

AURUS INSTITUTE FOR RESOURCE DEVELOPMENT

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# Reading the Ground

Geophysics campaign design for greenfield mineral exploration:  
choosing the methods, sequencing the survey and turning anomalies into  
drill-ready targets

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TECHNICAL PAPER · EXPLORE

July 2026 · ~45-min read

Aurus Technical Committee



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# Evidence before assertion.

MINING · INFRASTRUCTURE · ENGINEERING · ENVIRONMENT

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# A greenfield campaign is a sequence of bets, and geophysics prices them

A greenfield exploration project begins with almost nothing: a large licence, a regional geological idea and a budget that will not survive drilling the whole property. Geophysics is how that property is narrowed from thousands of square kilometres to a handful of holes without turning over the ground. Every survey measures a physical contrast, magnetic, density, electrical, radiometric or acoustic, that stands in for the geology the explorer cannot yet see, and each method answers a different question at a different cost. Designing the campaign is deciding which questions to ask, in which order, so that cheap wide surveys retire most of the ground before expensive narrow ones, and drilling, the most expensive measurement of all, is spent only where several independent methods agree.

This paper is written for two readers. The **explorer and project geologist** designing or auditing a campaign will find a method-by-method account of what each survey senses, what it cannot, and how the surveys sequence into a defensible programme. The **investor, lender or joint-venture partner** deciding whether a programme is disciplined will find a vocabulary for telling a campaign that de-risks from one that merely acquires data. The through-line is the same for both: a geophysical anomaly is a hypothesis, not a discovery, and the value of a campaign is the rate at which it converts hypotheses into decisions.

**The methods are a toolkit, not a hierarchy.** Magnetics maps contrasts in magnetic susceptibility, dominated by magnetite and pyrrhotite, and is the near-universal first pass because almost every geology carries a magnetic signature. Gravity reads bulk density and finds the dense targets, massive sulphide, banded iron formation, chromite, that other methods miss. Radiometrics measures potassium, thorium and uranium in the top few tens of centimetres of ground, so it maps surface lithology and alteration rather than buried ore. Electromagnetic methods sense conductivity and hunt massive sulphides; induced polarisation measures chargeability and is the workhorse for the disseminated sulphides of a porphyry system, where the grains never connect into a conductor. Seismic images acoustic-impedance contrasts at the highest resolution and the highest cost, and earns its place in basins, over deep targets and in evaporite and coal settings. No method is universal; the campaign is the choice among them.

**ANOMALY** · a measured departure from the expected regional field of a physical property, magnetic, gravity, electrical or radiometric, that may indicate a geological feature of interest. An anomaly is evidence, not a deposit: it acquires meaning only when a physical-property model and a geological setting explain it.

## What disciplined campaign design adds: five findings

- **Sequence beats coverage.** The cheapest way to waste an exploration budget is to acquire every method everywhere. A staged programme runs wide, cheap airborne surveys first, retires most of the licence, and reserves ground methods and drilling for ranked targets (Chapter 1).
- **Match the method to the physical property, not the deposit name.** A target is detectable only if it contrasts with its host in a property some method measures. The first design question is which physical contrast the sought deposit actually presents, and only then which survey reads it (Chapters 2, 4).
- **Data quality is designed, not repaired.** Base-station diurnal correction, removal of the International Geomagnetic Reference Field, terrain and drift corrections and a stated noise tolerance are specified before a crew mobilises; a survey acquired outside tolerance cannot be processed back into specification (Chapters 3, 6).

- **An inverted model is non-unique.** Any geophysical inversion admits many earth models that fit the data equally well. A defensible target rests on inversion constrained by geology, petrophysics and, wherever available, drilling, never on a colourful image read at face value (Chapter 6).
- **The drill target is a joint decision.** The highest-confidence targets are where several independent methods, and the geology, coincide. Ranking that coincidence, and handing the rig a target with a stated depth, geometry and expected physical response, is where geophysics pays for itself (Chapter 7).

### Who should read this paper

For the **explorer**, Chapters 1 and 2 set the design logic and the physics, Chapters 3 through 5 walk the airborne, ground and seismic method families in the order a campaign deploys them, and Chapters 6 through 8 cover the data discipline, the target decision and a programme method to hold a campaign against. For the **investor or partner**, the same chapters give a precise account of what each line item in a survey budget buys and a diagnostic for whether a programme is converting spend into decisions. The paper cites the primary instruments directly: the JORC Code 2012 for reporting discipline and Competent-Person practice, and the International Geomagnetic Reference Field maintained by the International Association of Geomagnetism and Aeronomy for the magnetic datum.

### How to use this paper

Read **front to back** for the full method, from the physics to the campaign playbook. Read **Chapter 8 first** for the instrument, a staged programme with go and no-go gates, then trace each stage back to the method that earns it. Or read **by exhibit**: the thirteen exhibits and five stat tiles, each with its source line, carry the paper's framework content, and the exhibit index in the back matter maps every one to its references. The signature exhibit, the target-generation cascade of Chapter 6, is the paper's centrepiece; like the closing playbook it is a framework instrument and carries no data from any specific survey.

### The through-line, stated plainly

The argument reduces to one proposition: on a greenfield property the order in which methods are deployed matters more than any single method, because each survey both narrows the ground and pays for the next. A campaign that acquires the right method last, after drilling has already been committed on weaker evidence, will have spent its money in the wrong sequence even if every individual survey was competently run. The discipline this paper sets out is the discipline of sequence: wide before narrow, cheap before dear, several methods before one hole, and a stated decision at every stage rather than a growing archive of maps.

A final orientation. This is a technical paper, not a survey specification and not a substitute for a Competent Person's judgement on a particular property. Its method science, what each survey senses and how the data are corrected, is established applied geophysics, stated at practice grade; its reporting-discipline claims are cited to the JORC Code 2012 on the public record; and the numeric survey bands it quotes, line spacings, flying heights, array dimensions, are stated as industry practice conventions rather than as figures from any one project. Where a parameter depends on the target and terrain, the paper says so rather than presenting a single number as universal.

# Five figures that frame a campaign

7

PRIMARY GEOPHYSICAL METHODS A GREENFIELD CAMPAIGN CHOOSES AMONG: MAGNETIC, GRAVITY, RADIOMETRIC, ELECTROMAGNETIC, INDUCED-POLARISATION AND RESISTIVITY, SEISMIC AND MAGNETOTELLURIC

Applied geophysics, method families by physical property sensed

THRESHOLD

5 years

MINIMUM RELEVANT EXPERIENCE A COMPETENT PERSON MUST HOLD TO REPORT EXPLORATION RESULTS UNDER THE JORC CODE 2012

Joint Ore Reserves Committee, JORC Code, 2012 Edition

14<sup>th</sup>

GENERATION OF THE INTERNATIONAL GEOMAGNETIC REFERENCE FIELD, FINALISED NOVEMBER 2024, THE REGIONAL DATUM REMOVED FROM MAGNETIC SURVEY DATA

IAGA, IGRF-14; NOAA National Centers for Environmental Information, 2024

30–45 cm

DEPTH OF GROUND FROM WHICH GAMMA-RAY SPECTROMETRY SENSES POTASSIUM, THORIUM AND URANIUM: RADIOMETRICS MAPS THE SURFACE, NEVER BURIED ORE

Applied geophysics, gamma-ray spectrometry response depth

STAGES

3

STAGES OF THE DE-RISKING FUNNEL EVERY CAMPAIGN RUNS: RECONNAISSANCE, TARGET DEFINITION AND DRILL-READY CONFIRMATION

Staged exploration practice (reconnaissance, targets, infill)

HOW TO READ THIS PAGE

Each figure is a durable framework fact, transcribed from a code, a reference model or established method science. These are the fixed points a greenfield geophysics campaign is designed around; the chapters that follow read each method precisely and then sequence them into a programme.

## How this paper is organised

CHAPTER	THE QUESTION IT ANSWERS	ANCHOR SOURCE
1 · The greenfield problem	Why sequence a campaign, and in what order?	Staged practice; JORC 2012
2 · What each method senses	Which physical property stands in for which geology?	Applied geophysics
3 · Airborne reconnaissance	What do magnetics, radiometrics, gravity and AEM retire first?	IGRF; aeromagnetic practice
4 · Ground follow-up	Which ground method resolves which ranked target?	IP-resistivity; ground practice
5 · Seismic	Where does the most expensive method actually earn its cost?	Reflection and borehole seismic
6 · Quality and inversion	How is the data made defensible, and why is a model non-unique?	IGRF; inversion practice
7 · The drill target	How is multi-method evidence ranked into a hole?	Integration practice
8 · The Aurus method	How does a team hold a campaign to all of the above?	Chapters 1–7

## What this paper is, and is not

It is a practitioner’s account of the geophysical methods used to explore a greenfield mineral property and a method for sequencing them into a disciplined campaign. It is not a survey specification, a procurement document or a record of any specific client project. The method science is established applied geophysics; the reporting-discipline claims are cited to the JORC Code 2012; the numeric survey bands are stated as industry practice, not as figures from any one project. The closing playbook and the signature cascade are framework instruments and carry no project data.



# 1

EXPLORE · THE GREENFIELD PROBLEM

## Reconnaissance, target, drill-ready

A campaign is a funnel. Its job is to retire ground cheaply so that drilling is spent only where several methods agree.

---

3

STAGES IN THE DE-RISKING FUNNEL

7

PRIMARY METHODS TO SEQUENCE

1st

MAGNETICS, THE NEAR-UNIVERSAL FIRST PASS

A greenfield licence is mostly unknown ground. The explorer holds a regional geological idea and a budget, and the entire task is to spend that budget in the order that learns the most per dollar. Geophysics is the instrument of that order: it measures physical contrasts across ground that has not been walked, and it does so at costs that span three orders of magnitude, from a few dollars a line-kilometre of airborne magnetics to the price of a single deep diamond hole. Designing a campaign is deciding which of those measurements to buy, and in which sequence, so that the property is narrowed by the cheap surveys before the dear ones are committed.

The organising principle is a funnel. At the top sits the whole licence, hundreds or thousands of square kilometres, and a question that can be answered from the air: where is the geology permissive, and where is it not? At the bottom sits a drill target, a volume of rock a few hundred metres across with a stated depth and expected physical response, and a question only the drill can settle: is the mineralisation there, and at what grade? Between the two, each stage narrows the ground by roughly an order of magnitude and raises the cost per unit area by about the same, so that the money follows the confidence rather than leading it.

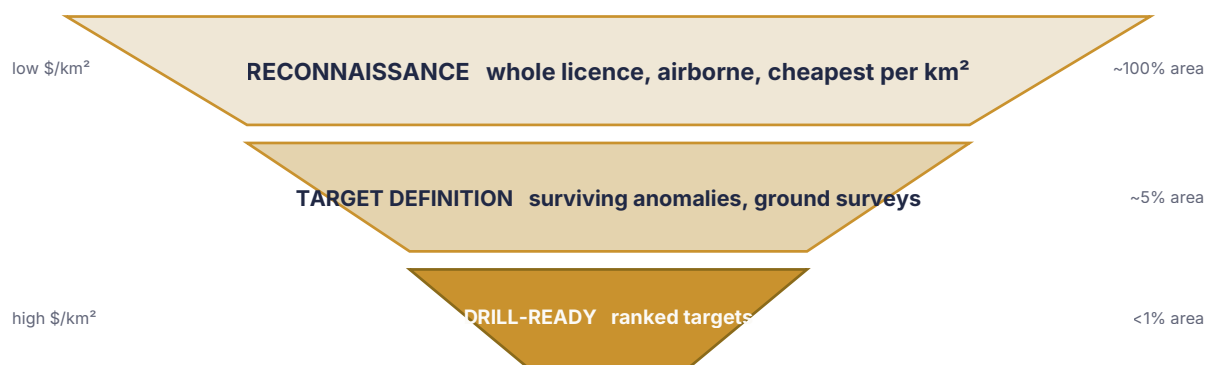
## The three stages, and what each retires

**Reconnaissance** covers the entire property with wide, fast, cheap surveys, almost always airborne, and its product is not a target but a rejection: most of the licence is shown to be unprospective and set aside. **Target definition** takes the small fraction that survives and applies ground surveys and infill lines, resolving each surviving anomaly into a shape with a depth and a physical-property signature. **Drill-ready confirmation** takes the ranked targets and adds whatever is needed, a detailed ground survey, a physical-property measurement, a second independent method, to justify the hole and predict what it should intersect. Each stage has a go and no-go gate: an anomaly that fails to strengthen under closer look is retired, not carried forward on optimism.

### EXHIBIT 1 · CAPABILITY INSTRUMENT, NO PROJECT DATA

#### The de-risking funnel: ground retired, cost raised, at every stage

Illustrative proportions. Area falls by roughly an order of magnitude per stage; cost per unit area rises by about the same.



Framework instrument. Staged exploration practice (reconnaissance, targets, infill); proportions illustrative, not from any survey. Rows WP06-03, WP06-20.

## Match the method to the contrast, not the deposit

The first design question is not which method is best but which physical contrast the sought deposit presents against its host rock. A magnetite-rich iron formation is a strong magnetic and gravity target and almost invisible to radiometrics. A porphyry copper system is a chargeability target for induced polarisa-

tion, a weak conductor at best, and often ringed by a potassium-alteration halo that radiometrics can map. A massive sulphide body is a conductor that electromagnetic methods find directly and a density high that gravity confirms. If a deposit contrasts with its host in no property any survey measures, geophysics cannot see it, and the campaign must lead with geochemistry or geological mapping instead. The methods are a toolkit indexed by physical property, and Exhibit 2 is that index.

## EXHIBIT 2 · CAPABILITY INSTRUMENT, NO PROJECT DATA

### The physical-property index: which survey reads which contrast

The deposit is detectable only if it contrasts with its host in the property the method senses.

METHOD	PHYSICAL PROPERTY SENSED	TYPICAL TARGET IT FINDS	BLIND TO
Magnetic	Magnetic susceptibility, remanence	Iron formation, magnetite skarn, structure, intrusions	Non-magnetic ore
Gravity	Bulk density	Massive sulphide, banded iron formation, chromite	Low-density-contrast bodies
Radiometric	Surface K, Th, U	Lithology, alteration, some uranium and REE	Anything buried below ~0.5 m
Electromagnetic	Electrical conductivity	Massive sulphide, graphite, conductive cover, water	Disseminated, disconnected sulphide
Induced polarisation	Chargeability	Disseminated sulphide, porphyry copper	Deep targets under conductive cover
Seismic	Acoustic impedance	Basin architecture, evaporites, deep and layered targets	Small, low-contrast bodies at high cost

Framework instrument. Established applied geophysics, physical-property basis of each method. Rows WP06-03 to WP06-10.

## Reporting discipline runs through every stage

A campaign that intends its results to support a public report, and every campaign raising capital eventually does, is bound by the reporting codes from the first survey line. Under the JORC Code 2012, geophysical survey results are Exploration Results, and Table 1 lists them expressly among the criteria a Competent Person must consider and disclose. The Code requires that such results be reported by a Competent Person who holds a minimum of five years of relevant experience in the style of mineralisation and the activity being undertaken, and that the report satisfy the guiding principles of Transparency, Materiality and Competence. The practical consequence is that survey specifications, instrument parameters, corrections applied and data-quality acceptance are recorded as the survey runs, not reconstructed afterwards, because Table 1 will ask for each of them. The JORC, SAMREC and CIM Definition Standards adopted by NI 43-101 are members of one CRIRSCO reporting family, so a campaign documented to that standard reports cleanly under the three regimes an African project is most likely to face.

## The cost of skipping a stage

The funnel is not a formality that a well-funded programme can shortcut. The most expensive mistakes in exploration come from spending out of sequence: drilling an airborne anomaly that a cheap ground survey would have shown to be a barren magnetic body, or commissioning a costly seismic programme before the potential-field and electrical methods have narrowed the search to ground that repays it. Each skipped stage removes a chance to say no cheaply, and every no that is deferred is paid for later at the cost of the

more expensive measurement. The reverse error, running every method everywhere for completeness, is the same mistake wearing the opposite mask: it spends the expensive stages on ground the cheap stages would have retired. Discipline is neither haste nor thoroughness for its own sake; it is spending each dollar only where the previous dollar earned the right to spend it.

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**A geophysical anomaly is a hypothesis, not a discovery. A campaign is worth what it spends turning hypotheses into decisions.**

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**Wide before narrow. Cheap before dear. Several methods before one hole. The sequence is the discipline.**

READING THE GROUND · THE DE-RISKING FUNNEL

# 2

EXPLORE · WHAT EACH METHOD SENSES

## Every map is a physical property

Behind every geophysical image is one contrast, magnetic, density, electrical, radiometric or acoustic, standing in for the geology.

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5

PHYSICAL PROPERTIES THE  
METHODS SENSE

nT

MAGNETICS RECORDED IN  
NANOTESLAS

K·Th·U

THE THREE RADIOMETRIC  
CHANNELS

Every geophysical survey measures one physical property, and every map it produces is that property drawn across the ground. Understanding a campaign means understanding those properties: what carries them, what target contrasts with its host, and what limits each measurement. This chapter walks the five contrasts the mineral-exploration toolkit reads, in the order a designer weighs them.

## Magnetic susceptibility: the near-universal first pass

The magnetic method senses contrasts in magnetic susceptibility and in remanent magnetisation, both dominated by the magnetite and pyrrhotite content of the rock. A magnetometer records the total magnetic intensity at the sensor, in nanoteslas, and the resulting field maps almost every geology because almost every rock carries some magnetic mineral. That universality is why magnetics leads a campaign: it images lithology, structure, intrusions and alteration in one cheap pass. Its standard interpretive products, reduction-to-pole, the first vertical derivative, the analytic signal and Euler deconvolution for depth-to-source, are the vocabulary of a magnetic interpretation, and Chapter 3 sets out how they are computed and read.

## Density: the method that finds the dense ore

The gravity method reads lateral contrasts in bulk rock density. After the standard corrections, latitude, free-air, the Bouguer slab and terrain, the Bouguer anomaly isolates the density structure of the ground. Dense targets stand out as gravity highs: massive sulphide, banded iron formation, chromite. Low-density features, some alteration systems and salt, read as lows. Gravity is the natural partner to magnetics because density and susceptibility are independent properties, so a body that is both dense and magnetic is confirmed twice, and a gravity high with no magnetic expression is itself diagnostic. Micro-gravity resolves the detailed scale and airborne gravity gradiometry extends the method across a district.

### EXHIBIT 3 · CAPABILITY INSTRUMENT, NO PROJECT DATA

#### The methods by physical property, target and reach

Depth reach and relative cost are practice bands, not figures from any one survey.

METHOD	PROPERTY	WHAT IT MAPS	DEPTH REACH	REL. COST
Magnetic (TMI)	Susceptibility	Lithology, structure, intrusions, iron	Shallow to deep	Low
Gravity	Density	Massive sulphide, iron formation, basins	Shallow to deep	Low to medium
Radiometric	Surface K, Th, U	Surface lithology and alteration	Surface only	Low
Electromagnetic	Conductivity	Massive sulphide, cover, palaeochannels	Near to moderate	Medium
IP and resistivity	Chargeability	Disseminated sulphide, porphyry copper	Near to moderate	Medium to high
Seismic reflection	Acoustic impedance	Basin, evaporite, deep layered targets	Deep	Highest
Magnetotelluric	Deep conductivity	Deep structure, porphyry, geothermal	Very deep	High

Framework instrument. Established applied geophysics; cost and depth bands are practice conventions. Rows WP06-03 to WP06-13.

## Remanence, and why a magnetic low can be a target

Susceptibility is only half of the magnetic story. Rocks also carry remanent magnetisation, a permanent field frozen in at the time of their formation, and where the remanence opposes the present field a strongly magnetic body can read as a magnetic low rather than a high. The ratio of remanent to induced magnetisation, the Koenigsberger ratio, governs which effect dominates, and it is high in exactly the rocks an explorer cares about, many iron oxides and some intrusions. The practical consequence is that a magnetic in-

terpretation cannot be read as a simple map of magnetite abundance; a pronounced low can mark a reversely magnetised body of great interest, and separating induced from remanent effects is part of why petrophysical measurement on real samples, not the map alone, anchors a serious interpretation.

## Surface chemistry: what radiometrics can and cannot do

Gamma-ray spectrometry measures the natural emission of potassium, thorium and uranium, and it does so from the top thirty to forty-five centimetres of ground only, because gamma rays from any deeper are absorbed before they reach the sensor. This single fact governs how radiometrics is used and misused. It cannot see buried ore, so it is never a search tool for a concealed deposit. What it maps superbly is surface lithology, weathering and hydrothermal alteration, the potassium enrichment around a porphyry, for example, and it does so at almost no marginal cost because it flies on the same airborne platform as magnetics. The standard product is the ternary K-Th-U image, and its correct reading is as a geological map of the surface, not a depth sounding.

## Conductivity and chargeability: the two electrical questions

Two different electrical properties answer two different exploration questions. **Conductivity**, read by electromagnetic methods, finds bodies that conduct: a massive sulphide lens, a graphite horizon, a palaeochannel filled with conductive water. **Chargeability**, read by induced polarisation, finds bodies that polarise without necessarily conducting, which is exactly the case of the disseminated sulphides in a porphyry system, where the grains are too sparse to form a connected conductor but each grain still stores and releases charge. Induced polarisation measures that stored charge, in the time domain as a decaying voltage after the current is switched off, or in the frequency domain as a phase shift across injected frequencies, and it is acquired alongside resistivity in four-electrode arrays. The rule of thumb is durable: for a connected conductor, reach for electromagnetics; for disseminated sulphide, reach for induced polarisation.

## Acoustic impedance, and the deep conductivity of magnetotellurics

Two methods reach where the others fade. Seismic reflection images contrasts in acoustic impedance, the product of density and seismic velocity, at the highest resolution of any method and the highest cost, which is why it is reserved for the settings that repay it, sedimentary and evaporite basins, deep targets and layered deposits. Magnetotellurics uses the natural electromagnetic field to image electrical conductivity to depths far beyond active-source electromagnetics, and earns its place on deep porphyry, basin-architecture and geothermal problems. Both are specialist instruments, deployed late and selectively; Chapters 5 and 6 return to them.

## Depth of investigation, and why it is never free

Every method carries a depth of investigation, the depth below which it can no longer resolve a target, and in every case that depth is bought with resolution, coverage or cost. A magnetic or gravity field falls away with distance from its source, so a deep body produces a broad, subdued anomaly that a wide line spacing may sample but a narrow one resolves; reaching deeper without losing the target means flying or walking more lines. An electrical or electromagnetic method reaches deeper by widening its transmitter-receiver separation, at the cost of lateral resolution. Seismic reaches deepest of all, and pays in money. There is no method that sees deep, sharp, wide and cheap at once, and a campaign that needs depth must decide which of the other three it will spend to get it. Stating the depth of investigation a survey was designed for, and therefore the depth below which it is silent, is part of an honest interpretation, because an anomaly's absence means nothing below the depth the method could reach.

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Name the contrast first. The method follows from the physics, and the deposit name is only a shorthand for the physics.

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# 3

EXPLORE · AIRBORNE RECONNAISSANCE

## The pass that retires the licence

Wide, fast and cheap, an airborne survey maps the whole property in one flight campaign and sets aside most of it.

---

**14th**

IGRF GENERATION REMOVED AS THE DATUM

**2**

PLATFORMS: FIXED-WING AND HELICOPTER

**3**

PRODUCTS IN ONE PASS: MAG, RADIOMETRICS, DEM

Reconnaissance is flown, not walked. An airborne survey covers the entire licence in days, records magnetics and radiometrics simultaneously, and produces the maps from which most of the property is set aside as unprospective. It is the cheapest data per unit area a campaign will ever buy, and the most consequential, because everything downstream is a follow-up of what the airborne pass reveals.

## Line spacing and clearance: resolution bought by the metre

Two parameters set the value and the cost of an airborne survey: the spacing between flight lines and the clearance above the ground. Closer lines and lower clearance resolve smaller and shallower features, at proportionally higher cost, because both raise the line-kilometres flown per unit area. As an industry practice band, regional reconnaissance flies lines two hundred to four hundred metres apart at sixty to one hundred metres clearance, while detailed follow-up over a target tightens to twenty-five to one hundred metre lines; the exact figures are chosen for the target size and the terrain, not read from a table. Platform follows terrain: fixed-wing aircraft fly high-level reconnaissance over gentle ground, and helicopters are used in mountainous terrain or wherever more detail is required. A single low-altitude pass typically returns three products at once: the magnetic field, the radiometric channels and a digital elevation model from the radar altimeter.

### EXHIBIT 4 · CAPABILITY INSTRUMENT, NO PROJECT DATA

#### Airborne survey design bands, reconnaissance to detailed

Practice bands, chosen for target size and terrain; not figures from any one survey.

SURVEY CLASS	LINE SPACING	CLEARANCE	PURPOSE AND PRODUCT
Regional reconnaissance	200–400 m	60–100 m	Retire the licence; district lithology and structure
Prospect-scale	100–200 m	40–80 m	Resolve anomaly groups into discrete targets
Detailed follow-up	25–100 m	30–60 m	Define a target's shape and depth before ground work
Co-acquired	same lines	same	Radiometrics (K, Th, U) and DEM at near-zero marginal cost

Framework instrument. Line-spacing and clearance bands are established survey practice; co-acquisition per aeromagnetic practice capture. Rows WP06-06, WP06-05.

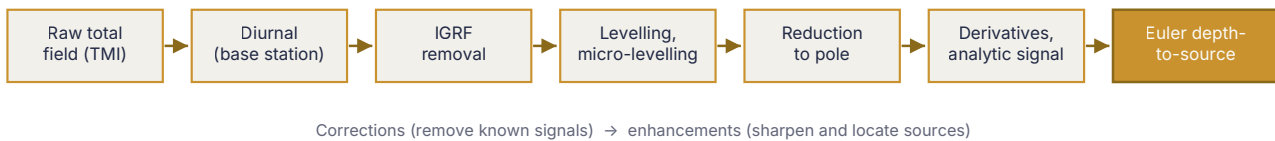
## The magnetic datum, and why the survey states it

A magnetic survey does not measure a deposit; it measures the whole field of the Earth, of which the crustal anomaly the explorer wants is a small part. Two large signals must be removed to isolate that anomaly. The first is the daily variation of the field, the diurnal, together with the larger excursions of magnetic storms; a stationary base-station magnetometer records this temporal field so it can be subtracted from the moving survey. The second is the main field of the Earth itself, described by the International Geomagnetic Reference Field, a standard mathematical model of the Earth's main magnetic field developed and maintained by the International Association of Geomagnetism and Aeronomy. The IGRF is revised on a roughly five-year cadence, its fourteenth generation finalised in November 2024, which is precisely why a competently reported survey states the IGRF generation and epoch it removed: the datum itself moves, and a result is only reproducible against a named version. Removing solar, regional and aircraft effects leaves the aeromagnetic map, which shows the spatial distribution and relative abundance of magnetic minerals.

## EXHIBIT 5 · CAPABILITY INSTRUMENT, NO PROJECT DATA

### From raw field to interpretable anomaly: the magnetic processing chain

Each step removes a known signal or sharpens a source; the order is not interchangeable.



Framework instrument. Processing order per established magnetic practice; datum and diurnal per the IGRF and aeromagnetic captures. Rows WP06-06, WP06-11, WP06-12.

## Radiometrics, calibrated, and the elevation model that comes free

The radiometric channels acquired on the same pass need their own discipline before they mean anything. The raw gamma counts are corrected for aircraft and cosmic background, for radon in the air, for the height of the sensor above ground and for the spectral overlap between the potassium, thorium and uranium windows, and the result is converted to ground concentrations against calibration pads of known composition. Done properly, the ternary image becomes a quantitative surface-geochemistry map; done carelessly, it is a set of pretty colours that drift with flying height. The same low pass also returns a digital elevation model from the radar or laser altimeter, at no additional flying cost, and that elevation model is not a by-product to discard: it carries the terrain the gravity survey must be corrected for and the drainage and structure a geologist reads directly.

### THEMATIC ASIDE

#### Drone-borne magnetometry: a capability, bounded honestly

Uncrewed aircraft now carry magnetometers and cameras at a fraction of the mobilisation cost of a crewed survey, flying tight lines low over a prospect and returning magnetic grids and photogrammetric models at prospect scale. The physics is the same as any magnetic survey; the gain is access and cost over small, difficult ground. The method is described here as a capability the discipline can field, not as a substitute for a district-scale crewed survey, whose endurance and coverage a drone does not match. Where a drone survey is flown, its parameters, sensor, line spacing, ground clearance and base-station correction, are recorded and reported exactly as any other magnetic survey, because the reporting codes do not soften for the platform.

## What the airborne pass hands to the ground crew

The reconnaissance product is a ranked set of anomalies, each with a preliminary interpretation: a magnetic high that may be an intrusion, a magnetic low that may be alteration, a radiometric potassium anomaly that may be a mineralised halo, a structural corridor picked from the derivative images. None of these is a target yet. They are the input to target definition, and the discipline of the stage is subtraction: the airborne pass exists to let the campaign say no to most of the licence cheaply, so that the ground programme, an order of magnitude more expensive per unit area, is aimed only at what survived the flight.

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**The airborne pass is bought to say no. Its value is the ground it lets a campaign set aside before the expensive work begins.**

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# 4

EXPLORE · GROUND FOLLOW-UP

## Where the anomaly becomes a shape

Ground surveys take the survivors of the airborne pass and resolve each one into a body with a depth, a geometry and a physical signature.

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4

GROUND METHODS OVER RANKED TARGETS

IP

THE DISSEMINATED-SULPHIDE WORKHORSE

3D

GRIDS BUILT FOR INVERSION, NOT JUST PROFILES

Target definition happens on the ground. The airborne pass named the survivors; the ground programme resolves each one from a coloured patch on a regional image into a body with a location, a depth, a geometry and a physical-property contrast strong enough to justify a hole. Ground methods cost far more per unit area than airborne surveys, which is exactly why they are reserved for the small fraction of the licence that survived reconnaissance.

## Ground magnetics and gravity: sharpening what the air began

Ground and drone-borne magnetic surveys tighten the station spacing to metres, resolving structures and contacts the airborne lines only hinted at, and they do so on the same physical property, so they integrate directly with the reconnaissance grid. Ground gravity, read station by station, is often the decisive follow-up for a dense target: a gravity high coincident with a magnetic anomaly separates a barren magnetite body from a potentially sulphide-bearing one, because sulphide adds density that magnetite alone does not. The two potential-field methods are cheap enough to run over a whole prospect and independent enough that their coincidence is real evidence.

## Induced polarisation: the method that earns the porphyry

For a disseminated-sulphide target, induced polarisation is the method that turns a permissive geology into a drill target. It measures chargeability, the ground’s capacity to store and release electrical charge, and disseminated sulphide is chargeable even when it is too sparse to conduct. The survey injects current through one pair of electrodes and reads the response through others, in a four-electrode array, pole-dipole, dipole-dipole or gradient, and recovers both chargeability and resistivity from the same measurement. The array geometry is a design choice: wider electrode separations reach deeper at the cost of resolution, so the array is sized to the expected target depth. A modern survey lays out a grid rather than isolated lines, because the target of the interpretation is a three-dimensional chargeability model, not a set of profiles.

### EXHIBIT 6 · CAPABILITY INSTRUMENT, NO PROJECT DATA

#### Ground-method selection by target type

The follow-up method is chosen for the physical contrast the target presents, and paired for independent confirmation.

TARGET TYPE	LEAD GROUND METHOD	CONFIRMING PAIR
Porphyry copper (disseminated)	Induced polarisation (chargeability)	Ground magnetics for the intrusion; radiometrics for K-alteration
Massive sulphide (connected)	Ground or downhole EM (conductivity)	Gravity for the density high
Iron formation, magnetite skarn	Ground magnetics	Gravity to separate barren from mineralised
Structurally controlled vein	Ground magnetics, resistivity	IP where sulphide is present
Concealed body under conductive cover	Ground EM, resistivity depth section	Gravity; drilling to calibrate

Framework instrument. Established follow-up practice by physical property. Rows WP06-04, WP06-07, WP06-08, WP06-09.

## Ground electromagnetics: conductors, and the noise that hides them

Ground electromagnetic systems, in the time domain or the frequency domain, are the direct search for a connected conductor: a massive-sulphide lens returns a strong, discrete electromagnetic response that is close to diagnostic. The difficulty is that conductive overburden, weathered clay, saline groundwater, is both common in the terrains where exploration happens and itself conductive, so it is at once the method's principal noise source and, in the search for palaeochannels or water, its target. Downhole electromagnetic surveys, run in an existing hole, extend the reach of the method past the cover and can detect a conductor off to the side of a hole that narrowly missed it, which is often the difference between abandoning a target and stepping out to the next hole.

## Downhole logging: measuring the rock the drill returned

Once a hole exists, geophysics moves inside it. Downhole logging runs sensors down the drill hole to measure the physical properties of the rock in place: magnetic susceptibility, density, natural gamma, resistivity and, in the right setting, sonic velocity and full-waveform acoustic response. These logs do two things a surface survey cannot. They calibrate the surface interpretation, tying a modelled susceptibility or density to a measured one at known depth, and they close the loop with petrophysics by supplying the property values a constrained inversion needs. A logged hole turns a single intersection into a column of physical-property ground truth, and a campaign that logs its holes learns far more per metre drilled than one that logs none, at a small fraction of the cost of the hole itself.

## The station-spacing discipline

Every ground method shares one design rule: the station and line spacing must be fine enough to sample the target without aliasing it, and no finer, because each halving of the spacing roughly doubles the cost. The spacing is set from the expected size and depth of the target, and it is recorded, because under the reporting codes the survey parameters, station spacing, array type, instrument and acceptance criteria, are part of what a Competent Person must disclose about a geophysical result. A ground programme that cannot state its own sampling density cannot defend the target it produces.

## Resistivity sections, and reading the ground in depth

Resistivity, acquired in the same four-electrode arrays as induced polarisation, produces a depth section rather than a map, and it is the ground method that most directly images the vertical structure a drill hole will pass through. Widening the electrode spacing samples deeper, so a survey that steps its spacing through a range builds a two-dimensional section of resistivity against depth, an image an inversion then sharpens into a model of the layering below the line. In terrains with conductive cover the section separates the barren overburden from the resistive or conductive basement beneath it, and it maps the depth to bedrock that a drilling programme must plan for. Paired with the chargeability from the same survey, resistivity distinguishes a conductive-but-barren clay from a chargeable sulphide, which is often the difference between a wasted hole and a good one. The design choices, array type, electrode spacing range and line orientation, follow from the target depth and the expected geometry, and like every other survey parameter they are recorded for the report.

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Ground surveys are where a campaign spends real money. They are aimed only at what the air could not retire, and only at the contrast the target actually presents.

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# 5

EXPLORE · SEISMIC FOR MINERAL EXPLORATION

## The expensive method, used on purpose

Seismic reflection is the highest-resolution image in geophysics and the dearest. In mineral exploration it is deployed selectively, where the geometry repays it.

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### 2D·3D

REFLECTION SURVEY MODES

### VSP

TIES SURFACE DATA TO A BOREHOLE

### basins

WHERE SEISMIC EARNS ITS COST

Seismic reflection is the method that built the petroleum industry, and in mineral exploration it is the specialist instrument, brought out when the target is deep, layered or hosted in a basin, and left in the case otherwise. It images contrasts in acoustic impedance, the product of density and seismic velocity, at a resolution no potential-field or electrical method approaches, and at a cost that forbids using it to search wide ground. Understanding when seismic earns its place, and when it does not, is a mark of a disciplined campaign.

## Reflection, refraction and the borehole tie

Three seismic techniques serve three purposes. **Reflection**, in two dimensions or three, images layering and structure at depth and is the reason to bring seismic at all: a 3D reflection volume over a basin resolves faults, unconformities and reservoir or evaporite geometry that no other method can see. **Refraction**, including uphole and shallow-refraction surveys, resolves the near-surface velocity structure and the weathered layer, which both corrects the reflection data and maps rockhead for engineering. **Vertical seismic profiling** places geophones in a borehole and ties the surface seismic to the exact depths intersected by the hole, converting a seismic image in time into one in depth and calibrating the whole survey to ground truth. The standard land energy source is Vibroseis, a controlled vibratory sweep that avoids the permitting and safety burden of explosive sources.

### EXHIBIT 7 · CAPABILITY INSTRUMENT, NO PROJECT DATA

#### The seismic techniques, and where each earns its cost

Resolution and cost are relative to the other geophysical methods; seismic is the high end of both.

TECHNIQUE	IMAGES	EARNs ITS COST WHEN	REL. COST
2D reflection	Structure along a line	Reconnaissance of basin architecture, corridor sections	High
3D reflection	A volume of the subsurface	Evaporite, potash, coal and deep layered targets	Highest
Refraction, uphole	Near-surface velocity	Static corrections; rockhead and weathering for engineering	Low to medium
Vertical seismic profile	Surface-to-borehole tie	A hole exists and the survey must be tied to it in depth	Medium

Framework instrument. Established exploration-seismic practice. Rows WP06-10, WP06-21.

#### THEMATIC ASIDE

##### Where 3D seismic is worth its price: the evaporite and potash basin

Potash and salt sit in layered sedimentary basins whose structure, the depth and continuity of a target seam, the faulting that displaces it, the dissolution that thins it, is exactly what reflection seismic resolves and what potential-field methods cannot. In these settings a 3D seismic volume is not a luxury but the primary structural dataset, acquired to full mining-industry data-quality standards with daily, weekly and monthly reporting and a documented chain of custody on the original field data. The acquisition and processing of such a survey is a self-contained mandate, and the exploration target that follows is defined from the seismic image together with the drilling that ties it to depth.

## The processing decides what the survey sees

A raw seismic record is not an image; it becomes one only through a processing sequence as consequential as the acquisition. Static corrections remove the distortion of the weathered near-surface, informed by the refraction and uphole surveys; velocity analysis builds the model that converts recorded time into depth;

stacking combines many source-receiver pairs to lift signal above noise; and migration moves reflected energy to its true subsurface position, collapsing diffractions and steepening faults into their real geometry. Each step embeds assumptions, above all the velocity model, and a poor velocity model can place a reflector, and therefore a target, in the wrong place at the wrong depth. This is why a seismic interpretation is trusted only when it is tied to a borehole through a vertical seismic profile, and why the same discipline that governs potential-field inversion, constrain the model with independent ground truth, governs seismic depth conversion.

## **The honest limits of seismic on hard-rock targets**

Seismic is not a universal upgrade. On a small, irregular, hard-rock ore body with weak impedance contrast against a complex crystalline host, reflection seismic can cost a great deal and image little, and the potential-field and electrical methods will often outperform it per dollar. The method rewards layered or basinal geometry and deep targets; it struggles with small bodies of low contrast in structurally noisy ground. The design decision is therefore specific: seismic is commissioned when the target's geometry is one seismic resolves and the depth or value justifies the cost, and it is left aside when a cheaper method answers the same question. Treating seismic as a status symbol rather than a tool is a reliable way to overspend a programme.

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**Seismic is the sharpest image in geophysics and the most expensive. A disciplined campaign commissions it for a reason, not for reassurance.**

AURUS TECHNICAL COMMITTEE

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# 6

EXPLORE · DATA QUALITY, CORRECTION AND INVERSION

## A model is a hypothesis, not a picture

Corrections make the data honest; inversion turns it into an earth model. Every such model is one of many that fit, and its authority comes from the constraints on it.

---

**14th**

IGRF DATUM REMOVED AND RECORDED

**QA**

ACCEPTANCE SET BEFORE THE CREW MOBILISES

**1 of many**

EARTH MODELS AN INVERSION ADMITS

Between the raw measurement and the drill target lie two steps that decide whether a campaign is defensible: the corrections that remove everything the survey measured that is not the target, and the inversion that turns the corrected data into a picture of the ground. Both are where good campaigns separate from expensive ones, because both are invisible in the final map and entirely determine what it means.

## Data quality is specified before mobilisation, not audited after

A survey acquired outside tolerance cannot be corrected back into specification; the noise is in the data permanently. So the acceptance criteria are written into the survey specification before a crew mobilises: the base-station sampling and the diurnal tolerance beyond which acquisition pauses, a noise envelope on the field measurement, heading and lag checks for an airborne platform, and repeat-line statistics. The reporting codes reinforce the discipline, because a Competent Person disclosing a geophysical result must state the instruments, the parameters and the data-quality acceptance under Table 1, and cannot report a result whose quality was never defined. The credential a disciplined survey aims for is complete data-quality acceptance against a pre-agreed standard, recorded as the survey runs.

## Gridding, and the artefacts worth distrusting

Survey data is measured along lines and then interpolated into the continuous grid an interpreter reads as an image, and the interpolation itself can manufacture features that are not in the ground. Lines flown or walked on different days sit at slightly different levels, and if the levelling is imperfect the grid shows corrugations parallel to the survey lines that an untrained eye may read as geological trends. Interpolation across a wide line spacing invents smooth structure between lines that the data never sampled, so a feature elongated exactly along the flight direction deserves suspicion until a tie-line or an infill survey confirms it. The lesson is not to distrust the image but to know how it was made: a competent interpretation is read with the survey's line direction, spacing and levelling in mind, and a feature that aligns with the acquisition geometry is checked before it is believed.

### EXHIBIT 8 · CAPABILITY INSTRUMENT, NO PROJECT DATA

#### The correction cascade, and what each step removes

The target anomaly is what remains after every known non-target signal is removed.

CORRECTION	REMOVES	SO THAT THE MAP SHOWS
Diurnal (base station)	Daily and storm variation of the field	Only the spatial, not the temporal, field
IGRF removal	The Earth's main field, to a named generation and epoch	The crustal anomaly of interest
Levelling, micro-levelling	Line-to-line acquisition differences	A continuous, level grid without corrugations
Terrain and drift (gravity)	Topographic mass and instrument drift	The Bouguer density anomaly
Reduction to pole (magnetics)	Skew from the field's inclination	Anomalies centred over their sources

Framework instrument. Correction sequence per established practice; datum per the IGRF capture. Rows WP06-11, WP06-12, WP06-14.

## Inversion, and the discipline of non-uniqueness

An inversion takes the corrected field, magnetic, gravity, electromagnetic or chargeability, and computes a distribution of the physical property in the ground that would reproduce it. The colourful three-dimensional models that result are persuasive, and they are also non-unique: for any dataset there are many dis-

tributions of susceptibility, density or conductivity that fit the measurements equally well, differing in depth, in geometry and in amplitude. This is not a defect of a particular algorithm; it is a property of potential-field and electrical physics. The honest response is to constrain the inversion with everything independent that is known, the mapped geology, petrophysical measurements of susceptibility and density on real samples, and above all any drilling, so that the returned model is the one earth consistent with the data and the geology, not merely the one the software preferred. A target justified by an unconstrained inversion read at face value is a target justified by an assumption.

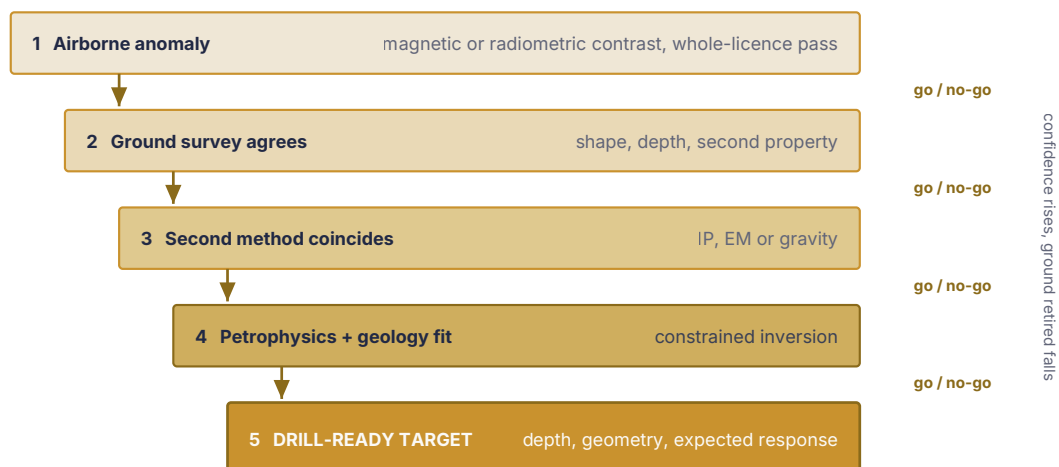
## Joint inversion: many datasets, one earth

The strongest answer to non-uniqueness is to make several methods share one model. Joint inversion computes a single earth that must reproduce the magnetic field, the gravity field and the electrical response together, so that the geometry each method would accept alone is disciplined by what the others will allow. Where the properties are linked by petrophysics, a rock that is dense is also, in a given deposit type, magnetic or chargeable, that coupling narrows the admissible models further. The method does not abolish non-uniqueness; nothing does. It reduces it, by requiring the model to satisfy more independent constraints at once, and it makes the residual assumptions explicit rather than hidden inside one dataset. A target that survives a joint inversion constrained by petrophysics and geology is a target a Competent Person can defend, because its confidence is stated in terms of what it was tested against.

### EXHIBIT 9 · SIGNATURE FRAMEWORK INSTRUMENT, NO PROJECT DATA

#### The target-generation cascade: independent evidence stacked to a drill decision

A target advances only through a go gate, where a further independent line of evidence strengthens it; failing to strengthen is a no-go.



Framework instrument. The paper's centrepiece: staged, evidence-gated target generation; no data from any survey. Rows WP06-03, WP06-04, WP06-08, WP06-14, WP06-20.

The cascade is the paper's argument in one figure. Each stage adds an independent line of evidence, and a target advances only if the new evidence strengthens it. An airborne anomaly that no ground survey can shape is retired; a ground anomaly that no second method confirms is retired; a coincidence of methods that the petrophysics and geology cannot explain is retired. What reaches the rig is not the strongest single anomaly but the one that survived the most independent tests, carrying a stated depth, geometry and expected physical response the hole can be measured against.

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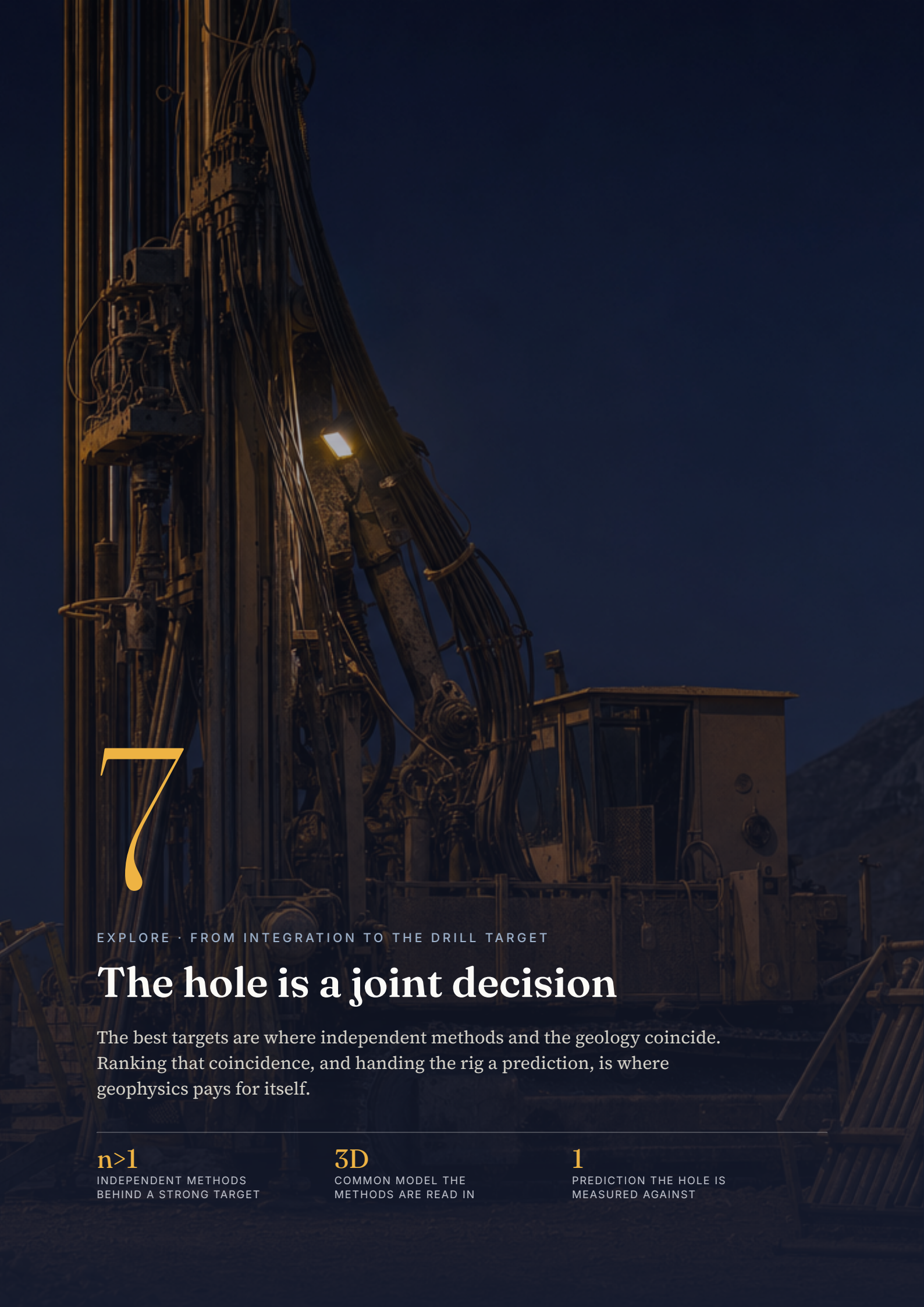
Constrain the inversion, or it will tell you what you assumed. The authority of a model is the weight of the independent evidence tied to it.

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**An inverted model is a hypothesis with a colour scheme. Its authority is the ground truth tied to it, and nothing else.**

READING THE GROUND · DATA QUALITY AND INVERSION



# 7

EXPLORE · FROM INTEGRATION TO THE DRILL TARGET

## The hole is a joint decision

The best targets are where independent methods and the geology coincide. Ranking that coincidence, and handing the rig a prediction, is where geophysics pays for itself.

**n>1**

INDEPENDENT METHODS  
BEHIND A STRONG TARGET

**3D**

COMMON MODEL THE  
METHODS ARE READ IN

**1**

PREDICTION THE HOLE IS  
MEASURED AGAINST

A campaign does not produce magnetic maps, gravity images and chargeability sections; it produces decisions about where to drill. The step that turns the first into the second is integration: bringing every survey into one spatial model, ranking the places where independent lines of evidence agree, and handing the rig a target defined precisely enough that the hole either confirms it or refutes it. This is the stage at which geophysics either earns its budget or becomes an archive.

## Integration means one model, not a stack of maps

The methods must be read together, in a common three-dimensional environment, because their power is in coincidence. A magnetic high alone is permissive; a magnetic high that is also a gravity high, also a chargeability anomaly, and also sits on a mapped structure in a favourable host, is a target. Industry-standard tools support this: gridding and image processing in packages such as Oasis Montaj, implicit geological modelling in Leapfrog, and physical-property inversion feeding a shared model volume. Integration also disciplines the interpretation, because a feature that is strong in one method and absent in every other is a prompt to ask why, whether it is a real single-property body or an artefact, before it consumes a hole.

### EXHIBIT 10 · CAPABILITY INSTRUMENT, NO PROJECT DATA

#### Ranking the coincidence: an integration matrix

A schematic scoring of candidate targets by independent lines of evidence; the strongest target is the one that agrees across the most.

CANDIDATE	MAGNETIC	GRAVITY	IP / EM	GEOLOGY	RANK
Target A	strong	strong	strong	favourable	1
Target B	strong	weak	strong	favourable	2
Target C	strong	absent	absent	neutral	retire
Target D	weak	strong	weak	favourable	3

Framework instrument. Illustrative scoring, no survey data; the method is coincidence of independent evidence. Rows WP06-03, WP06-04, WP06-08, WP06-14.

## The discipline of the false positive

Integration is also where a campaign protects itself from its own enthusiasm. Geophysical data is full of anomalies that look like targets and are not: a magnetic feature that turns out to be a buried pipeline or a lightning strike, a conductor that is a graphite horizon rather than sulphide, a gravity high that is a dense but barren mafic body, a chargeability response from clay rather than ore. Each of these is a real measurement and a false target, and each has cost a programme its best hole more than once. The defence is the same coincidence logic read in reverse: an anomaly strong in one property and absent in every other, and unsupported by geology, is treated as suspect until explained, not as a discovery because it is large. A disciplined interpreter spends as much effort explaining away the tempting single-method anomaly as promoting the modest one that several methods confirm.

## The handoff: what the rig should receive

A target is drill-ready when it can be handed to the rig as a prediction, not a hope. That prediction states the target's location and orientation, the depth to its top, its expected geometry, and, crucially, the physical response the hole should intersect: the susceptibility, density or chargeability the model implies, so that the drilling either matches the prediction or falsifies it. A hole planned this way is an experiment with a

stated hypothesis, and it produces information whether it hits or misses, because a miss that also fails to find the predicted physical property tells the interpreter the model was wrong, while a miss that does intersect the predicted property tells them the geology, not the geophysics, was the surprise.

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**EXHIBIT 11 · CAPABILITY INSTRUMENT, NO PROJECT DATA**

**The geophysics-to-drilling handoff sheet**

What a disciplined interpretation hands the rig, so that every hole tests a stated prediction.

ELEMENT HANDED OVER	WHAT IT LETS THE HOLE DO
Target location and orientation	Collar and azimuth placed to intersect the modelled body
Depth to top and expected geometry	Plan hole length and dip; set casing and survey plan
Predicted physical response	Compare downhole property to the model; confirm or falsify
Confidence and alternatives	Rank against the next target; decide step - out or abandon
Downhole survey plan	Downhole EM or logging to see past the hole where useful

Framework instrument. The interpretation-to-drilling interface in disciplined practice. Rows WP06-14, WP06-08, WP06-10.

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**Drill a prediction, not a hope. A hole that tests a stated physical response returns information whether it hits or misses.**

AURUS TECHNICAL COMMITTEE

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# 8

EXPLORE · THE AURUS CAMPAIGN-DESIGN METHOD

## A programme built on gates

The method is the sequence: wide before narrow, cheap before dear, several methods before one hole, and a stated decision at every gate.

---

**3**

STAGED GATES,  
RECONNAISSANCE TO DRILL

**100%**

DATA-QUALITY ACCEPTANCE IS  
THE STANDARD

**CP**

COMPETENT-PERSON  
DISCIPLINE THROUGHOUT

The preceding chapters set out the methods and the physics; this one sets out how a team holds a campaign to them. The Aurus method is not a proprietary technique, it is a discipline of sequence and evidence, expressed as a staged programme with explicit gates, run to reporting-code standards from the first line, and designed so that money always follows confidence rather than leading it.

## The programme, stage by stage

The design begins from the deposit model and the physical contrast it should present, not from a preferred method, and it lays out the three stages of the funnel with a decision at each boundary. Stage one retires the licence from the air. Stage two resolves the survivors on the ground. Stage three confirms and hands over the ranked targets. Each gate is a written go or no-go: an anomaly carried forward must have strengthened under closer look, and one that has not is retired rather than drilled on optimism. The programme is costed so that the cheap stages are complete, and most of the ground abandoned, before the expensive stages are committed.

### EXHIBIT 12 · CAPABILITY INSTRUMENT, NO PROJECT DATA

#### The staged campaign playbook, with its gates

Each stage ends in a written decision; spend is authorised stage by stage, never all at once.

STAGE	WORK	GATE TO PASS BEFORE SPENDING ON THE NEXT
0 · Design	Deposit model, target physical contrast, method choice	A contrast a method can sense is identified, or lead with geochemistry
1 · Reconnaissance	Airborne magnetics, radiometrics, DEM over the licence	Most of the ground retired; a ranked anomaly set defined
2 · Target definition	Ground magnetics, gravity, IP-resistivity, ground EM	Anomalies resolved to shapes; a second method agrees
3 · Drill-ready	Petrophysics, constrained inversion, detailed survey	A predicted physical response the hole can be measured against
4 · Drill and iterate	Test the prediction; downhole survey; revise the model	Confirm, step out or retire; feed results back to stage 2

Framework instrument. The staged, gated programme in disciplined practice; no project data. Rows WP06-20, WP06-03, WP06-08, WP06-14.

## Logistics, safety and permitting are part of the design

A greenfield campaign in remote terrain lives or dies on things that are not geophysics: access, camp, fuel, the weather window, medical evacuation, community consent and the environmental permit for cut-lines and drill pads. These are designed alongside the survey, not bolted on, because a technically perfect programme that cannot be mobilised safely into its ground is not a programme. Data-acquisition costs are best passed through at direct cost, and a house that runs its own campaigns holds no equity in the ground it assesses, which keeps the recommendation about the geology rather than the position. The reporting discipline runs throughout: survey parameters, corrections and acceptance recorded as the work proceeds, so that the result stands as an Exploration Result a Competent Person can sign.

## Designing the campaign around the terrain, not despite it

The non-geophysical design lines that decide whether a survey can be delivered.

DESIGN LINE	WHAT IT GOVERNS
Access and mobilisation	Platform choice, crew rotation, fuel and spares logistics
Weather and daylight window	Survey calendar; diurnal-quiet acquisition periods
Safety and medical cover	Remote-site HSE plan, evacuation, lone-worker controls
Permitting and community consent	Cut-lines, drill pads, environmental clearance ahead of work
Data management and chain of custody	Field-data integrity, daily to monthly reporting, acceptance

Framework instrument. Remote-campaign delivery discipline. Rows WP06-06, WP06-20, WP06-24.

## The economics of the sequence

The staged programme is a financial instrument as much as a technical one. Its whole purpose is to spend the smallest sum that will justify the next, larger sum, so that a property is condemned cheaply if it deserves to be and advanced only on strengthening evidence. Read as a portfolio of options, each gate is a decision to buy the next stage or walk away, and the value of the design is the money it saves on the ground it retires early. This is why acquisition costs are best passed through at direct cost with no resale margin, why the sequence is authorised stage by stage rather than as a single budget, and why a campaign is judged not by how much data it gathered but by how efficiently it converted spend into decisions. A programme that drills before the cheap stages have spoken has inverted its own economics, however good the individual surveys were.

## The Aurus view

Aurus consultants bring combined decades of experience in geology, geophysics, geochemistry, drilling, ESIA, scoping studies, PFS, DFS, NI 43-101, JORC and AACE-class estimating, and the firm designs and, where a mandate requires, runs multi-method campaigns in difficult terrain rather than only advising on them. The bench works fluently in the full method vocabulary, ground and airborne magnetics, reduction-to-pole and the derivatives, radiometrics, 2D and 3D seismic and vertical seismic profiling, magnetotellurics, induced-polarisation and resistivity inversion, Euler deconvolution, and in the platforms that integrate them. The credential note below states one delivered campaign in its approved, anonymised form; the rest of the practice appears as the method, because the argument of this paper is a method and not a portfolio.

### AURUS PRACTICE NOTE

Aurus designed and executed a ground magnetic and radiometric reconnaissance campaign over a 24 km<sup>2</sup> grid of a manganese exploration permit in Central Africa, delivered under Competent-Person supervision to the CRIRSCO-family codes (JORC 2012 and SAMREC) and the CIM Definition Standards incorporated by NI 43-101, with complete data-quality acceptance, delineating priority iron-manganese targets across one-fifth of the prospected ground and defining the follow-up geochemistry and infill-geophysics programme.

The practice also works at engagement grade across the wider method set: it has been engaged to acquire and process a 3D seismic programme over a coastal evaporite basin to mining-industry data-quality standards with full chain of custody, and has prepared within its practice a regional exploration synthesis integrating more than ten thousand stream-sediment and soil geochemical samples with regional airborne magnetics and structural target generation. Descriptions here are anonymised to project type and scale; no client is named.

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**A programme that cannot show its work has not finished it.  
The record that survives diligence is part of the deliverable,  
not an afterthought.**

AURUS TECHNICAL COMMITTEE

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## **What a defensible campaign leaves behind**

The lasting product of a disciplined campaign is not the drill result alone but the record that lets someone else trust it. Under the reporting codes that governs the survey parameters, the instruments, the corrections applied and the data-quality acceptance, all recorded as the work proceeded rather than reconstructed afterwards, together with the interpretation logic that ranked one target above another and the physical prediction each hole was drilled to test. A campaign documented this way survives due diligence, because a reviewer can follow every decision from the raw field measurement to the collar of the hole. It also survives a change of team, because the reasoning does not live only in the head of the geophysicist who ran it. The discipline that makes a campaign efficient in the field is the same discipline that makes it defensible on paper, and the two are not separable: a programme that cannot show its work has not finished it.

The method holds whatever the commodity. Iron, copper, manganese, potash, gold: the physical contrast differs, the sequence does not. Name the contrast, sequence the surveys wide before narrow, stack independent evidence at every gate, constrain the model with everything known, and hand the rig a prediction. A campaign run this way spends its money in the right order, and that, more than any single instrument, is what separates a discovery programme from an archive of maps.

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**The instrument is the sequence. Wide before narrow,  
several methods before one hole, a stated decision at  
every gate.**

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**Money should follow confidence,  
never lead it. The order in which a  
campaign spends is the campaign.**

READING THE GROUND · AURUS INSTITUTE FOR RESOURCE DEVELOPMENT

# Codes, models and method sources

Every framework fact in this paper is cited to a published code, a reference model, or an established method source archived on disk. Numeric survey bands (line spacings, flying heights, array dimensions, seismic fold) are stated as industry practice conventions and are not attributed to any single survey; the Method and evidence note that follows sets out that distinction in full.

1. Joint Ore Reserves Committee (JORC), The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (The JORC Code), 2012 Edition. The Competent-Person minimum five-year relevant-experience requirement, the Table 1 treatment of geophysical survey results as Exploration Results, and the guiding principles of Transparency, Materiality and Competence. Official PDF retrieved and archived to `_evidence/sources/wp06/jorc_code_2012.pdf` (2026-07-09). Rows WP06-01, WP06-02.
2. International Association of Geomagnetism and Aeronomy (IAGA), International Geomagnetic Reference Field, 14th generation (IGRF-14), coefficients finalised November 2024; product page hosted by the NOAA National Centers for Environmental Information (NCEI). The IGRF as the standard model of the Earth's main field, revised on a roughly five-year cadence and removed from magnetic survey data to isolate the crustal anomaly. Capture archived to `_evidence/sources/wp06/capture_igrf_iaga_2026-07-09.md`. Rows WP06-11, WP06-12.
3. Aeromagnetic survey method (established applied geophysics): the magnetometer records total magnetic intensity at the sensor; solar, regional and aircraft effects are subtracted to isolate the anomaly; fixed-wing aircraft fly reconnaissance and helicopters fly detail. Method-fact capture archived to `_evidence/sources/wp06/capture_aeromagnetic_method_2026-07-09.md` (2026-07-09). Rows WP06-06, WP06-11, WP06-12.
4. Induced polarisation method (established applied geophysics): chargeability as the measured property; time-domain and frequency-domain (spectral) acquisition; four-electrode arrays acquired jointly with resistivity. Method-fact capture archived to `_evidence/sources/wp06/capture_induced_polarization_2026-07-09.md` (2026-07-09). Rows WP06-08, WP06-09.
5. CRIRSCO reporting-code family: the JORC Code (Australasia), the SAMREC Code (South Africa) and the CIM Definition Standards adopted by NI 43-101 (Canada) as members of one reporting family, so a campaign documented to that standard reports cleanly across the three regimes. Row WP06-02b.
6. Aurus internal credential register (approved anonymised phrasing, reproduced in isolation on disk): the delivered 24 km<sup>2</sup> multi-method reconnaissance block and the combined-decades default flagship claim, archived to `_evidence/sources/wp06/factbase_pc08_approved_block.md`. These are approved anonymised credentials, not market statistics. Rows WP06-20, WP06-23.

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A survey states the datum it removed, the tolerance it held and the model it constrained. Everything else is decoration.

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# The evidence chain, and where practice bands replace statistics

## Exhibit source index

EXHIBIT	CONTENT	EVIDENCE ROWS
1	The de-risking funnel	WP06-03, WP06-20 (framework)
2	Physical-property index of methods	WP06-03 to WP06-10 (framework)
3	Methods by property, target, reach	WP06-03 to WP06-13 (framework)
4	Airborne survey design bands	WP06-06, WP06-05 (practice bands)
5	Magnetic processing chain	WP06-06, WP06-11, WP06-12
6	Ground-method selection by target	WP06-04, WP06-07, WP06-08, WP06-09
7	Seismic techniques and where each earns cost	WP06-10, WP06-21 (framework)
8	The correction cascade	WP06-11, WP06-12, WP06-14
9	Target-generation cascade (signature)	WP06-03, -04, -08, -14, -20
10	Integration and ranking matrix	WP06-03, -04, -08, -14 (framework)
11	Geophysics-to-drilling handoff	WP06-14, WP06-08, WP06-10
12	Staged campaign playbook	WP06-20, -03, -08, -14 (framework)
13	Designing around the terrain	WP06-06, WP06-20, WP06-24

## Method science, practice bands and statistics

This paper draws on three kinds of claim, and marks them differently. **Method science**, what each survey senses, how the data are corrected, why an inversion is non-unique, is established applied geophysics, stated at practice grade; it is corroborated by the archived aeromagnetic and induced-polarisation captures and, for the magnetic datum, by the IGRF reference. **Reporting-discipline claims**, the Competent-Person threshold and the treatment of geophysical results as Exploration Results, are cited to the JORC Code 2012, whose official text is archived on disk. **Numeric survey bands**, line spacings, flying heights, array dimensions, are stated as industry practice conventions chosen for target and terrain, never as figures from a named survey; the exhibits that carry them say so in their source lines.

## Anonymisation and the one delivered credential

The paper names no client and describes no specific project by identifying detail. The single delivered-practice credential, the 24km<sup>2</sup> multi-method reconnaissance, appears only in its approved anonymised form, at project type and scale, and traces to a register artifact reproduced in isolation on disk. The engagement-grade references, a 3D seismic acquisition-and-processing mandate and a regional exploration synthesis, are stated with the verbs their evidence supports, engaged to and prepared within our practice, and never carry magnitudes that would re-identify a programme. No survey figure in any exhibit derives from a client dataset.

## Open items, named

Two items are flagged in the honest spirit the series requires. First, the JORC Code is quoted in its 2012 Edition; a code-review process has been signalled across the CRIRSCO family, so a reader relying on this paper for a live reporting decision should confirm the current edition at the point of use. Second, the method captures for aeromagnetism and induced polarisation summarise established, uncontested science

rather than a contested claim; the one primary-text artifact behind the paper is the JORC Code PDF, and the reference model behind the magnetic datum is the IGRF. Where a parameter depends on the target and the terrain, the paper states a band and its reason rather than a single number.

### **How to test this paper**

Every figure and statistic in the source carries a row comment of the form WP06-nn beside it, keyed to the evidence dossier; a reader may extract them and confirm that each traces to a code, a reference model or an archived method source, and that no orphan or unused row exists. The framework exhibits are labelled as capability instruments carrying no project data, and the signature cascade and the closing playbook are explicitly method, not portfolio.

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**Mark the method science, cite the code, band the  
practice figure, and never let a client dataset stand  
behind a framework exhibit.**

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# The vocabulary of applied geophysics

**ANALYTIC SIGNAL** · a magnetic enhancement combining the horizontal and vertical field gradients; its amplitude peaks over a source edge and is largely independent of magnetisation direction, so it helps locate contacts.

**ANOMALY** · a measured departure of a physical property from its expected regional value; evidence of a possible geological feature, not a deposit.

**BOUGUER ANOMALY** · the gravity field after latitude, free-air, slab and terrain corrections, isolating lateral contrasts in bulk rock density.

**CHARGEABILITY** · the capacity of ground to store and slowly release electrical charge; the property induced polarisation measures, diagnostic of disseminated sulphide.

**COMPETENT PERSON** · under the JORC Code 2012, a professional with a minimum of five years of relevant experience who may report Exploration Results, Mineral Resources or Ore Reserves.

**CONDUCTIVITY** · the ease with which a rock passes electrical current; sensed by electromagnetic methods, high in massive sulphide, graphite and saline water.

**CRIRSCO FAMILY** · the group of national reporting codes (JORC, SAMREC, the CIM standards behind NI 43-101 and others) built on a common template.

**DIURNAL CORRECTION** · removal of the daily and storm-driven variation of the geomagnetic field, using a stationary base-station magnetometer.

**EULER DECONVOLUTION** · a technique that estimates the depth and position of magnetic or gravity sources from the field and its gradients.

**GAMMA-RAY SPECTROMETRY** · radiometrics: measurement of natural potassium, thorium and uranium emission from the top few tens of centimetres of ground, mapping surface lithology and alteration.

**GRAVITY METHOD** · measurement of small lateral variations in the gravitational field caused by density contrasts in the subsurface.

**IGRF** · the International Geomagnetic Reference Field, the IAGA standard model of the Earth's main field, revised about every five years and removed from magnetic data.

**INDUCED POLARISATION (IP)** · an electrical method measuring chargeability in the time or frequency domain, the workhorse for disseminated-sulphide and porphyry targets.

**INVERSION** · the computation of a subsurface physical-property model that reproduces the measured field; non-unique, so constrained by geology and petrophysics.

**MAGNETIC SUSCEPTIBILITY** · the degree to which a rock is magnetised by an applied field, dominated by magnetite and pyrrhotite content.

**MAGNETOTELLURICS (MT)** · use of the natural electromagnetic field to image electrical conductivity to great depth, beyond active-source electromagnetics.

**PETROPHYSICS** · measurement of physical properties (susceptibility, density, conductivity) on rock samples, used to constrain and calibrate geophysical inversion.

**REDUCTION TO POLE (RTP)** · a magnetic transform that repositions anomalies over their sources by correcting for the field's inclination.

**REFLECTION SEISMIC** · imaging of acoustic-impedance contrasts at depth in two or three dimensions; the highest-resolution and highest-cost method.

**REFRACTION SEISMIC** · use of refracted arrivals to resolve near-surface velocity and the weathered layer, including uphole surveys.

**RESISTIVITY** · the inverse of conductivity, mapped in four-electrode arrays alongside induced polarisation.

**TOTAL MAGNETIC INTENSITY (TMI)** · the strength of the total magnetic field recorded at the sensor, in nanoteslas, the primary magnetic measurement.

**VERTICAL SEISMIC PROFILE (VSP)** · a seismic survey with geophones in a borehole, tying surface data to depth and calibrating the image to ground truth.

**VIBROSEIS** · a controlled vibratory land seismic source, avoiding the permitting and safety burden of explosives.

## AURUS INSTITUTE FOR RESOURCE DEVELOPMENT

### Reading the Ground

Geophysics campaign design for greenfield mineral exploration. A paper in the Aurus white paper library, Explore pillar.

Prepared by the Aurus Technical Committee, July 2026. Working draft 1: Explore Technical Paper; adversarial certification pending.

Citation policy: every framework fact is cited to a published code, a reference model or an established method source archived on disk; numeric survey bands are stated as industry practice, not attributed to any single survey; the one delivered credential appears only in its approved anonymised form. No client is named.

Typefaces: Fraunces (display), Source Serif 4 (text) and Inter (labels and exhibits).

Imagery generated and art-directed in-house. This edition carries six commissioned images, none depicting people.

Working draft for adversarial review; not for external distribution in this state.

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