# Module 3: Ore Grades, Cut-Offs & What "Good" Actually Looks Like

## Why this matters

A resource is just tonnage × grade. The grade tells you whether the project is economic. Without grade context, you can't tell a tier-1 deposit from a moose pasture.

This module gives you benchmarks by commodity so when you see a drill hit or resource update, you immediately know whether it's interesting or marketing.

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## Key concepts first

### Cut-off grade

The minimum grade above which rock is classified as economic to mine. Below cut-off = waste.

- Lower cut-off = more tonnes, lower average grade
- Higher cut-off = fewer tonnes, higher average grade
- Companies can manipulate the headline by adjusting cut-off. Always check the footnote.

### Strip ratio

Open-pit mining only. Tonnes of waste that must be moved per tonne of ore.

- 1:1 = excellent (ore right at surface)
- 3:1 to 5:1 = typical for most metals

- 8:1+ = high cost; only justified for high-grade or high-value ore
- 15:1+ = usually marginal at best

# Recovery rate

% of contained metal that can actually be extracted through processing.

- 90–95% = excellent (typical for clean sulphides)
- 70–85% = average
- <60% = problematic ("refractory" ore — needs expensive processing like roasting, pressure oxidation, or fine grinding)

# Head grade vs in-situ grade

- **In-situ grade** = grade of rock in the ground (the resource grade)
- **Head grade** = grade of rock fed to the processing plant
- They're often different because of dilution from waste rock during mining and selective mining (taking only the best stuff first in early years).

# Mining dilution

Waste rock that gets mixed with ore during extraction. Typically 5–15% in open pit, sometimes more in narrow-vein underground. Reduces head grade vs in-situ.

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# Grade benchmarks by commodity

## Gold (g/t Au)

| Context | Grade |
|---|---|
| Bulk-tonnage open pit | 0.5–1.5 g/t |
| Average open pit | 1–3 g/t |
| High-grade open pit | 3–5 g/t |
| Underground average | 4–8 g/t |
| High-grade underground | 8–15 g/t |
| Bonanza | 30+ g/t |

| Context | Grade |
|---|---|
| World-class deposit | usually >5 g/t with scale, or 1–2 g/t at very large scale (Cadia, Boddington) |

Cut-off grades typically:

- Open pit: 0.3–0.8 g/t
- Underground: 2–4 g/t

**ASX framing: PC2** drill intercepts in the 5–15 g/t Au range over meaningful widths place it in the high-grade open pit / underground crossover zone — well above marginal, well above the cut-off. **MI6** discoveries in similar high-grade ranges. The grade range matters more than any single eye-catching intercept — Module 4 covers how to read drill announcements properly.

# Copper (% Cu)

| Deposit type | Typical grade |
|---|---|
| Porphyry (large open pit) | 0.3–0.8% Cu |
| World-class porphyry | >0.6% Cu with billion-tonne scale |
| IOCG (Olympic Dam style) | variable; 0.5–2% Cu often with Au, U, REE credits |
| Sediment-hosted (Zambian/Congo style) | 1–5% Cu |
| Underground vein | 1–5% Cu typical |

Often quoted as **CuEq** (copper equivalent) — combines Cu with by-product credits (Au, Ag, Mo). Always check the assumptions: which prices, which recoveries, are by-product recoveries realistic? See the dedicated section below — equivalent grades are the single most common misread in mining announcements.

# Lithium

**Spodumene (hard rock):** measured in % $Li_2O$

- Greenbushes (WA, world's best): ~2.0%+ $Li_2O$
- Pilgangoora, Mt Marion, Wodgina: 1.0–1.5% $Li_2O$ typical
- Cut-off: 0.5–0.7% $Li_2O$
- Below 1% is generally marginal in the current market

**Brine (Salar):** measured in mg/L Li or ppm

- Atacama (Chile, world's best): 1500–2700 mg/L
- Argentine salars: typically 200–800 mg/L

- Mg:Li ratio matters — high magnesium = expensive processing

**ASX framing: GLN's** Hombre Muerto West sits at 859 mg/L average (with recent tests hitting 981 mg/L) — upper tier for Argentine brines, but well below Atacama. Critically, the Mg:Li ratio is low at HMW, which is why the project is economic where higher-grade salars with worse impurity profiles aren't. **ELV's** spodumene operation in Quebec operates in the typical 1.0–1.5% $Li_2O$ range; the economics there depend on hard-rock conversion costs and spodumene pricing more than on grade differentiation.

**Sedimentary / clay:** newer, no proven commercial production at scale (yet). Treat with skepticism.

# Nickel

**Sulphide nickel:** % Ni

- 0.5–1% = marginal
- 1–2% = average
- 2%+ = high grade
- World-class: Voisey's Bay, Norilsk, Mt Keith

**Laterite nickel:** % Ni (different processing — HPAL or ferronickel)

- 0.8–1.5% typical
- Capex-intensive; HPAL plants have a brutal history of cost overruns and operational issues

# Iron Ore (% Fe)

- DSO (Direct Shipping Ore): >58% Fe is the rough benchmark for sale
- Premium: >62% Fe (the Pilbara benchmark)
- Magnetite concentrates: 65–70% Fe after beneficiation
- Hematite from raw mining: 55–62% typical
- Below 50%: marginal without significant beneficiation

Impurities matter as much as grade — silica, alumina, phosphorus all carry penalties. Discounts and premiums are real money.

# Rare Earths (REE)

Reported as **TREO%** (Total Rare Earth Oxide). But TREO alone is misleading.

- TREO grade: 1–5% typical for hard rock; 0.05–0.2% for ionic clay deposits (much lower but easier to process)

- **The split matters more than total grade.** What % of the TREO is the magnet rare earths — Nd, Pr, Dy, Tb? Cerium and Lanthanum are oversupplied and worth little.
- "NdPr%" of TREO is the key second number. >20% is good.
- Mt Weld and Mountain Pass are world-class because of grade *and* split.

# Uranium ($U_3O_8$ or % e$U_3O_8$)

- 0.05–0.1% $U_3O_8$ (500–1000 ppm): low grade but mineable in Australia (e.g., in-situ leach amenable)
- 0.2–1% $U_3O_8$: average to good
- 1%+ $U_3O_8$: world-class (Athabasca Basin, Canada)
- Cigar Lake / McArthur River: 15%+ $U_3O_8$ (the only deposits in this league globally)

# Silver (g/t Ag)

Often a by-product. As primary commodity:

- 50–150 g/t Ag = average
- 150–400 g/t = high grade
- 500+ g/t = bonanza

Silver-equivalent (AgEq) calculations are common — same caveats as CuEq below.

# Zinc / Lead (% Zn, % Pb)

Usually reported together as Pb+Zn% or as Zn-equivalent:

- 5% Pb+Zn = marginal
- 8–12% Pb+Zn = average
- 15%+ Pb+Zn = high grade
- Often by-product silver credits

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# Equivalent grades — the recurring trap

This is the single most common way mining announcements mislead retail. It deserves a dedicated section because it sits at the intersection of every other concept in this module.

# What equivalent grades are

When a deposit contains multiple commodities, companies often report a single "equivalent" grade by converting all by-products into units of the primary commodity at assumed prices and recoveries.

So a deposit with 1.0 g/t Au, 5 g/t Ag, and 0.5% Cu might be reported as "1.8 g/t AuEq" or "8.5 g/t AgEq" or "1.1% CuEq" depending on which metal the company chooses as the primary.

# Why this is a trap

The headline equivalent grade can be misleading in three different directions, and you need to check all three:

**1. Price assumptions.** The conversion uses commodity prices set by the company. If gold is priced at US$3000/oz and copper at US$10,000/t in the calculation, the equivalent figure looks great. If gold drops to US$2000/oz, the "AuEq" calculation no longer reflects reality. Always check the price deck in the footnote and ask: do these prices look conservative, current, or aggressive?

**2. Recovery assumptions.** Different metals recover at different rates from the same ore. Gold might recover at 92%, copper at 88%, silver at 75%. If the company assumes 90% recovery across all metals to simplify the equivalent calculation, the number is inflated. Real plants don't recover all metals equally.

**3. By-product reality.** Some by-product credits never get realised because:

- The off-take agreement doesn't pay for them (gold credits in copper concentrate are paid; rare earth credits often aren't)
- The processing flowsheet doesn't actually recover them at scale
- Smelter terms charge penalties that consume part of the credit value
- The market for the by-product is too thin or volatile to monetise reliably

# The "low primary grade hidden by big credits" pattern

When you see a low equivalent grade for the primary metal, it usually means the actual primary grade is much worse than what the equivalent suggests.

Example pattern: a company announces "1.5 g/t AuEq" sounds reasonable for an open pit. But when you read the footnotes:

- Actual gold grade: 0.4 g/t

- The remaining 1.1 g/t AuEq comes from silver, lead, and zinc credits
- The economics are now entirely dependent on silver/lead/zinc prices, recoveries, and concentrate marketability — not gold

This is structurally different from a project that's actually 1.5 g/t Au with no by-products. The risk profile is different. The investor case is different. But the headline reads identically.

# How to read equivalent-grade announcements

Always do this short check:

1. **What's the primary metal grade alone?** The footnotes will state it. If they don't, that itself is a flag.
2. **What's the by-product split?** What % of the equivalent is coming from each metal?
3. **What price deck is used?** Are those prices current, lagged, or forward?
4. **What recoveries are assumed?** Are they consistent with the metallurgical testwork actually done?
5. **Does the off-take or smelter pay for those by-products?** Polymetallic concentrates have notoriously complex terms.

If the actual primary grade is below the marginal threshold for that commodity (Module 3 benchmarks above), the project's economics live or die on the by-products — even if the equivalent number looks healthy.

# When equivalent grades are legitimate

They are not always misleading. A genuine polymetallic deposit (think Olympic Dam — copper, gold, uranium, REE, silver) genuinely produces all those metals and the equivalent is a useful summary measure. A genuine VMS deposit (zinc, lead, copper, silver, gold) is sold as a polymetallic concentrate and the equivalent reflects realised value.

The trap is when equivalent grades get used to dress up a project where the primary metal isn't economic on its own and the by-product credits are speculative.

# One-line rule

**Always check the primary grade alone. If the primary alone is below the marginal threshold, the equivalent grade is doing real work in the announcement — find out exactly what work, before the equivalent goes into your thesis.**

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# How to spot a tier-1 deposit in 30 seconds

A tier-1 deposit generally combines:

1. **Scale** — billion-tonne+ for porphyry, 100Mt+ for sulphide-hosted base metals, multi-Moz for gold
2. **Grade** — well above the marginal threshold for that deposit type (and on the *primary* metal, not equivalent)
3. **Strip ratio** — favourable, especially in early years
4. **Metallurgy** — clean, high recovery, no refractory issues
5. **Infrastructure** — close to power, water, roads, port
6. **Jurisdiction** — Australia, Canada, USA, Scandinavia, parts of South America are tier-1; many parts of Africa/Asia carry sovereign risk discounts

If a deposit checks 5/6 of those, it'll get built. If it checks 2/6, it'll bounce around as a "story" stock for years.

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# How to spot a marginal deposit

- Primary metal grade close to or below the cut-off for that commodity
- Headline grade is an "equivalent" grade that's doing heavy lifting from speculative by-products
- Strip ratio above 6:1 for non-precious metals
- Metallurgical recovery below 75%
- Remote with no infrastructure
- Sovereign risk jurisdiction
- High capex relative to projected NPV (capex > NPV is a red flag)

These projects often "become economic" only at peak commodity prices, then disappear when prices normalise.

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# The grade-tonnage trade-off

Big and low-grade vs small and high-grade — both can work, but not always for the same investor.

- **Large/low-grade** (e.g., porphyry copper at 0.5%): high capex, long mine life, leverage to commodity price, harder to permit. Good for majors, harder for juniors.
- **Small/high-grade** (e.g., narrow-vein gold at 15 g/t): lower capex, shorter mine life, faster payback, easier to permit. Good for juniors and mid-tiers.

A junior pursuing a 1bn tonne porphyry needs $2bn capex — they will get diluted to oblivion or sell to a major. A junior with a 500koz high-grade UG project at 8 g/t can self-fund construction.

**Match the deposit to the company's ability to develop it.**

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# Practical exercise

For every deposit you're tracking, write down:

1. Commodity and deposit type
2. Resource grade and where it sits on the benchmark above
3. **If reported as an equivalent grade — what's the primary metal grade alone?**
4. Strip ratio (if open pit)
5. Recovery rate from met testwork
6. Cut-off applied to the resource
7. Is this a tier-1, tier-2, or marginal deposit?

If grade context is missing from your thesis, you are speculating on the *story*, not the *rock*.

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# What I'm uncertain about

- "Marginal" thresholds shift with commodity prices. A 1 g/t Au open pit was uneconomic at $400/oz gold; it's clearly economic at $3000+/oz. Always think in current/forward price context.
- REE economics are unusually complex because pricing varies enormously across the 17 elements and end-market demand is policy-driven (magnet demand for EVs, wind turbines, defence). Specific cut-offs change with NdPr pricing.
- Lithium grade thresholds have moved a lot through the 2022–2025 cycle; some marginal projects that were viable at $80k/t spodumene are deeply uneconomic at $700/t. Verify against current commodity prices.
- Equivalent grade conventions vary by company and broker. The math is simple in principle but the assumptions are everything. When in doubt, ignore the equivalent and look at the primary metal grade alone.

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