

# MICA Analysis: What tools are available?...

**Session ID:** 07da983b-bdd6-455d-bc2a-0a65ccf84389

**Query:** What tools are available?

**Generated:** 2026-01-27 02:38 UTC

*Generated: 2026-01-26 20:38:42*

*Generated by MICA*

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# 1. Executive Summary

# MICA Capabilities: Comprehensive Summary

## 2. Analysis

# MICA Capabilities: Comprehensive Summary

## Executive Summary

MICA (Materials Intelligence Co-Analyst) is an AI-powered analytical system designed to support Department of Energy critical materials supply chain analysis. The system provides three core capabilities:

1. \*\*Analytical Frameworks\*\*: Ten specialized frameworks covering supply chain criticality assessment, vulnerability analysis, market dynamics, technology evaluation, and policy prioritization
2. \*\*Information Tools\*\*: Web search, document analysis, and multi-step orchestration capabilities for gathering and synthesizing intelligence
3. \*\*User-Friendly Approach\*\*: A structured "Three-Question Method" that guides analysts to select appropriate tools based on information needs, complexity, and urgency

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## Detailed Findings

### 1. MICA's Built-In Analytical Capabilities

#### Core Analytical Frameworks (10 Total) MICA employs structured methodologies for consistent, comprehensive analysis:

- \*\*Framework 1: Supply Chain Criticality Assessment\*\* - Evaluates materials using supply risk (geographic concentration, political stability, substitutability) and importance to clean energy missions
- \*\*Framework 2: Supply Chain Mapping & Vulnerability Analysis\*\* - Identifies dependencies and bottlenecks across extraction, processing, manufacturing, and end-use stages
- \*\*Framework 3-10\*\*: Additional frameworks covering market dynamics, cost analysis, technology assessment, geopolitical risk, environmental/regulatory compliance, alternative evaluation, scenario modeling, and policy prioritization

#### Information Processing Tools - \*\*Web Search\*\*: Real-time access to current market data, news, and developments - \*\*Document Analysis\*\*: Extraction and synthesis from government reports, research papers, and industry analyses - \*\*Orchestrator\*\*: Strategic planning capability that coordinates multi-step analyses and integrates multiple frameworks

### 2. External Tools Ecosystem

#### Commercial Data Platforms (Subscription-Based) - \*\*S&P; Global Market Intelligence\*\*. Comprehensive commodity data, pricing, and forecasts - \*\*Benchmark Mineral Intelligence\*\*. Battery supply chain specialization (\$25K-\$100K+ annually) - \*\*Roskill Information Services\*\*. Deep commodity-specific technical analysis - \*\*CRU Group\*\*. Cost modeling and capacity databases - \*\*Wood Mackenzie\*\*. Energy and materials market intelligence

\*\*Note\*\*: These are external commercial tools that complement MICA's capabilities but require separate procurement.

#### Specialized Databases The analysis identified numerous specialized resources including:  
- USGS Mineral Commodity Summaries (free, government) - IEA Critical Minerals databases (free)  
- UN Comtrade for trade flow analysis (free) - Various academic and industry-specific databases

### 3. Tool Selection Guidance

#### The Three-Question Method MICA provides a simplified decision framework:

\*\*Question 1: What do I need to know?\*\* - Factual information → Web Search (minutes) - Understanding/explanation → Orchestrator with appropriate framework (20-60 minutes) - Decision support → Multi-framework comprehensive analysis (1-3 hours)

\*\*Question 2: How complex is the question?\*\* - Simple (single fact) → Direct web search - Moderate (multiple data points) → Single framework analysis - Complex (strategic/multi-faceted) → Orchestrated multi-framework approach

\*\*Question 3: How urgent vs. thorough?\*\* - Quick answer → Most direct path - Thorough analysis → Comprehensive framework application - Leadership presentation → Full rigor with documentation

#### Practical Application Examples - \*\*"What's the current lithium price?"\*\* → Web Search (2-5 minutes) - \*\*"How critical is dysprosium?"\*\* → Framework 1: Criticality Assessment (30-45 minutes) - \*\*"Should we invest in domestic rare earth processing?"\*\* → Orchestrated analysis using Frameworks 1, 2, 6, and 10 (2-3 hours)

#### ## 4. Analytical Approach Characteristics

MICA's methodology emphasizes: - \*\*Evidence-based analysis\*\*: Grounding findings in available data with source citation - \*\*Transparency\*\*: Clear statement of limitations and assumptions - \*\*Structured thinking\*\*: Consistent application of analytical frameworks - \*\*Actionable outputs\*\*: Focus on decision-support for policy and investment - \*\*Multi-source synthesis\*\*: Integration of information across diverse sources

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#### ## Limitations and Caveats

1. \*\*Data Access\*\*: MICA cannot directly access proprietary commercial databases (S&P; Global, Benchmark Mineral Intelligence, etc.) without separate subscriptions
2. \*\*Real-time Limitations\*\*: Web search provides current information but may not access all paywalled or restricted content
3. \*\*Analytical Boundaries\*\*: MICA provides analysis and recommendations but cannot make final policy decisions
4. \*\*Source Quality\*\*: Analysis quality depends on availability and reliability of underlying data sources
5. \*\*Uncertainty\*\*: Complex supply chain questions often involve assumptions that should be validated with subject matter experts

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#### ## Recommendations

### For Immediate Use 1. \*\*Start with the Three-Question Method\*\* to quickly identify the right analytical approach 2. \*\*Use Web Search for factual queries\*\* requiring current information 3. \*\*Apply Framework 1 (Criticality Assessment)\*\* for material prioritization questions 4. \*\*Leverage the Orchestrator\*\* for complex, multi-dimensional strategic questions

### For Enhanced Capabilities 1. \*\*Consider commercial database subscriptions\*\* (Benchmark Mineral Intelligence, S&P; Global) for enhanced data access 2. \*\*Develop query templates\*\* for recurring analysis types to streamline workflows 3. \*\*Build institutional knowledge\*\* by documenting successful analytical approaches 4. \*\*Integrate MICA with existing DOE data systems\*\* where possible

### For Optimal Results 1. \*\*Be specific in queries\*\*: "What is China's share of rare earth processing capacity?" vs. "Tell me about rare earths" 2. \*\*Specify desired output format\*\*: Brief, comprehensive report, data table, etc. 3. \*\*Indicate urgency and depth requirements\*\* to guide tool selection 4. \*\*Request source citations\*\* when evidence documentation is critical

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\*\*Bottom Line\*\*: MICA provides a comprehensive analytical toolkit combining built-in frameworks, information gathering capabilities, and strategic orchestration. The system is most effective when users clearly articulate their information needs and select tools matched to query complexity and urgency requirements.

### **3. Results: step\_0**

# Analysis: MICA's Capabilities Documentation

## Overview This analysis documents MICA's (Materials Intelligence Co-Analyst) complete toolset and capabilities for critical materials supply chain analysis.

## Available Tools & Capabilities

### 1. \*\*Information Retrieval & Research\*\* - \*\*Web Search\*\*: Access to current information about materials markets, policies, and industry developments - \*\*Document Analysis\*\*: Ability to process and synthesize information from reports, academic papers, and policy documents - \*\*Data Integration\*\*: Combining information from multiple sources to create comprehensive analyses

### 2. \*\*Analytical Capabilities\*\*

#### Supply Chain Analysis - \*\*Mapping supply chains\*\* from mining through processing to end-use applications - \*\*Identifying bottlenecks\*\* and single points of failure - \*\*Assessing geographic concentration\*\* and geopolitical risks - \*\*Evaluating alternative sources\*\* and supply diversification options

#### Market & Economic Analysis - \*\*Price trend analysis\*\* and cost modeling - \*\*Supply-demand balance\*\* assessments - \*\*Import dependency\*\* calculations - \*\*Trade flow analysis\*\* between countries and regions - \*\*Production capacity\*\* evaluation (current and planned)

#### Technology & Materials Assessment - \*\*Material substitution\*\* feasibility analysis - \*\*Recycling and circular economy\*\* potential - \*\*Processing technology\*\* comparisons - \*\*Purity requirements\*\* and specifications for different applications

#### Risk Assessment - \*\*Geopolitical risk\*\* evaluation - \*\*Environmental and regulatory\*\* compliance analysis - \*\*Supply disruption\*\* scenario modeling - \*\*Criticality assessments\*\* using DOE frameworks

## 3. \*\*Query Processing Approach\*\*

MICA employs a structured methodology:

1. \*\*Query Understanding\*\*: Decompose complex questions into analyzable components
2. \*\*Planning\*\*: Develop multi-step analysis plans tailored to the query
3. \*\*Research\*\*: Gather relevant information from available sources
4. \*\*Synthesis\*\*: Integrate findings into coherent insights
5. \*\*Recommendations\*\*: Provide actionable conclusions with supporting evidence

## 4. \*\*Knowledge Domains\*\*

#### Critical Materials Coverage - \*\*Rare Earth Elements\*\*: All 17 REEs, with focus on Nd, Pr, Dy, Tb for magnets - \*\*Battery Materials\*\*: Li, Co, Ni, graphite, manganese - \*\*Semiconductor Materials\*\*: Silicon, gallium, germanium, specialty gases - \*\*Structural Materials\*\*: Aluminum, copper, specialty alloys - \*\*Other Critical Materials\*\*: Per DOE critical materials list

#### Geographic Expertise - Major producing regions (China, Australia, Chile, DRC, etc.) - Processing hubs and refining capacity - Emerging production regions - U.S. domestic resources and production

#### Policy & Regulatory Framework - DOE critical materials strategy - Defense Production Act applications - CHIPS Act and IRA implications - International trade agreements and restrictions

## 5. \*\*Output Formats\*\*

MICA can deliver: - \*\*Executive summaries\*\* for

## 4. Results: step\_1

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## 5. Results: step\_2

# Analysis Step: Commercial and Open-Source Tools for Critical Materials Intelligence

### ## Executive Summary

This analysis identifies and categorizes commercial and open-source tools available for critical materials supply chain analysis, complementing MICA's analytical capabilities. These tools span data platforms, visualization software, modeling systems, and specialized databases relevant to DOE's critical materials mission.

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### ## 1. DATA PLATFORMS & DATABASES

#### ### \*\*Commercial Platforms\*\*

#### \*\*S&P; Global Market Intelligence (formerly IHS Markit)\*\* - \*\*Focus\*\*: Comprehensive commodity market data, pricing, supply-demand forecasts - \*\*Coverage\*\*: Metals, minerals, battery materials, rare earths - \*\*Strengths\*\*: Historical price data, production statistics, trade flows - \*\*Use Case\*\*: Market analysis, price forecasting, capacity tracking - \*\*Access\*\*: Subscription-based, premium pricing

#### \*\*Benchmark Mineral Intelligence\*\* - \*\*Focus\*\*: Battery supply chain and raw materials - \*\*Coverage\*\*: Lithium, cobalt, nickel, graphite, rare earths for EVs - \*\*Strengths\*\*: Megafactory database, cost curves, supply chain mapping - \*\*Use Case\*\*: EV battery supply chain analysis, capacity planning - \*\*Access\*\*: Subscription (\$25K-\$100K+ annually)

#### \*\*Roskill Information Services\*\* - \*\*Focus\*\*: Individual metal market reports and databases - \*\*Coverage\*\*: 50+ metals and minerals including critical materials - \*\*Strengths\*\*: Deep technical analysis, mine-level data, cost analysis - \*\*Use Case\*\*: Detailed commodity-specific assessments - \*\*Access\*\*: Per-report purchase or subscription

#### \*\*CRU Group\*\* - \*\*Focus\*\*: Metals and mining market analysis - \*\*Coverage\*\*: Base metals, specialty metals, fertilizers - \*\*Strengths\*\*: Cost modeling, capacity databases, consulting services - \*\*Use Case\*\*: Production cost analysis, competitiveness assessments - \*\*Access\*\*: Subscription-based

#### \*\*Wood Mackenzie\*\* - \*\*Focus\*\*: Energy and materials market intelligence - \*\*Coverage\*\*: Metals, mining, power & renewables integration - \*\*Strengths\*\*: Long-term forecasts, asset-level analysis - \*\*Use Case\*\*: Strategic planning, investment decisions - \*\*Access\*\*: Premium subscription

#### ### \*\*Government & Public Databases\*\*

#### \*\*USGS Mineral Commodity Summaries\*\* - \*\*Source\*\*: U.S. Geological Survey - \*\*Focus\*\*: Annual production, consumption, trade data for minerals - \*\*Coverage\*\*: 90+ mineral commodities - \*\*Strengths\*\*: Authoritative, free, historical data back decades - \*\*Limitations\*\*: Annual updates, 1-2 year data lag - \*\*Access\*\*: \*\*FREE\*\* - <https://www.usgs.gov/centers/nmic>

#### \*\*USGS Minerals Yearbook\*\* - \*\*Source\*\*: U.S. Geological Survey - \*\*Focus\*\*: Detailed country and commodity chapters - \*\*Coverage\*\*: Global minerals production and trade -

\*\*Strengths\*\*: Comprehensive, peer-reviewed - \*\*Limitations\*\*: 3-4 year publication lag - \*\*Access\*\*: \*\*FREE\*\*

#### \*\*UN Comtrade Database\*\* - \*\*Source\*\*: United Nations Statistics Division - \*\*Focus\*\*: Internati

## 6. Results: step\_3

# Analysis Step: Analytical Frameworks Documentation

## Executive Summary

This analysis documents the analytical frameworks that MICA employs for critical materials supply chain intelligence. These frameworks provide structured methodologies for approaching different types of queries, ensuring comprehensive, consistent, and actionable analysis for DOE decision-making.

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## 1. CORE ANALYTICAL FRAMEWORKS

### \*\*Framework 1: Supply Chain Criticality Assessment\*\*

\*\*Purpose\*\*: Evaluate the criticality of materials to national security and economic prosperity

\*\*Methodology\*\* (Based on DOE/NAS Framework): 1. \*\*Supply Risk Assessment\*\* - Geographic concentration (HHI - Herfindahl-Hirschman Index) - Political stability of producing nations (using governance indicators) - Substitutability constraints - Recycling rates and potential - Stockpile availability

2. \*\*Importance to Clean Energy\*\* - Role in energy transition technologies - Demand growth projections - Performance criticality (can it be substituted without performance loss?) - Volume requirements vs. global production

3. \*\*Criticality Matrix\*\* - \*\*X-axis\*\*: Supply risk (low to high) - \*\*Y-axis\*\*: Importance to mission (low to high) - \*\*Output\*\*: Prioritization for policy intervention

\*\*Application Example\*\*: - Query: "How critical is dysprosium to U.S. energy security?" - Framework guides analysis through supply concentration (China dominance), importance (permanent magnets in wind turbines, EVs), substitution limits, and recycling challenges

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### \*\*Framework 2: Supply Chain Mapping & Vulnerability Analysis\*\*

\*\*Purpose\*\*: Identify dependencies, bottlenecks, and single points of failure

\*\*Structure\*\*:

\*\*Stage 1: Extraction\*\* - Mine locations and ownership - Reserve concentrations - Production capacity and utilization - Regulatory environment - Environmental/social risks

\*\*Stage 2: Processing/Refining\*\* - Separation and purification facilities - Technology requirements - Processing capacity by region - Quality/purity specifications - Waste streams and environmental impact

\*\*Stage 3: Manufacturing\*\* - Intermediate product manufacturing (e.g., cathode materials, rare earth magnets) - Geographic distribution - Technology leaders - Capacity constraints

\*\*Stage 4: End-Use Integration\*\* - Final product assembly - Technology applications - Demand centers - Substitution possibilities at application level

**\*\*Stage 5: Recovery/Recycling\*\*** - Collection systems - Recycling technologies - Recovery rates - Economic viability

**\*\*Vulnerability Identification\*\***: - **Chokepoints**: Where >50% capacity is in single country/company - **Technology barriers**: Proprietary processes or IP constraints - **Infrastructure gaps**: Missing links in domestic supply chain - **Regulatory risks**: Export restrictions, environmental regulations - **Geopolitical risks**: Political instability, trade tensions

**\*\*Output Format\*\***: - Visual supply chain map (described textually) -

## 7. Results: step\_4

# Analysis Step: User-Friendly Tool Taxonomy

## Executive Summary

This step organizes MICA's available tools and capabilities into a clear, user-friendly taxonomy that enables analysts to quickly identify the right tool for their analytical needs. The taxonomy categorizes tools by function, use case, and analytical framework alignment.

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## MICA'S TOOL TAXONOMY

### **CATEGORY 1: INFORMATION GATHERING TOOLS**

#### **1.1 Web Search** - **Function**: Retrieve current information from online sources - **Best For**: - Recent news and developments - Current market prices and trends - Company announcements and policy updates - Verification of facts across sources - **Limitations**: - May not access paywalled content - Data quality varies by source - Requires source evaluation - **Framework Alignment**: All frameworks (data gathering phase)

#### **1.2 Document Analysis** - **Function**: Extract and synthesize information from specific documents - **Best For**: - Government reports (USGS, DOE, NAS) - Research papers and technical studies - Industry reports and market analyses - Policy documents and legislation - **Framework Alignment**: All frameworks (evidence base)

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### **CATEGORY 2: ANALYTICAL & SYNTHESIS TOOLS**

#### **2.1 Orchestrator (Strategic Planning)** - **Function**: Develop comprehensive analysis plans and coordinate complex multi-step analyses - **Best For**: - Breaking down complex queries into manageable steps - Designing analytical workflows - Integrating multiple frameworks - Coordinating parallel analytical tracks - **When to Use**: - Multi-faceted questions requiring several frameworks - Comprehensive assessments (e.g., "Should we invest in X?") - Strategic planning exercises - Policy option evaluations - **Framework Alignment**: - Policy Prioritization (Framework 10) - Alternative Assessment (Framework 6) - Integrated multi-framework analyses

**Example Applications**: - "Develop a comprehensive strategy for lithium supply security" - "Evaluate all options for reducing rare earth dependency" - "Create an investment prioritization framework for critical minerals"

#### **2.2 Synthesis Engine (Built-in Capability)** - **Function**: Integrate information from multiple sources into coherent analysis - **Best For**: - Connecting disparate data points - Identifying patterns and trends - Drawing insights from multiple frameworks - Creating unified narratives from complex information - **Framework Alignment**: All frameworks (synthesis phase)

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### ### \*\*CATEGORY 3: SPECIALIZED ANALYTICAL CAPABILITIES\*\*

#### \*\*3.1 Supply Chain Analysis\*\* - \*\*Function\*\*: Map and evaluate material flows from mine to end-use - \*\*Best For\*\*: - Identifying bottlenecks and chokepoints - Vulnerability assessments - Dependency mapping - Stage-by-stage risk evaluation - \*\*Framework Alignment\*\*: - Supply Chain Mapping (Framework 2) - Import Dependency Analysis (Framework 3) - Geopolitica