



U.S. Department of Energy

Categorical Exclusion Determination Form

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Proposed Action Title: Mining Innovations for Negative Emissions Resource Recovery (MINER) Program (FOA No. DE-FOA-0002707 and DE-FOA-0002708)

Program or Field Office: Advanced Research Projects Agency - Energy

Location(s) (City/County/State): AZ, CA, CO, CT, DC, GA, KY, IL, IN, MA, MD, MI, MN, MO, NM, NV, NY, PA, TX, UT, VA, WA, WV, WY

Proposed Action Description:

THIRD AMENDED PROGRAMMATIC NEPA DETERMINATION (See attached original Programmatic Determination, dated December 20, 2022, First Amended Determination, dated January 17, 2023, and Second Amended Determination, dated January 31, 2023). The MINER Program is composed of 17 small-scale research and development projects that will be conducted by universities, for-profit entities, and federal laboratories. This Third Amended Determination adds 5 projects (Columbia University, University of Kentucky, Pacific Northwest National Laboratory, Travertine Technologies, and Harvard University) (see Attachment A for projects covered by this and the prior Determinations, with the 5 additional project highlighted in bold). This project is covered by and fits within the class of actions identified under the DOE Categorical Exclusions identified below. This assessment was based on a review of the proposed scope of work and the potential environmental impacts of each project. The seven additional prime recipients have certified that all project tasks will be conducted in accordance with established safety and materials/waste management protocols and pursuant to applicable Federal, State, and Local regulatory requirements.

Categorical Exclusion(s) Applied:

A9 - Information gathering, analysis, and dissemination

B3.6 - Small-scale research and development, laboratory operations, and pilot projects

B3.15 - Small-scale indoor research and development projects using nanoscale materials

For the complete DOE National Environmental Policy Act regulations regarding categorical exclusions, including the full text of each categorical exclusion, see Subpart D of [10 CFR Part 1021](#).

Regulatory Requirements in 10 CFR 1021.410(b): (See full text in regulation)

The proposal fits within a class of actions that is listed in Appendix A or B to 10 CFR Part 1021, Subpart D.

To fit within the classes of actions listed in 10 CFR Part 1021, Subpart D, Appendix B, a proposal must be one that would not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environment, safety, and health, or similar requirements of DOE or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities (including incinerators), but the proposal may include categorically excluded waste storage, disposal, recovery, or treatment actions or facilities; (3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that preexist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources, including, but not limited to, those listed in paragraph B(4) of 10 CFR Part 1021, Subpart D, Appendix B; (5) involve genetically engineered organisms, synthetic biology, governmentally designated noxious weeds, or invasive species, unless the proposed activity would be contained or confined in a manner designed and operated to prevent unauthorized release into the environment and conducted in accordance with applicable requirements, such as those listed in paragraph B(5) of 10 CFR Part 1021, Subpart D, Appendix B.

There are no extraordinary circumstances related to the proposal that may affect the significance of the environmental effects of the proposal.

The proposal has not been segmented to meet the definition of a categorical exclusion. This proposal is not connected to other actions with potentially significant impacts (40 CFR 1508.25(a)(1)), is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1508.27(b)(7)), and is not precluded by 40 CFR 1506.1 or 10 CFR 1021.211 concerning limitations on actions during preparation of an environmental impact statement.

Based on my review of the proposed action, as NEPA Compliance Officer (as authorized under DOE Order 451.1B), I have determined that the proposed action fits within the specified class(es) of action, the other regulatory requirements set forth above are met, and the proposed action is hereby categorically excluded from further NEPA review.

NEPA Compliance Officer: Approved via email

Date Determined: February 22, 2023



U.S. Department of Energy Categorical Exclusion Determination Form

Submit by E-mail

Proposed Action Title: Mining Innovations for Negative Emissions Resource Recovery (MINER) Program (FOA No. DE-FOA-0002707 and DE-FOA-0002708)

Program or Field Office: Advanced Research Projects Agency - Energy

Location(s) (City/County/State): AZ, CA, CO, IL, MA, MD, MI, MN, MO, NM, NV, NY, TX, UT, VA, WA

Proposed Action Description:

SECOND AMENDED PROGRAMMATIC NEPA DETERMINATION (See attached original Programmatic Determination, dated December 20, 2022 and First Amended Determination, dated January 12, 2023). The MINER Program seeks to increase the U.S. domestic supplies of copper, nickel, lithium, cobalt, and other rare earth elements. Specifically, projects funded under the MINER Program aim to (1) decrease comminution energy by 50% compared to state-of-the-art; (2) increase yield of energy-relevant minerals by reducing unrecovered energy-relevant minerals in the tailings by 50% compared to state-of-the-art; and (3) enable the negative emissions production of key minerals by sequestering >10 wt.% CO₂e per metric ton of carbon dioxide-reactive ore processed. If successful, the commercial-ready technologies developed under the MINER projects will decrease energy use of mineral processing and increase the yield of energy-relevant minerals via novel net-zero or negative emission technologies. The MINER Program is composed of 17 small-scale research and development projects that will be conducted by universities, for-profit entities, and federal laboratories. This Second Amended Determination adds 1 project (University of Arizona) (see Attachment A for all 9 projects covered by this and the prior Determinations). This project is covered by and fits within the class of actions identified under the DOE Categorical Exclusions identified below. This assessment was based on a review of the proposed scope of work and the potential environmental impacts of each project. The prime recipient has certified that all project tasks will be conducted in accordance with established safety and materials/waste management protocols and pursuant to applicable Federal, State, and Local regulatory requirements.

Categorical Exclusion(s) Applied:

A9 - Information gathering, analysis, and dissemination

B3.6 - Small-scale research and development, laboratory operations, and pilot projects

B3.15 - Small-scale indoor research and development projects using nanoscale materials

For the complete DOE National Environmental Policy Act regulations regarding categorical exclusions, including the full text of each categorical exclusion, see Subpart D of [10 CFR Part 1021](#).

Regulatory Requirements in 10 CFR 1021.410(b): (See full text in regulation)

The proposal fits within a class of actions that is listed in Appendix A or B to 10 CFR Part 1021, Subpart D.

To fit within the classes of actions listed in 10 CFR Part 1021, Subpart D, Appendix B, a proposal must be one that would not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environment, safety, and health, or similar requirements of DOE or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities (including incinerators), but the proposal may include categorically excluded waste storage, disposal, recovery, or treatment actions or facilities; (3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that preexist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources, including, but not limited to, those listed in paragraph B(4) of 10 CFR Part 1021, Subpart D, Appendix B; (5) involve genetically engineered organisms, synthetic biology, governmentally designated noxious weeds, or invasive species, unless the proposed activity would be contained or confined in a manner designed and operated to prevent unauthorized release into the environment and conducted in accordance with applicable requirements, such as those listed in paragraph B(5) of 10 CFR Part 1021, Subpart D, Appendix B.

There are no extraordinary circumstances related to the proposal that may affect the significance of the environmental effects of the proposal.

The proposal has not been segmented to meet the definition of a categorical exclusion. This proposal is not connected to other actions with potentially significant impacts (40 CFR 1508.25(a)(1)), is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1508.27(b)(7)), and is not precluded by 40 CFR 1506.1 or 10 CFR 1021.211 concerning limitations on actions during preparation of an environmental impact statement.

Based on my review of the proposed action, as NEPA Compliance Officer (as authorized under DOE Order 451.1B), I have determined that the proposed action fits within the specified class(es) of action, the other regulatory requirements set forth above are met, and the proposed action is hereby categorically excluded from further NEPA review.

NEPA Compliance Officer: Signed via email

Date Determined: January 31, 2023



U.S. Department of Energy

Categorical Exclusion Determination Form

Submit by E-mail

Proposed Action Title: Mining Innovations for Negative Emissions Resource Recovery (MINER) Program (FOA No. DE-FOA-0002707 and DE-FOA-0002708)

Program or Field Office: Advanced Research Projects Agency - Energy

Location(s) (City/County/State): CA, CO, IL, MA, MD, MI, MN, MO, NM, NV, NY, TX, UT, VA

Proposed Action Description:

FIRST AMENDED PROGRAMMATIC NEPA DETERMINATION (See attached original Programmatic Determination, dated December 20, 2022). The MINER Program is composed of 17 small-scale research and development projects that will be conducted by universities, for-profit entities, and federal laboratories. This First Amended Determination adds 7 projects (Columbia University, Colorado School of Mines, Johns Hopkins University, Michigan Technological University, Missouri University of Science and Technology, Phoenix Tailings, Inc., and University of Nevada, Reno) (see Attachment A for projects covered by this and the prior Determination, with the 7 additional projects highlighted in bold). These projects are covered by and fit within the class of actions identified under the DOE Categorical Exclusions identified below. This assessment was based on a review of the proposed scope of work and the potential environmental impacts of each project. The seven additional prime recipients have certified that all project tasks will be conducted in accordance with established safety and materials/waste management protocols and pursuant to applicable Federal, State, and Local regulatory requirements.

Categorical Exclusion(s) Applied:

A9 - Information gathering, analysis, and dissemination

B3.6 - Small-scale research and development, laboratory operations, and pilot projects

B3.15 - Small-scale indoor research and development projects using nanoscale materials

For the complete DOE National Environmental Policy Act regulations regarding categorical exclusions, including the full text of each categorical exclusion, see Subpart D of [10 CFR Part 1021](#).

Regulatory Requirements in 10 CFR 1021.410(b): (See full text in regulation)

The proposal fits within a class of actions that is listed in Appendix A or B to 10 CFR Part 1021, Subpart D.

To fit within the classes of actions listed in 10 CFR Part 1021, Subpart D, Appendix B, a proposal must be one that would not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environment, safety, and health, or similar requirements of DOE or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities (including incinerators), but the proposal may include categorically excluded waste storage, disposal, recovery, or treatment actions or facilities; (3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that preexist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources, including, but not limited to, those listed in paragraph B(4) of 10 CFR Part 1021, Subpart D, Appendix B; (5) involve genetically engineered organisms, synthetic biology, governmentally designated noxious weeds, or invasive species, unless the proposed activity would be contained or confined in a manner designed and operated to prevent unauthorized release into the environment and conducted in accordance with applicable requirements, such as those listed in paragraph B(5) of 10 CFR Part 1021, Subpart D, Appendix B.

There are no extraordinary circumstances related to the proposal that may affect the significance of the environmental effects of the proposal.

The proposal has not been segmented to meet the definition of a categorical exclusion. This proposal is not connected to other actions with potentially significant impacts (40 CFR 1508.25(a)(1)), is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1508.27(b)(7)), and is not precluded by 40 CFR 1506.1 or 10 CFR 1021.211 concerning limitations on actions during preparation of an environmental impact statement.

Based on my review of the proposed action, as NEPA Compliance Officer (as authorized under DOE Order 451.1B), I have determined that the proposed action fits within the specified class(es) of action, the other regulatory requirements set forth above are met, and the proposed action is hereby categorically excluded from further NEPA review.

NEPA Compliance Officer: **Approved via email**

Date Determined: **January 17, 2023**



U.S. Department of Energy

Categorical Exclusion Determination Form

Submit by E-mail

Proposed Action Title: Mining Innovations for Negative Emissions Resource Recovery (MINER) Program (FOA No. DE-FOA-0002707 and DE-FOA-0002708)

Program or Field Office: Advanced Research Projects Agency - Energy

Location(s) (City/County/State): Arlington, Texas; Los Angeles, California

Proposed Action Description:

The MINER Program seeks to increase the U.S. domestic supplies of copper, nickel, lithium, cobalt, and other rare earth elements. Specifically, projects funded under the MINER Program aim to (1) decrease comminution energy by 50% compared to state-of-the-art; (2) increase yield of energy-relevant minerals by reducing unrecovered energy-relevant minerals in the tailings by 50% compared to state-of-the-art; and (3) enable the negative emissions production of key minerals by sequestering >10 wt.% CO₂e per metric ton of carbon dioxide-reactive ore processed. If successful, the commercial-ready technologies developed under the MINER projects will decrease energy use of mineral processing and increase the yield of energy-relevant minerals via novel net-zero or negative emission technologies.

The MINER Program is composed of 16 small-scale research and development projects that will be conducted by universities, for-profit entities, and federal laboratories. This Determination covers 1 of the 16 projects (University of Texas - Arlington) (see Attachment A). This project is covered by and fits within the class of actions identified under the DOE Categorical Exclusions identified below. This assessment was based on a review of the proposed scope of work and the potential environmental impacts of each project. All project tasks will be conducted in accordance with established safety and materials/waste management protocols and pursuant to applicable Federal, State, and Local regulatory requirements

Categorical Exclusion(s) Applied:

A9 - Information gathering, analysis, and dissemination

B3.6 - Small-scale research and development, laboratory operations, and pilot projects

B3.15 - Small-scale indoor research and development projects using nanoscale materials

For the complete DOE National Environmental Policy Act regulations regarding categorical exclusions, including the full text of each categorical exclusion, see Subpart D of [10 CFR Part 1021](#).

Regulatory Requirements in 10 CFR 1021.410(b): (See full text in regulation)

The proposal fits within a class of actions that is listed in Appendix A or B to 10 CFR Part 1021, Subpart D.

To fit within the classes of actions listed in 10 CFR Part 1021, Subpart D, Appendix B, a proposal must be one that would not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environment, safety, and health, or similar requirements of DOE or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities (including incinerators), but the proposal may include categorically excluded waste storage, disposal, recovery, or treatment actions or facilities; (3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that preexist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources, including, but not limited to, those listed in paragraph B(4) of 10 CFR Part 1021, Subpart D, Appendix B; (5) involve genetically engineered organisms, synthetic biology, governmentally designated noxious weeds, or invasive species, unless the proposed activity would be contained or confined in a manner designed and operated to prevent unauthorized release into the environment and conducted in accordance with applicable requirements, such as those listed in paragraph B(5) of 10 CFR Part 1021, Subpart D, Appendix B.

There are no extraordinary circumstances related to the proposal that may affect the significance of the environmental effects of the proposal.

The proposal has not been segmented to meet the definition of a categorical exclusion. This proposal is not connected to other actions with potentially significant impacts (40 CFR 1508.25(a)(1)), is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1508.27(b)(7)), and is not precluded by 40 CFR 1506.1 or 10 CFR 1021.211 concerning limitations on actions during preparation of an environmental impact statement.

Based on my review of the proposed action, as NEPA Compliance Officer (as authorized under DOE Order 451.1B), I have determined that the proposed action fits within the specified class(es) of action, the other regulatory requirements set forth above are met, and the proposed action is hereby categorically excluded from further NEPA review.

NEPA Compliance Officer: Approved via email

Date Determined: December 20, 2022

Attachment A: Projects in the MINER (FOA No. DE-FOA-0002707 and DE-FOA-0002708) Program

Prime Recipient (Control No.)	Project Title	Project Description	Categorical Exclusion
Columbia University (2707-1523)	Hydrometallurgical Production of Domestic Metals for Energy Transition	Columbia University will develop new processes with lower environmental impact to obtain energy relevant metals from mines that are olivine-rich at lower cost than state of the art processes. Olivine is a CO ₂ -reactive waste product that can be returned as tailings after capture carbon from the air. Columbia will improve the yield of nickel (Ni) and copper (Cu) from its partner mining operation, simultaneously increasing the amount of carbon captured per kilogram of metal. Innovations are based on a recent discovery of rapid mineral-leach kinetics with reagents that can be regenerated by an electrochemical process inspired by flow-battery technologies. The chemistry and process may enable the replacement of smelters for processing sulfide minerals. The technology has been proved for copper-sulfide minerals, which will improve the yields of Cu and ultimately Ni. This project is comprised of bench-scale laboratory activities, with an outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials and permits that it will need over the course of this project.	A9, B3.6
University of Kentucky (2707-1555)	Development of a Carbon-Negative Process for Comminution Energy Reduction and Energy- Relevant Mineral Extraction through Carbon Mineralization and Biological Carbon Fixation	The University of Kentucky's proposed technology will use CO ₂ emitted at or near operating mines and processing operations to reduce the energy consumed during grinding by more than 50% while improving the recovery of critical energy relevant minerals by 20% or greater. In this approach, CO ₂ will be mixed with ore containing the valuable minerals, especially copper (Cu) and rare earth elements, to improve the efficiency of grinding and separation. Additionally, biological fixation of CO ₂ will be studied and employed in producing acid that can be used to recover Cu from low grade feedstocks. If successful, the project will provide a novel carbon-negative process using waste CO ₂ to increase the amount of recoverable valuable energy-relevant minerals. This project is comprised of bench-scale laboratory activities, with an outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials and permits that it will need over the course of this project.	A9, B3.6

Attachment A: Projects in the MINER (FOA No. DE-FOA-0002707 and DE-FOA-0002708) Program

Prime Recipient (Control No.)	Project Title	Project Description	Categorical Exclusion
<p>Pacific Northwest National Laboratory (2707-1502)</p>	<p>Supercritical CO2-Based Mining for Carbon-Negative Critical Mineral Recovery</p>	<p>Efficient, net carbon negative and cost-effective technologies are needed to decarbonize the mining industry, address depletion of high value ore grades, minimize hazardous legacy of tailing piles, and ultimately develop a resilient supply chain of domestic energy-relevant bearing minerals. This project aims to deliver the first integrated technology and comprehensive suite of methods for in situ scCO2-Enhanced Mineral Recovery (scCO2-EMR) and permanent carbon storage via mineralization of mafic-ultramafic formations. If successful, this project will establish a methodology for identifying exploration vectors used for ranking target assets across the U.S. and expanding the energy relevant mineral supply chain by exploiting low value ores while creating a carbon-negative pathway, reducing energy cost by 63% and mineralizing ~110 kg CO2 per kg of metal extracted. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	<p>A9, B3.6</p>
<p>Travertine Technologies, Inc. (2708-1505)</p>	<p>Ex Situ Tailings Leaching and Lateritization with Electrolytic Acid Recycling for Critical Metal Concentration and Mineral Carbon Sequestration</p>	<p>Travertine will launch a transformative process that integrates strong acid treatment of mining waste or tailings with electrolytic acid recycling. Leached critical elements are recovered as oxides, while carbonate minerals are precipitated using carbon dioxide (CO2) from the air. Travertine will develop the design basis for a 1 ton/day CO2 removal system to demonstrate the technical feasibility and commercial viability of this concept, taking it from proof-of-concept to field-ready. If successful, the project will offer a commercially viable approach that will maximize critical element yield from domestic resources while minimizing environmental impacts and potentially sequestering hundreds of millions of tons of carbon dioxide every year. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	<p>A9, B3.6</p>
<p>Harvard University (2702-1519)</p>	<p>Developing Advanced NMR Techniques to Predict and Monitor</p>	<p>Harvard University will develop advanced nuclear magnetic resonance (NMR) methods for evaluating the chemistry of CO2 mineralization in CO2 reactive rocks. Reactions with these rocks enables the permanent sequestration of CO2, and</p>	<p>A9, B3.6</p>

Attachment A: Projects in the MINER (FOA No. DE-FOA-0002707 and DE-FOA-0002708) Program

Prime Recipient (Control No.)	Project Title	Project Description	Categorical Exclusion
	<p>CO2 Storage and Mineralization for Enhanced Mining Exploration and Operation</p>	<p>promotes enhanced mineral extraction. Mineralization reactions occur only in pores occupied by CO2; thus, understanding CO2 transport and distribution in rock porosities is key to efficient mineralization and sequestration. NMR well-logging allows accurate evaluation of CO2 reactive rock formations to optimize field development for the economical deployment of mining and carbon storage. If successful, Harvard will expand the productive fields for CO2 injection and enhanced mining by 100%. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	
<p>Arizona State University (2702-1515)</p>	<p>Re-Mining Red Mud Waste for CO2 Capture and Storage and Critical Element Recovery (RMCCS-CER)</p>	<p>Arizona State University in partnership with Pacific Northwest National Laboratory will advance in-situ and ex-situ techniques to determine the solubility and thermodynamic properties of various sodium rare earth element (REE) carbonates, REE (hydroxy)carbonates, REE phosphate, and REE (oxy)hydroxides in various solutions and pressures and temperature conditions, with or without the presence of carbon dioxide (CO2). The team will use the results to construct a database for optimizing conditions that efficiently recover energy-relevant minerals in red mud waste. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	<p>A9, B3.6</p>
<p>Colorado School of Mines (2707-1553)</p>	<p>Block Modeling of the Carbonation Potential of Ore Deposits Using Cutting-Edge Core Scanning Technology and Advanced Machine Learning Algorithms</p>	<p>The Colorado School of Mines will develop a novel technological solution to enable mining companies to quantitatively model the carbonation potential of CO2-reactive copper-nickel-platinum-group element ore deposits using cutting-edge X-ray fluorescence core scanning technology and advanced machine learning techniques. The quantitative models will allow the first of its kind cost-benefit analysis of the total carbonation potential of ore deposits to demonstrate that adapting negative emission technologies will become an integral part of mine feasibility studies. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety)</p>	<p>A9, B3.6</p>

Attachment A: Projects in the MINER (FOA No. DE-FOA-0002707 and DE-FOA-0002708) Program

Prime Recipient (Control No.)	Project Title	Project Description	Categorical Exclusion
		<p>approvals necessary for use of all the materials that it will need over the course of this project.</p>	
<p>Columbia University (2707-1561)</p>	<p>Innovative Stirred Media Mill Reactor with Integrated Carbon Mineralization and Electrochemical Separation of Critical Metals (critical SMIM-e)</p>	<p>Columbia University will develop a more energy efficient, highly integrated renewable-energy-driven carbon mineralization and metal recovery technology from low-grade ores. The concept will enable concurrent metal valorization and CO2 sequestration via an autogenous, reactive comminution reactor system that can simultaneously provide high specific surface area mineral particles and accelerate mineral dissolution by removing silicon-rich passivation layers. This approach reduces comminution energy consumption and can be coupled with sustainable carbon mineralization and electrochemical recovery of key energy minerals using selective oxidation and reduction pathways. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	<p>A9, B3.6</p>
<p>Johns Hopkins University (2707-1550)</p>	<p>Carbon-Negative Mining from Gangue Minerals Enabled by Energy-Efficient Electrosynthesis of Acid and Base</p>	<p>Johns Hopkins University will develop sustainable mining of critical elements, such as manganese (Mn), cobalt (Co), nickel (Ni), copper (Cu), etc., from gangue minerals. The technology is based on robust acid-base chemistries and renewable electricity as the power source. It will enable the use of unconventional mineral sources for mining of energy-relevant critical metals. It will also avoid high-temperature thermochemical processing, minimize the discharge of hazardous chemical wastes and substantially reduce the carbon emission of mining industries. The proposed process represents a sustainable approach toward increasing domestic supplies of critical materials required for the transition to clean energy. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	<p>A9, B3.6</p>
<p>Michigan Technological</p>	<p>Energy Reduction and Improved Critical Mineral Recovery from</p>	<p>Michigan Technological University (MTU) will achieve a decrease of 10 wt% CO2 equivalent per tonne of ore processed compared with the current methods for primary nickel extraction by storing CO2 in CO2-reactive minerals and recovering 80% of energy-</p>	<p>A9, B3.6</p>

Attachment A: Projects in the MINER (FOA No. DE-FOA-0002707 and DE-FOA-0002708) Program

Prime Recipient (Control No.)	Project Title	Project Description	Categorical Exclusion
<p>University (2707-1510)</p>	<p>Low-Grade Disseminated Sulphide Deposits and Mine Tailings</p>	<p>relevant minerals from both sulfide and nickel-bearing silicate minerals in mine tailings. MTU will validate (1) 200 kg of CO2 storage per tonne of magnesium-rich and iron-rich silicate minerals in mine tailings within 4 hours after processing with 10% energy reduction compared with state-of-the-art, and (2) a recovery of 50-80% yield of nickel from domestic low-grade disseminated sulfide ores. An estimated 2.2 million tonnes of CO2 per year will be sequestered in mine tailings that are permanently and safely stored with a decrease of 100 kg of CO2 equivalent per tonne of ore processed. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	
<p>Missouri University of Science and Technology (2707-1528)</p>	<p>Reduce Comminution Energy and Improve Energy Relevant Mineral Yield Using Carbon-Negative Oxalate Reactions</p>	<p>Missouri University of Science and Technology aims to establish a novel pathway to extract energy-relevant minerals, such as nickel and cobalt, from CO2-reactive and low-grade silicate feedstock (e.g., lean ore, mine waste, and geologic formations) via a novel pretreatment using a CO2- or biomass-derived organic acid that can dissolve silicates efficiently and liberate metals. The progressive dissolution will be followed by the precipitation of oxalate products, turning the bulky silicate rocks into micron-sized crystal particles and amorphous silica. The micron-sized crystal particles reduce the need for energy-intensive comminution during mineral beneficiation, and the separated crystalline oxalates will be further processed using hydrometallurgical approaches to separate the desired energy-relevant minerals. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	<p>A9, B3.6</p>
<p>Phoenix Tailings, Inc. (2708-1515)</p>	<p>CO2 GONE – CO2 Gasification of Ore for Nickel Extraction</p>	<p>Phoenix Tailings' CO2 GONE process uses and recycles carbon dioxide (CO2) to extract energy-relevant minerals, primarily nickel (Ni) and magnesium (Mg), from iron- and aluminum-rich ore through carbonation with CO2. Using CO2 with high pressures, temperatures and mixing breaks the rock structure and allows for greater extraction of energy relevant elements like Ni and Mg, which are then converted to metal carbonates (NiCO3, MgCO3). The resulting NiCO3 and MgCO3 are chemically separated by</p>	<p>A9, B3.6</p>

Attachment A: Projects in the MINER (FOA No. DE-FOA-0002707 and DE-FOA-0002708) Program

Prime Recipient (Control No.)	Project Title	Project Description	Categorical Exclusion
		<p>ammonia (NH3) and refined to generate high-purity nickel oxide (NiO) and magnesium carbonate. The process is carbon negative, sequesters CO2, and recycles CO2 and NH3 to keep the system operating efficiently. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	
<p>University of Nevada, Reno (2707-1516)</p>	<p>Accelerated Reactive Carbonation Process (ARCP) for Energy Efficient Separation of Rare Earth Minerals</p>	<p>The University of Nevada, Reno, will develop and test an accelerated reactive carbonation process to enable improved mineral liberation, energy-efficient comminution (grinding), and enhanced separation of rare earth elements from low-grade bastnaesite-bearing ores. High-pressure grinding rolls will pre-crush the ores to generate internal micro-cracks that will facilitate the subsequent carbonation and grinding process. The carbonation reaction will convert REE-bearing silicate minerals to REE-bearing carbonate minerals. The carbonation reaction from silicate to carbonate will soften the minerals, therefore reduce the comminution energy by 50% and increasing the total REEs yield by at least 20%. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	<p>A9, B3.6</p>
<p>University of Texas – Arlington (2707-1507)</p>	<p>RECLAIM: Electrochemical Lithium and Nickel Extraction with Concurrent Carbon Dioxide Mineralization</p>	<p>The University of Texas at Arlington will develop acoustic stimulation and electrolytic proton production to produce lithium (Li) and nickel (Ni) from CO2-reactive minerals and rocks that contain calcium (Ca) and magnesium (Mg), while sequestering CO2 in the form of carbonate solids. First, an electric potential will be applied to water to simultaneously produce acidity and alkalinity. Then, solid feedstocks (Li/Ni/Ca/Mg-rich igneous and sedimentary minerals) will be dissolved in the acidic anolyte under acoustic stimulation. This project is limited to bench-scale laboratory activities, with no outdoor or field-testing component, and has already obtained the required EH&S (Environmental, Health and Safety) approvals necessary for use of all the materials that it will need over the course of this project.</p>	<p>A9, B3.6, B3.15</p>

Bold text indicates the five projects added in the Third Amended CX.