹ More specifically, Virginia's regulatory framework lacks an adequate financial assurance system, which poses a fiscal and environmental risk to the Commonwealth. Additionally, Virginia lacks opportunities for a diverse public to be engaged in permitting processes and a modern system for review of environmental impacts from potential gold mining projects.

GEOLOGIC CHARACTERISTICS AND PROBABLE MINING OPERATIONS

Most known gold occurrences in Virginia are associated with metamorphic and igneous rocks in the Piedmont physiographic province, except for a few small occurrences in the Blue Ridge province (Figure 1). These deposits in Virginia occur in lens-shaped, low-sulfide, gold-quartz veins (1 to 5 percent pyrite) that dip at steep angles, making shallow open pit and underground mining the most likely methods to mine the gold ore. Massive sulfide bodies can occur in close proximity to the low-sulfide, gold-quartz vein deposits in Virginia and if appropriate engineering controls are not in place during mining, acid rock drainage and metals could be released. All available evidence indicates that Virginia gold deposits are generally smaller than those in other major gold-producing states, which suggests that shipping gold ore or pyrite concentrates off-site for the later stages of processing may be more economical, should commercial gold mining take place in the Commonwealth. This is significant because the magnitude of the potential impacts of gold mining can scale with the size of the operations and whether processing occurs on- or off-site

¹ In this report, commercial gold mines refer to larger and more technologically complex operations than small-scale gold mines. Small-scale gold mines are typically low-technology, labor-intensive mineral extraction and processing activities carried out mostly by local people (Hilson and Maconachie, 2020).



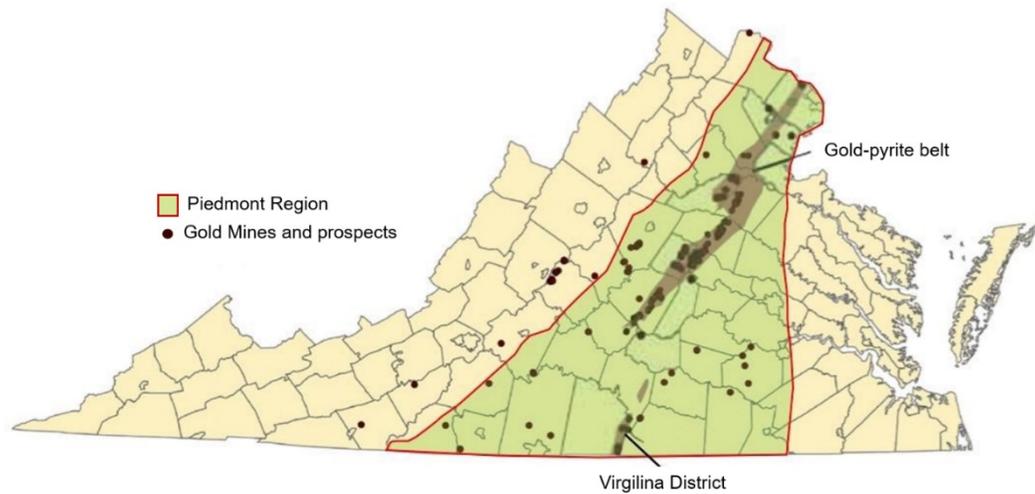


FIGURE 1 Locations of historic gold mines and prospects in Virginia. Most known gold occurrences in Virginia are associated with metamorphic and igneous rocks in the Piedmont physiographic province, except for a few small occurrences in the Blue Ridge province. Two major gold districts occur in the Piedmont: the gold-pyrite belt in the north-central part of the state, and the Virgilina district in south-central Virginia. SOURCE: Modified from Sweet (2007).

POTENTIAL ENVIRONMENTAL AND HEALTH IMPACTS

Potential impacts were assessed in the context of the environmental, geologic, and social conditions of the gold-bearing regions of the Commonwealth. A robust regulatory framework and modern best practices can significantly reduce many of the impacts associated with gold mining, but the risk of adverse impacts cannot be completely eliminated.

Potential impacts of concern for Virginia gold mining include:

- **Acid rock drainage (ARD).** Gold mining activities can release drainage that is high in acidity, salinity, and elevated concentrations of toxic metals to surface water and groundwater, if appropriate engineering controls are not in place. Many gold deposits in Virginia occur in low-sulfide, gold-quartz veins, however, adjacent massive sulfide deposits or sulfide-bearing rock can be disturbed during mining. Site-specific characterization, engineering controls, and monitoring throughout the life cycle of gold mines are important to minimize and mitigate ARD that could negatively impact surface water and ecological communities.
- **Metals from gold mining.** Site-specific geologic conditions determine whether gold mining activities

could release toxic metals (including antimony, arsenic, cadmium, lead, mercury, and/or thallium) in sufficient quantities to pose human health threats to surrounding communities. Gold deposits near massive sulfide deposits have higher risk of toxic metal discharge. Therefore, any future efforts to mine gold deposits in Virginia should be accompanied by detailed studies to characterize the mineralogy and geochemistry of each deposit and its surrounding rock.

- **Remobilization of legacy contaminants.** Since mercury and gold readily combine together to form an alloy, mercury was used at historical gold mines in Virginia to help recover gold. Future gold mining operations could remobilize legacy mercury that was released from these historic operations, unless appropriate extraction and processing circuits are implemented to capture the mercury. Because of mercury's high toxicity, careful characterization for mercury is essential at all potential mine sites in order to protect environmental and human health.
- **Rare but catastrophic events.** Catastrophic failures of gold mine tailings dams and cyanide solution containment structures are low-likelihood but high-consequence events that have caused significant impacts in localities where they have occurred. Tailings dam failures can cause fatalities,

injury, and destruction of property, as well as long-term ecological effects. In contrast, a cyanide spill poses acute risks that can kill aquatic life and contaminate drinking water supplies. Tailings and cyanide containment structures need to be designed to accommodate high-precipitation and flooding events, the frequency and severity of which has increased due to climate change.

- **Cumulative health risks.** Different hazard types, especially chemical and nonchemical stressors (e.g., poverty, discrimination), can interact to affect human health in complex and dynamic ways. These multiple, sometimes synergistic, stressors can lead to asymmetric impacts within and between communities, and historically underresourced and underrepresented populations are often most affected.

RECOMMENDATION: To minimize impacts to human health and the environment, the Virginia General Assembly and state agencies should ensure that robust site- and project-specific analyses of impacts are completed prior to the permitting of a gold mining project.

VIRGINIA'S REGULATORY FRAMEWORK

Although most of Virginia's mineral mining laws and regulations seem suitable for the types of mines now operating in the state, the current regulatory framework is not adequate to address the potential impacts from commercial gold mining. Gold mining raises a number of environmental and public health issues that merit additional attention and suggest a need for changes in laws, regulation, and guidance.

Review of Impacts

Virginia's current regulatory system lacks an effective and consistent process for review of environmental impacts from potential gold mining projects, making it unlikely that a robust collection, evaluation, and review of site-specific data and their impacts on the public health and welfare of surrounding communities will take place. The National Environmental Policy Act (NEPA) requires federal agencies to consider the potential environmental effects on natural resources, as

well as social, cultural, and economic resources, before permitting. Unlike some other states, Virginia law does not require a NEPA-like review for mining occurring on private land.

Exemptions

Virginia provides exemptions from regulatory oversight for off-site processing and exploratory drilling which are not commensurate with the potential impacts from those operations.

- **Off-site processing:** Gold processing facilities in Virginia that are not located on site with active mining or extraction ("toll mills") would not require a permit from the Mineral Mining Program. While toll mills may be required to obtain permits from other agencies to protect air quality and water quality, the lack of regulatory oversight by the Mineral Mining Program means that site characterization, project plans and designs, and the implementation of best practices for operations, reclamation, and long-term stewardship may not be adequately addressed.
- **Exploratory drilling:** Virginia's current laws and regulations exempt exploratory drilling for mineral resources. Impacts on the environment during initial exploration are generally minor, localized, and easily reclaimed, but greater oversight would ensure community participation at the earliest appropriate stage and would lessen the likelihood of these localized impacts.

Financial Assurance

Virginia's bonding requirements are insufficient to cover the costs of reclamation and long-term stewardship of gold mining and processing operations, which poses a fiscal and environmental risk to the Commonwealth in the case of the bankruptcy of mining enterprises or abandonment of their mining sites.

- **Bonding rates:** Virginia's bonding rates are based solely on disturbed acreage, which can lead to under-collection of bonds for gold mining and processing operations because they do not account

for additional costs like post-closure water management. Additionally, Virginia offers a bond pool, called the Minerals Reclamation Fund, with even lower per-acre rates and pooled risk, which could be depleted by the reclamation and long-term stewardship activities needed for some gold mining projects.

- **Exemptions from bonding:** Virginia’s exemptions from bonding for underground gold mining (without significant surface effects), small-scale gold mining, and toll mills do not reflect the costs necessary to conduct reclamation and long-term stewardship at those operations. No financial assurance is provided to the Commonwealth for these exempt operations, which poses a fiscal and environmental risk to the Commonwealth and its citizens.

Performance Standards

Virginia’s performance-based laws and regulations provide flexibility for the site-specific designs of each project, but do not provide sufficient guidance for operators to achieve goals and do not offer sufficient metrics for regulators to evaluate. Fiscal and environmental risks to the Commonwealth would be reduced with improved guidance and performance

standards on best practices for the collection of baseline information, water management, and waste rock management.

Public Engagement and Environmental Justice

The current requirements for public engagement in Virginia are inadequate and compare unfavorably with other states, the federal government, and modern best practices. For example, there is a scarcity of project details in the new permit notifications, a short deadline provided for filing objections or a request for hearing, and a limited number of area residents that are required to be notified, with no specific inclusion of tribal communities. Virginia regulations that are applicable to mineral mining will need to be amended to prevent disparate impacts and to reach the goals set out in the Environmental Justice Act, which the Virginia legislature passed in 2020.

RECOMMENDATION: To protect against the potential impacts of gold mining, the General Assembly and state agencies should update Virginia’s laws and its regulatory framework.

COMMITTEE ON POTENTIAL IMPACTS OF GOLD MINING IN VIRGINIA

William A. Hopkins (*Chair*), Virginia Polytechnic Institute and State University; **Kwame Awuah-Offei**, Missouri University of Science and Technology; **Joel D. Blum**, University of Michigan; **Robert J. Bodnar**, Virginia Polytechnic Institute and State University; **Thomas Crafford**, U.S. Geological Survey (retired); **Fiona M. Doyle**, University of California, Berkeley; **Jami Dwyer**, Barr Engineering Company (retired); **Elizabeth Holley**, Colorado School of Mines; **Paul A. Locke**, Johns Hopkins Bloomberg School of Public Health; **Scott M. Olson**, University of Illinois; **Brian S. Schwartz**, Johns Hopkins Bloomberg School of Public Health; **M. Garrett Smith**, Montana Department of Environmental Quality; and **Shiliang Wu**, Michigan Technological University

STUDY STAFF

Stephanie Johnson, Study Director; **Margo Regier**, Study Director; **Clara Phipps** (until June 2022), Senior Program Assistant; **Miles Lansing** (starting July 2022), Program Assistant; and **Chioma Onwumelu** (until May 2022), Mirzayan Fellow

This Consensus Study Report Highlights was prepared by the Board Earth Sciences and Resources based on the Consensus Study Report *The Potential Impacts of Gold Mining in Virginia* (2022).

The study was sponsored by the Virginia Department of Energy and the National Academy of Sciences Arthur L. Day Fund. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project.

This Consensus Study Report is available from the National Academies Press (800) 624-6242 | <http://www.nap.edu> | <http://www.nationalacademies.org>

To read the full report, please visit <http://www.nationalacademies.org/BESR>

Division on Earth and Life Studies

NATIONAL ACADEMIES Sciences
Engineering
Medicine