

A gated model for emerging risk in global mining

Four binding gates applied to ten mining implications. Two survive.

Cycle 1 of a standing register. Cycle 2 falls due before 10 November 2026.

6

GLOBAL TRENDS SCANNED

Each with a measured indicator

10

EVIDENCED IMPLICATIONS

Each carries a dated anchor

8

BELONG TO THE LINE

Each has a dated loss precedent

2

QUALIFY AS EMERGING

Neither can be priced today

A standing register with four binding gates and a defined way out.

Six feeds, two of them continuous, scanned against the global mining and metals sector.

WHAT THE REGISTER COVERS

- Global mining and metals. Six trends, one page each, cut off 11 September 2026.
- A 1 to 10 year horizon, after the CRO Forum convention.
- Every entry carries a dated, attributable signal or it does not enter.

HOW AN ENTRY EARNS ITS PLACE

- Four gates, all binding. A failure routes, it is not ignored.
- Five types, A to E, each with its own exit trigger.
- A named owner, a treatment, and the date that closes it.

THE SIX FEEDS

Macro and geopolitical	Legal and regulatory	Operational and supplier	Capital and insurance	Community and litigation	Technology and vendor
QUARTERLY	CONTINUOUS	QUARTERLY	QUARTERLY	QUARTERLY	CONTINUOUS

So what? Without a gate and an exit, a risk list only ever grows.

Two of ten implications qualify as emerging. Both are concentration.

The other eight carry a dated loss precedent, which makes them quantifiable and puts them with line management.

10

IMPLICATIONS DERIVED

From six global trends.

8

BELONG TO THE LINE

Each has a dated precedent.

2

QUALIFY AS EMERGING

Neither can be priced.

C

TYPE OF BOTH ENTRIES

Both are systemic.

Extraterritorial licensing prices non-Chinese provenance

Chinese rules now reach goods made outside China. Suspended to 10 November 2026, **with no extension announced**. The April 2025 rare-earth controls never lapsed.

Autonomous fleets may fail together

Four OEMs supply 88% of the 3,832 autonomous haul trucks tracked worldwide. Concentration is evidenced. **Correlated failure has no precedent.**

Why only two

At the 3% group EBITDA threshold, materiality admits almost everything, so uncertainty is the binding gate. Eight of the ten are already quantified, and those eight leave the register with a treatment budget attached.

So what? An emerging register earns its keep by emptying itself into the line register.

Neither entry has a loss precedent. That is why both qualify.

Each carries its gate results, an owner, a treatment and the trigger that closes it.

RISK 1 · SYSTEMIC, TYPE C

Extraterritorial licensing of foreign goods

Any product with 0.1% or more Chinese rare earth needs a MOFCOM licence, whoever makes it. **No extension announced.**

Signal MOFCOM 61 and 62, 9 October 2025.

FOUR GATES

Materiality Pass. Licence denial halts Tier-1 output.

Uncertainty Pass. The rule has never taken effect.

Horizon Pass. 2 to 5 years.

Evidence Pass. Dated and attributable.

Owner Group General Counsel, with Supply Chain.

Treatment Map rare-earth content across the top twenty suppliers.

Trigger Suspension expires 10 Nov 2026.

RISK 2 · SYSTEMIC, TYPE C

Correlated failure across autonomous fleets

Four OEMs supply 88% of 3,832 tracked autonomous trucks. Whether those fleets **share a failure point** is unknown.

Signal GlobalData Mining Intelligence Center, July 2025.

FOUR GATES

Materiality Pass. Fleet-wide stoppage exceeds 30 days.

Uncertainty Pass. No basis to price a multi-OEM failure.

Horizon Pass. 5 to 10 years.

Evidence Pass. The concentration is dated; the failure mode is not.

Owner Chief Information Officer, with Mining Operations.

Treatment Test the four brands for a shared dependency.

Trigger A vendor-side fleet outage at any operator.

So what? Research is the only treatment either entry can carry today.

4 MOFCOM Announcements 61 and 62, 9 Oct 2025; 70, 7 Nov 2025, suspending 55 to 58, 61 and 62 to 10 Nov 2026; 72, 9 Nov 2025. Announcement 18 of 2025 (seven medium and heavy rare earths, 4 Apr 2025) is not suspended. 5 GlobalData Mining Intelligence Center, Jul 2025: Caterpillar, Komatsu, Tonly and LGMG account for 88% of 3,832 tracked autonomous haul trucks. Single-vendor failure is a line risk, managed by contract and business continuity, and is not carried here. The register carries only the correlated case, in which fleets from more than one OEM stop for the same reason. Whether that case exists is the research task. The candidate common-mode vectors are a shared satellite-positioning and correction dependency, a common perception-sensor supply chain, a common fleet-management or traffic-control software layer, and a common remote-operations and connectivity pattern. None is evidenced as shared across the four OEMs today. The concentration satisfies the evidence gate; the failure mode does not, which is why confidence is Low and the treatment is research rather than a hedge.

Eight of ten implications already carry a dated loss precedent.

The status column follows the anchor. A dated anchor puts the exposure with the line.

TREND	IMPLICATION	ANCHOR	HORIZON	CONF	TYPE	CLUSTER	STATUS
Geopolitical	Market access turns political	Antimony regulus, Rotterdam: +228% to \$39,000/t, Nov-24 ⁶	Realised	High	A	Cascade	LINE
Legal	Host states reset terms by statute	Mali: \$430m settled; Loulo-Goukoto gold -76% in 2025 ⁷	Realised	High	A	Cascade	LINE
	Export quotas reshape supply	DRC export quota: 96,600t contained cobalt, 2026-27 ⁸	Realised	High	A	Cascade	LINE
	Extraterritorial licensing of foreign goods	Oct-25 rules reach foreign goods above 0.1% content ⁴	2-5y	Low	C	Cascade	EMERGING
Technological	IT and OT converge	Norsk Hydro: 40 countries, extrusion plants manual ⁹	Realised	Med	A	Independent	LINE
	Autonomous fleets may fail together	Four OEMs, 88% of 3,832 tracked autonomous trucks ⁵	5-10y	Low	C	Cascade	EMERGING
Economic	One asset reprices the global balance	Grasberg: 800kt wet material; PTFI 2026 -59% guided ¹⁰	Realised	High	A	Independent	LINE
	Insurance sets project pace, not price	Freeport: \$0.7bn collected after a \$0.5bn deductible ¹⁰	Realised	Med	A	Adjacent	LINE
Environmental	Weather now lands in quarterly output	Chile Jul-26: output -9.4% y/y on storms; guidance cut ¹¹	Realised	High	A	Independent	LINE
Societal	Courts settle legitimacy, years late	Cobre Panamá: suspended Nov-23, milling restarted May-26 ¹³	Realised	High	A	Cascade	LINE

6 of 10	CASCADE	Export control → friend-shored capital → volatile jurisdictions → statutory capture → force majeure → price spike → automation → licence erodes → permitting delay → shortfall.
3 of 10	INDEPENDENT	Geotechnical failure, cyber intrusion, drought and flood. These arrive whatever any government does, and the cascade hedge does nothing for them.

Insurance sits adjacent to the cascade rather than on it. The sequence is ZMK's causal hypothesis. Each link is separately evidenced; the ordering is inference.

So what? Send the treatment budget with them, or the transfer is a filing exercise.

6 Reuters, 3 Dec 2024, citing Argus "Antimony Regulus, trioxide grade, min 99.65% Sb, duty-unpaid Rotterdam": +228% year to date to \$39,000/t at late Nov 2024. Regulus is ingot metal, not the oxide. Cross-check on the same grade: USGS, via Argus, \$17.50/lb in Nov 2024, which is \$38,581/t at 2,204.62 lb/t, 1.1% below. 7 Barrick Mining; Mali settlement 24 Nov 2025, \$430m payable to the state. Separately, a \$1,035m loss on deconsolidation booked in Q2 2025 when the Loulo-Goukoto complex was derecognised: an accounting charge, not a payment. The two figures measure different things and are not alternatives. Loulo-Goukoto attributable gold 22.5t to 5.5t in 2025, -76%. 8 ARECOMS Decision 004/2025: export quota on cobalt contained in hydroxide, 87,000t base plus 9,600t strategic, not a production cap. 4 MOFCOM 61 and 62, 9 Oct 2025. 9 Norsk Hydro states 40 countries; Extruded Solutions, not the smelters, carried the largest losses. Nyrstar (Jan 2019) and Evolution (Aug 2024) were IT-only and both stated operations were unaffected. 10 Freeport: PTFI 2026 guidance now about 0.7bn lb Cu and 650koz Au, roughly 59% below pre-incident; \$0.7bn insurance collected in Q2 2026 after a \$0.5bn deductible. 11 Chile INE, 31 Aug 2026: Jul-26 output 403,424t against 445,322t, -9.4%, the lowest July since 2011, on northern storms; 35 to 55kt of 2026 guidance withdrawn. 12 The IEA's 2024-vintage 7% copper water-risk figure is not carried into GCMO 2026, its method was never published, and GCMO 2024 gave about 10% on a droughts-only basis. It is not used as an anchor; the Chile loss above replaces it. 13 First Quantum: milling restarted May 2026, 30 to 40kt guided for 2026.

China is the dominant refiner in 19 of 20 strategic minerals.

More than half of that group sits under export control. Each trend carries a measured indicator, a dated marker and a direction.

TREND	INDICATOR	HORIZON	WHAT MOVED, AND WHEN
Geopolitical Fragmentation replaces cooperation	#1 2026 LIST, 18% OF RESPONDENTS ¹⁴	1-2y	Geoeconomic confrontation tops the 2026 list at 18%, up two places. Armed conflict is second at 14%. ¹⁴
Legal and regulatory Statecraft runs through statute	7 DATED MEASURES, JUL-23 TO OCT-25 ¹⁵	1-2y	Gallium and germanium Jul-23. Graphite Oct-23. Antimony Aug-24. US dual-use Dec-24. Tungsten and four more Feb-25. Seven rare earths Apr-25. Technology and foreign-made goods Oct-25. Suspended in part to 10 Nov 2026. ⁴
Technological Capability outpaces institutions	30 → 5 ADVERSE OUTCOMES OF AI, 2-YR TO 10-YR ¹⁴	5-10y	No risk climbed further in the survey. Of four named incidents, only Norsk Hydro disrupted production. ⁹
Economic Resilience thins across the board	+8 PLACES: DOWNTURN AND INFLATION, 2-YR ¹⁴	1-2y	Downturn and inflation each rose eight places, to 11th and 21st. Asset bubble burst rose seven, to 18th. ¹⁴
Environmental Physical risk is arriving now	-9.4% CHILE COPPER OUTPUT, JUL- 26 Y/Y ¹¹	1-2y	Storms cut Chilean output to 403,424t in July 2026, the lowest July since 2011. Antofagasta and Lundin withdrew 35 to 55kt of guidance. Structural water stress is a separate vector: ICMM puts 65.7% of facilities on a high water-risk axis. ¹⁶
Societal and demographic Information integrity shapes consent	#2 MISINFORMATION, 2-YEAR OUTLOOK ¹⁴	2-5y	Misinformation ranks second on the two-year outlook, after two years at first. Polarization is third. On the 2026 list it sits fifth. ¹⁴

So what? Law now moves faster than geology, and it moves with dates attached.

14 WEF (2026), The Global Risks Report 2026, 21st ed., Geneva. GRPS n=1,302 usable of 1,564, fielded 12 Aug to 22 Sep 2025. WEF publishes three separate instruments: a single-pick current-year list, which is the only one carrying percentages, and two-year and ten-year severity rankings, which carry none. Ranks are labelled here by instrument because the same risk sits differently on each. 15 Global Trade Alert, Chinese export controls on critical raw materials: inventory and short history. 11 Chile INE, 31 Aug 2026; Antofagasta and Lundin Mining guidance releases, Jul and Aug 2026. 16 ICMM Global Mining and Metals Water Dataset, 22 Jul 2026: facility count across about 12,000 facilities, not production share. Cochilco's Mar-26 projection has Chilean copper mining seawater use rising from 40.7% of supply in 2024 to about 67.6% by 2034, so exposure and expected disruption are diverging. The July storm loss is a weather event; the water figures are structural exposure. The two are not aggregated. 12 IEA (2025 and 2026), Global Critical Minerals Outlook, Executive summary, CC BY 4.0. Verbatim: "China is the dominant refiner for 19 of the 20 minerals analysed, holding an average market share of around 70%"; "more than half of a broader group of energy-related minerals are subject to some form of export controls". The 2026 edition (16 Jul 2026) restates the refining share as 72% in 2025 excluding rare earths. The rejected 2024 copper water-risk figure is dealt with at note 13 on the implications page. 4 MOFCOM and State Council instruments; Announcement 26 of 2026, effective 1 Jul 2026, added a public reporting mechanism for export-control violations. 9 Company incident disclosures.

Three decisions, and a Cycle 2 date before 10 November 2026.

Cycle 1 closes with a published change log. Cycle 2 opens two new feeds and tests the scan for bias.

DECISIONS FOR THE COMMITTEE

- Accept eight implications into the line register, and release the treatment budget with them.
- Approve the two research tasks, name an owner for each, and report at Cycle 2.
- Set the Cycle 2 date. It has to land before the suspension expires.

WHAT CYCLE 2 ADDS

- Make supplier declaration of rare-earth content a standing request.
- Open a feed on vendor concentration in mine autonomy.
- Test the scan for type bias.

CHANGE LOG · CYCLE 1

- | | |
|-----------|--|
| REMOVED | ICSG's Oct-25 forecast of a 150kt 2026 copper deficit. Replaced 23 Apr-26 by a 96kt surplus. ¹⁷ |
| RE-RATED | Cobre Panamá from offline to partial restart, and water from 5-10y to realised. |
| RE-BASED | Environmental anchor from the IEA 2024 figure to the Chile Jul-26 loss. ¹² |
| CORRECTED | Antimony to metal, Mali to asset level, autonomy to correlated failure. |
| ADDED | Nothing, since Cycle 1 opens the register. |
| NOT USED | Types D and E: no induced or decaying entry surfaced. One type B entry reached the watchlist, pending a dated signal. |

So what? The change log is how the committee checks that Cycle 1 ran.

ANNEXES

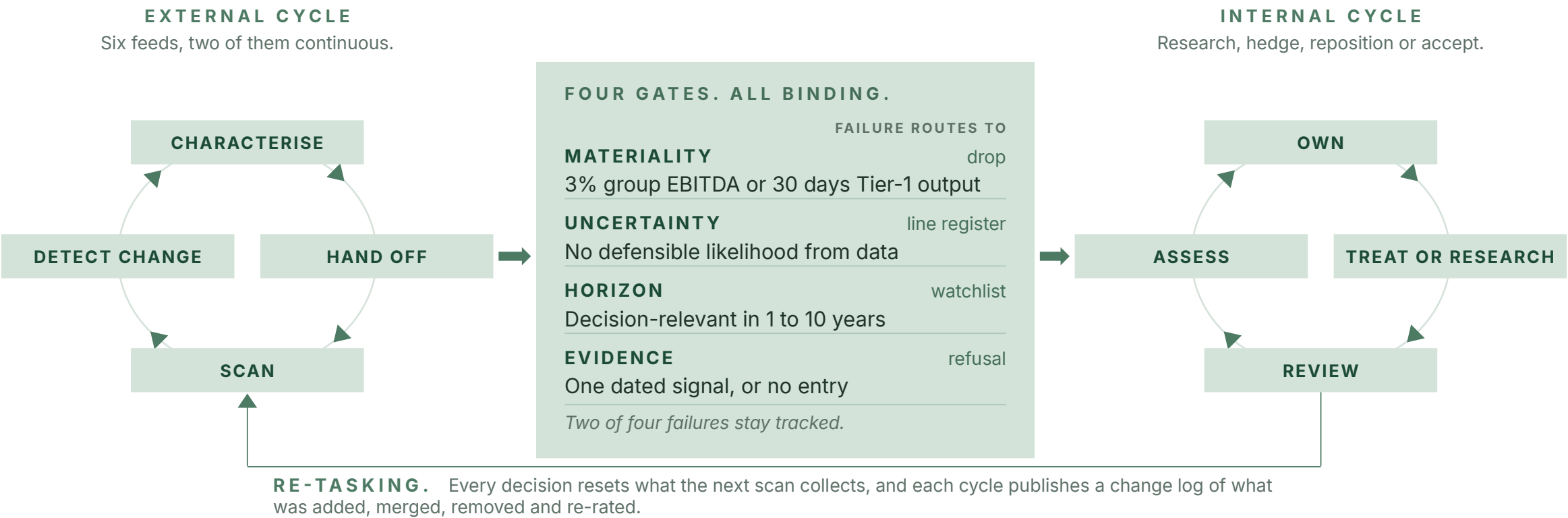
Method, definition, sources and further reading

The method and evidence behind the six pages above, and the trail from feed to register.

- A Method. Two loops of the risk intelligence cycle, and the four qualification gates.
- B Definition. What counts as emerging, the five types, and the exit criteria.
- C Sources. Seventeen named, dated sources. Fifteen are open access.
- D Further reading. Ten works, in reading order.

The internal cycle re-tasks the external scan after every decision.

ISO/TS 31050 risk intelligence cycle, with four binding gates between the external and internal cycles.



So what? A funnel returns what you already believed. A cycle returns what changed.

1 ISO/TS 31050:2023, Risk management — Guidelines for managing an emerging risk to enhance resilience, ISO/TC 262, 27 Oct 2023, 34pp. A Technical Specification, not a full International Standard. Clause 8 is "Risk intelligence cycle and managing emerging risks"; its two components are the external cycle and the internal cycle. 3 CRO Forum, Emerging Risk Initiative. The Initiative was founded in 2005; the radar is published annually, with editions publicly available from 2016. The six feeds are macro and geopolitical (quarterly), legal and regulatory (continuous), operational and supplier (quarterly), capital and insurance (quarterly), community and litigation (quarterly), technology and vendor (continuous). Feeds are collection channels; the six trends at page 6 are a reporting taxonomy. The mapping between them is many to many. Gates sort, they do not reject outright: a materiality failure is dropped and an evidence failure is refused, but an uncertainty failure goes to the line register and a horizon failure to the watchlist. Gate thresholds and feed cadence are ZMK design parameters.

Uncertainty decides what the register holds.

Three exits, each with a trigger and an action.

DEFINITION	THREE EXITS
A material exposure you cannot yet treat with confidence, decision-relevant within 1 to 10 years.	Becomes quantifiable → To the line register, with an owner. Signal reverses → Close. Log the reason and the date. Risk crystallises → Close, escalate, run the post-mortem.

TYPE	NAME	MEANING	EXAMPLE
A	Re-emergent	Known risk, new mechanism	Export control on a mature commodity
B	Novel	Fits no existing category	Dependence on an external AI ecosystem
C	Systemic	Connections change, parts do not	Friend-shored refineries fail together
D	Induced	Created by your own fix	Automation cuts jobs, erodes licence
E	Decaying	Materiality falling, releases capital	A bottleneck cleared by new capacity

So what? Without exits, this is just a second line register.

Every figure is traceable to a named, dated source.

Fifteen of seventeen are open access. Footnote numbers run in order of first appearance.

#	SOURCE	EVIDENCES	ACCESS	LOCATOR
1	ISO/TS 31050:2023, ISO/TC 262, 27 Oct 2023, 34pp	Risk intelligence cycle; external and internal cycles	Standard	iso.org/standard/54224.html
2	IRGC (2015), (2017) and (2018) guidelines	Definition basis; anticipate and respond protocol	Free	irgc.org
3	CRO Forum, Major Trends and Emerging Risk Radar, 2026 ed.	1 to 10 year horizon; change-log discipline	Free	thecroforum.org
4	MOFCOM Anns. 55-58, 61, 62, 70, 72; State Council Order 834	Extraterritorial scope; suspension to 10 Nov 2026	Primary	english.mofcom.gov.cn
5	GlobalData, Autonomous Trucks in the Global Mining Sector, 2025	Four OEMs, 88% of 3,832 tracked autonomous haul trucks	Paid	globaldata.com
6	Reuters, 3 Dec 2024, citing Argus; USGS MCS 2025 and 2026	Antimony regulus, Rotterdam, +228% to \$39,000/t	Free	reuters.com; doi.org/10.3133/mcs2026
7	Barrick Mining; Mali settlement, 24 Nov 2025; Mines Ministry	\$430m settled; Loulo-Gounkoto gold output -76%	Primary	barrick.com
8	DRC ARECOMS Decision 004/ARECOMS/2025, 20 Sep 2025	Export quota, 96,600t contained cobalt, 2026 and 2027	Primary	Ministry of Mines, DRC
9	Norsk Hydro, Nyrstar, Sibanye-Stillwater, Evolution disclosures	IT and OT convergence precedent, and its limits	Primary	hydro.com; evolutionmining.com.au
10	Freeport-McMoRan releases, Sep and Nov 2025; Q2 2026 Form 8-K	800kt wet material; PTFI 2026 -59%; \$0.7bn collected	Primary	investors.fcx.com; sec.gov
11	Chile INE, 31 Aug 2026; Antofagasta and Lundin Mining releases	Jul-26 output 403,424t, -9.4% y/y; guidance withdrawn	Primary	ine.gob.cl; antofagasta.co.uk
12	IEA, Global Critical Minerals Outlook 2025 and 2026, CC BY 4.0	Refining lead; export-control share; copper water risk	Free	iea.org/reports
13	First Quantum; Panama Supreme Court, 28 Nov 2023	Cobre Panama 350kt (2022); Apr-26 authorisation	Primary	first-quantum.com
14	WEF, The Global Risks Report 2026, 21st ed., GRPS n=1,302	Rankings on three instruments: 2026 list, 2-yr, 10-yr	Free	weforum.org/publications
15	Global Trade Alert, Chinese export controls inventory	Seven dated control measures, Jul-23 to Oct-25	Free	globaltradealert.org
16	ICMM Global Mining and Metals Water Dataset, 22 Jul 2026	65.7% of facilities on at least one high water-risk axis	Free	icmm.com/global-datasets/water
17	ICSG press statements, 7 Oct 2025 and 23 Apr 2026	2026 copper: 150kt deficit revised to a 96kt surplus	Free	icsg.org

ACCESS KEY	Free: open on the publisher's site. Primary: company or government disclosure, open. Standard: purchasable from ISO, abstract open. Paid: commercial research, cited figure stated publicly. Client: held on file, not public.
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So what? Only one paid report and the ISO standard are closed.

Ten works, in reading order for a first cycle.

Only the ISO technical specification must be purchased. The other nine are free.

01 START HERE

- **ISO/TS 31050:2023.** The only ISO deliverable on emerging risk, 34pp. [iso.org/standard/54224.html](https://www.iso.org/standard/54224.html) · paid

02 GOVERNANCE FRAME

- **IRGC (2015), Guidelines for Emerging Risk Governance.** Anticipate and respond. [irgc.org](https://www.irgc.org) · free
- **IRGC (2017), Introduction, revised.** Complexity, uncertainty, ambiguity. [irgc.org](https://www.irgc.org) · free
- **IRGC (2018), Governance of Systemic Risks.** Coupling, cascade, regime shift. doi.org/10.5075/epfl-irgc-257279 · free

03 PRACTITIONER BENCHMARK

- **CRO Forum, Major Trends and Emerging Risk Radar.** The 1 to 10 year horizon. thecroforum.org · free
- **WEF, The Global Risks Report.** Three instruments; read the methodology. weforum.org/publications · free

04 MINING DATA AND DISCLOSURE

- **EY, Top 10 business risks in mining and metals.** n=500, revenue above \$1bn. ey.com/en_gl/insights/mining-metals · free
- **Fraser Institute, Annual Survey of Mining Companies 2025.** 68 jurisdictions. fraserinstitute.org · free
- **USGS, Mineral Commodity Summaries 2026, 222pp.** The reference dataset. doi.org/10.3133/mcs2026 · free
- **GISTM (ICMM, UNEP, PRI); TNFD; IFRS S1 and S2.** The disclosure floor. thegtmi.org; tnfd.global; ifrs.org · free