04 April 2026

# Technical Report

# Geoscience Review of the Proposed Bendigo-Ophir Gold Project, Matakanui Gold Ltd, New Zealand

Dr Alexander McAlpine
[redacted]

## Declarations

I have read and complied with the Environment Court's code of conduct for expert witnesses in Part 9 of the Environment Court Practice Note and agree to abide by that code.

I am familiar with the Crown Minerals Act 1991, the Resource Management Act 1991, the Fast-track Approvals Act 2024, the Building (Dam Safety) Regulations 2022 and Amendment Regulations 2023 and the NZSOLD Dam Safety Guidelines 2024.

This report is provided in my personal capacity and has no association with my geoscience consulting business - Spectrum Exploration Ltd.

To the best of my knowledge neither Spectrum Exploration Ltd nor I have any pecuniary interest or business association with the Applicant or its associates, advisors, or business competitors.

No data or narrative in this report has been sourced using A.I.

Signed:

Dr Alexander McAlpine

Date: 04 April 2026

## Summary of expertise

I hold a 1st Class Honours degree and PhD in Geology from the University of Newcastle Upon Tyne (UK) - the latter funded through a Shell scholarship. I have over 40 years of work experience gained initially through diverse roles with the Shell International Group of companies. These encompassed: petroleum engineering (Aberdeen & offshore); reservoir geology (London); special studies (The Hague); geophysical research (Rijswijk, Netherlands); Maui-B and Kapuni Field appraisal and development planning (New Zealand); field development and unitization (London); a secondment to the UK Dept of Energy; and as Chief Geologist in Shell's Global Studies Team (The Hague).

I emigrated to New Zealand in 1991 and held various team-leader, manager, advisory and contract positions with: Petrocorp & Fletcher Challenge Energy Ltd (New Zealand); Santos Ltd (Australia); Contact Energy Ltd (New Zealand); Woodside Petroleum Ltd (Australia); and Todd Energy Ltd (New Zealand).

I have limited experience in hard rock mining, but extensive geotechnical training and experience within the fields of rock-mechanics, tectonics, hydrogeology, human-induced seismicity, enviromental monitoring and geochemical restoration.

I founded Spectrum Exploration Ltd in 1997 to provide geoscience consulting services and am now semi-retired.

I am a past president of the Taranaki Geological Society and a past national committee member of the Geological Society of New Zealand.

and

I am familiar with the geology, heritage and natural environment of the Bendigo-Ophir region and the Thomson George Track from numerous recreational visits.

# Contents

# 1. Executive Summary

This report presents my technical assessment of reports lodged by Matakanui Gold Ltd (the Applicant) in support of the proposed Bendigo-Ophir Gold Project (the Project). Observations are limited to the following three aspects of the Project Application:

**a) Immaturity of the Mine Development Concept**

The Applicant's Supporting Technical Report to the Fast Track Application "B.28 Peter O'Bryan & Associates Geotechnical Assessment Open Pit and Underground Mining - Rise and Shine Deposit, June 2025) frequently cautions that further data and analysis is required beforethe Project moves to the feasibility Stage. From these cautions I conclude the mine plan currently before the Expert Panel should be regarded as conceptual only and that any significant change to the mine concept will materially impact the majority of resource consents being sought.

b) **Risks from mining-induced seismicity**

The Applicant's technical reports lack any consideration of mining-induced seismic risks despite the unfavourable geological conditions at the Project site. Mining-induced seismicity differs from natural earthquakes in that it typically results in unexpected and sudden ground disturbances within, or very close to, the footprint of the mine itself. Such disturbances are capable of producing:

- rock falls and damage to ground supports and foundations;
- damage to fill bulkheads and potential liquefaction of fill mass; and
- damage to vital infrastructure such as: tailing storage facilities; water dams and weirs; mine service and ventillation shafts; towers and winders; and rupture of tanks and bins in process plants.[1]

I believe consideration of mining-induced seismicity should have shaped every aspect of the Applicant's proposed Project - from concept-selection through feasibility planning, operations, enviromental management, abandonment and legacy and has consequences for nearly all of the resource consents being sought in the Fast Track Application.

Mining-induced seismicity can also accelerate the natural earthquake activity across the wider region – increasing the harm to surrounding communities from both the quakes themselves and from heightened public alarm and anxiety.[2]

[1] Queensland Government Mines safety bulletin no. 168 (https://www.rshq.qld.gov.au/safety-notices/mines/seismic-emergency-response-and-preparedness)

[2] https://theconversation.com/earthquakes-triggered-by-humans-pose-growing-risk-71061

**c) Recovery of toxic and/or valuable by-products.**

The Application does not investigate options for the economic recovery of toxic and/or critical minerals that are currently planned to left abandoned as tailings or discharged into groundwater, surfacewater, land and air. Modern mining practice increasingly requires this be considered - ideally at a mine‘s concept-development stage, and retroactively for established mines.

Irrespective of New Zealand’s policies and directions on critical minerals, which are outside the scope of this Fast Track Application, I believe the Applicant should have provided an assessment of the direct and indirect benefits of reducing or eliminating toxic and critical mineral waste versus dumping it or releasing it to the environment.

## 2. Aim and Structure of this Report

This report addresses three geoscience[3] matters:

a) Immaturity and unsuitability of the current Pre-Feasibility Mine Development Concept for the approvals being sought

b) Absence of consideration of potential hazards from mining-induced seismicity; and

c) Absence of consideration of options to recover toxic and critical minerals from mine tailings.

Shortcomings in the current Pre-Feasibility Mine Development Concept are discussed in report, B.28 Peter O'Bryan & Associates Geotechnical Assessment Open Pit and Underground Mining. I broadly concur with that report and consider the identified shortcomings make the current mine development design concept to be premature as a basis for using as the basis for the resource consents being sought.

As mining-induced seismicity has not been widely studied or experienced in New Zealand I have included some background information on this. The single mention of mining-induced seismicity in the Applicant's Supporting Technical Reports[4] refers to a 2024 Pre-Feasibility study in which mining-induced seismicity is apparently listed as a potential risk.[5] That 2024 Pre-Feasibility Study is not included among the Fast-track supporting documents, though summaries of the 2024 and 2025 Pre-Feasibility Studies were lodged with the ASX and contain nothing to indicate whether mining-induced seismicity has been assessed. I conclude from theoretical considerations and analogue comparisons that mining-induced seismicity presents significant risk and must be expertly assessed before further project maturation.

The lack of consideration to the recovery of valuable toxic and critical minerals from mine tailings is discussed in the context that it falls short of good industry practice and bypasses the opportunity to greatly reduce the amount of toxic minerals being dumped, and the harmful environmental, social and legacy effects of the mine.

[3] Geoscience is the application of the pure sciences (chemistry, physics and biology) to the study of earth's atmosphere, hydrosphere, biosphere and lithosphere.
[4] B.28 Peter O'Bryan & Associates Geotechnical Assessment Open Pit and Underground Mining - Rise and Shine Deposit , July 2025 - page 16.
[5] PSM Consult Pty Ltd (PSM) Bendigo-Ophir Gold Project Pre-Feasibility Geotechnical Assessment Report PSM5131-003R DRAFT, dated 31 July 2024 (unpublished)

# 3. Key Matters of Concern

## 3a) Immaturity of the Mine Development Concept

The Applicant stated in 2025 that "The Updated Pre-Feasibility Study (PFS), released on 1 July 2025, confirmed the BOGP as a large-scale, long-life and technically robust development, ready to transition from study phase to execution following approvals." (Ref: Santana Minerals Ltd Half-Year Report (Dec 2025)

However, the Applicant's Supporting Technical Report to the Fast Track Application "B.28 Peter O'Bryan & Associates Geotechnical Assessment Open Pit and Underground Mining - Rise and Shine Deposit, June 2025) cautions that further data and analysis is required before moving to the feasibility Stage and states, for example:

> *Page 12 "The Rise and Shine Preliminary Feasibility Study had limited sub-surface data coverage. This is inferred to reflect time constraints and Santana Minerals Ltd has both awareness and acceptance of needs for further investigation and assessment. It is not unusual for Preliminary Feasibility Study investigations to have limited investigative coverage, necessitating broad extrapolation regarding ground conditions and requiring further data for appropriate feasibility assessment.......*
>
> *Page 14 "The restricted data coverage (discussed previously) further limits confidence in inferred rock mass capacity and anticipated ground response to mining activity.....*
>
> *Page 67 "*We stress the need for further investigation and analysis for feasibility assessment, detailed mine design and ongoing geotechnical assessment and review during mining once operations are established ".

Shortcomings in the Applicant's current mine development concept are extensively discussed in Report B.28. All other relevent geotechnical mine design documents submitted by the Applicant in support of the Fast Track application (Reports B.20, B.21 & , B.22) are dated June/August 2025 and presumably do not incorporate or reflect the recommendations and conclusions contained in Report B.28.

I thereore consider the mine plan currently before the Expert Panel should be regarded as conceptual only and that any significant change to the mine concept will materially impact the majority of resource consents being sought.

I also suggest the adverse tectonic and rock-mechnical conditions cautioned in Report B.28, together with risks of mining-induced seismicity[6], and discussed in the next section, require the Applicant to consider development options with a diminished open-pit component – potentially no larger than required to provide a secure underground mine portal. Reducing the open-pit dimensions would offer enormous additional benefits by greatly reducing the volume of waste-rock to be quarried, carried and stacked, thus greatly reducing deliterious impacts on the environmental, heritage, aesthetic and social values of the region.

[6] Report B.28 (page 16) refers to an unavailable report (PSM Consult Pty Ltd (PSM) Bendigo-Ophir Gold Project Pre-Feasibility Geotechnical Assessment Report PSM5131-003R DRAFT, dated 31 July 2024). that lists mining-induced seismicity as a risk to open pit and underground mining.

## 3b) Mining-Induced Seismicity

Potential adverse impacts of mining-induced seismicity are not covered in any of the Applicant's Supporting Technical Reports, but and require thorough analysis before the mine progresses to a Feasibility Stage design and resource consent requirements meaningfully considered.

Mining-induced seismicity is a subset of human-Induced seismicity, which encompasses a range of shaking effects and ground disturbances caused by the release of stored tectonic stresses in the shallow crust of the Earth and triggered by human activities of sufficient scale to cause the surrounding rock to rupture and/or deform. Thus defined, it excludes many commoner forms of ground disturbance where gravity, rock solution, landslides, creep, liquification and natural seismicity (earthquakes) are the driving agents.

Common activities associated with human-induced seismicity are illustrated in Figure-1.

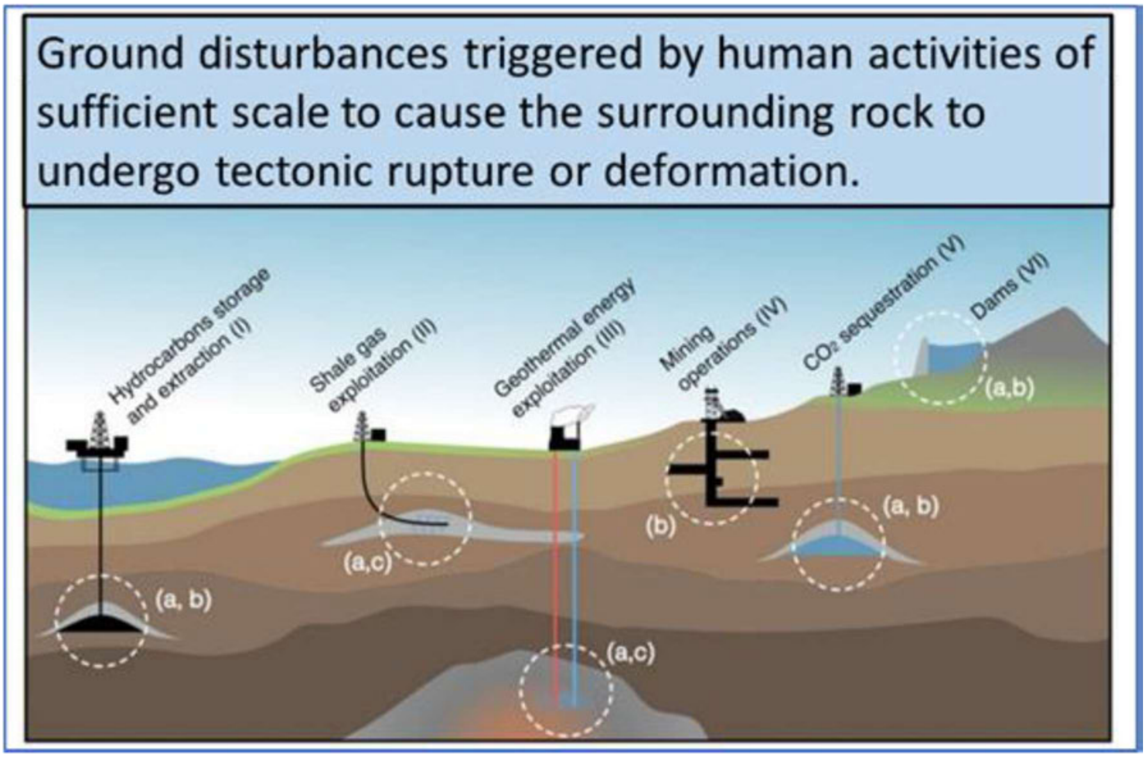


**Figure-1: Common Causes of Human-Induced Seismicity (Modified from American Geophysical Union Bulletin)** https://eos.org/editors-vox/the-challenges-posed-by-induced-seismicity

First identified in the early 1900's, human-induced seismicity is now widely recognised across a wide range of industry sectors. Public interest and concern has also markedly accelerated in recent decades – particularly around fracking, and tailings dam failures.

The Human-Induced Earthquake Database (HiQuake) [7] is the largest global database on human-induced seismicity and currently holds data for over 1,370 cases of human activities claimed, on scientific grounds, to have induced seismicity (earthquakes) and/or ground movements (see Figure-2). Induced earthquakes are usually small and cause little or no damage. Ground movement is often more consequential as it can damage project infrastructure (pits, shafts, dams wells, etc.), sometimes with catastrophic consequences.[8]

Only six cases of human-Induced seismicity in the database are from New Zealand. Four pertain to geothermal projects in the Taupo District, where well-fracking is now routinely employed to enhance steam production[9]. The other two are in the Canterbury Region, where hydro lake filling at Lake Benmore in 1966[10], and Lake Pukaki in 1978[11]., induced earthquakes of Magnitude 5.0 and 4.6 respectively

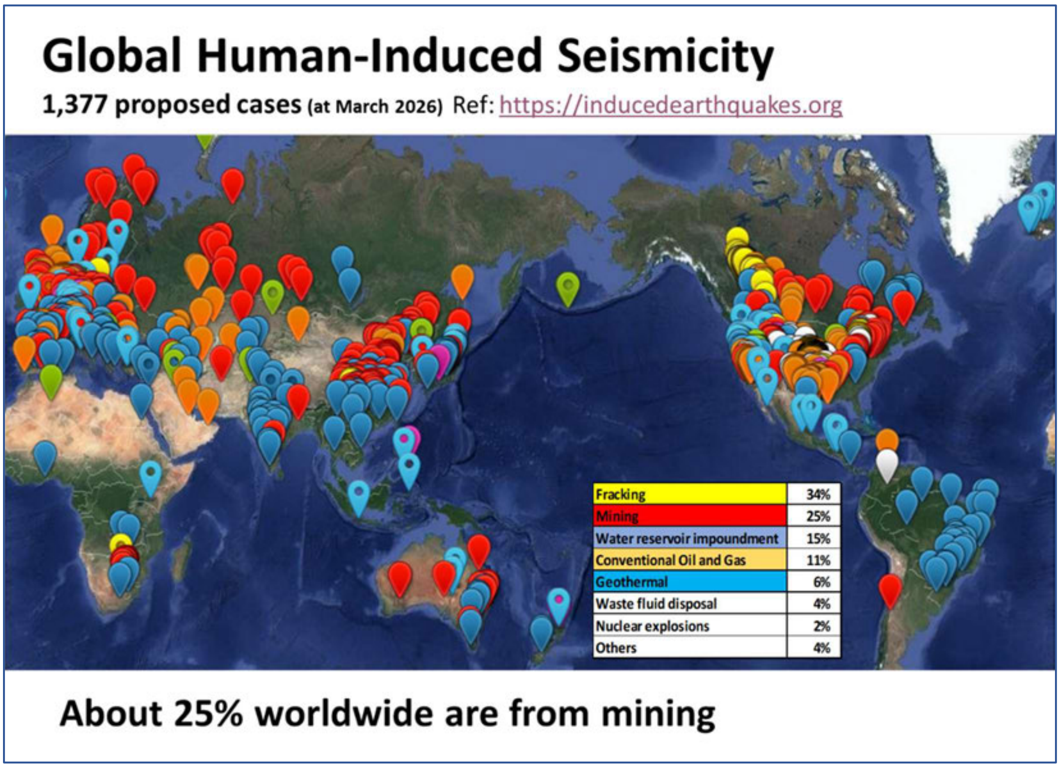


**Figure-2: Locations and Categories of Human-Induced Seismicity Cases**

7 Ref: Foulger, G. R., Wilson, M., Gluyas, J., Julian, B. R., & Davies, R. (2018). Global review of human-induced earthquakes. Earth-Science Reviews, 178, 438-514.

8 Ref: “The tailings dam failure of 5 November 2015 in SE Brazil and its preceding seismic sequence”, Geophys. Res. Lett., 43, 4929–4936, doi:10.1002/2016GL069257.

9 Pers. com. Dr Ted Montague, Contact Energy Ltd.

10R.D. Adams, “Statistical studies of earthquakes associated with Lake Benmore, New Zealand“; Engineering Geology Volume 8, 1974, Pages 155-169

11 Reyners, M; “Reservoir-induced seismicity at Lake Pukaki, New Zealand”, NZ Geophysical Journal (1988) 93, 127-135

The low number of known cases in NZ, has led to awareness and preparedness for induced-seismicity risks. This is evident by the topic being largely absent from the NZ regulations, programmes and guidelines for at-risk industries.

NZ guidelines for large dams emphasise designing for "once in x-thousand-year" earthquake events (natural seismicity) but ignore the potential risks of human-induced-seismicity causing shaking, ground deformation and rupturing in the immediate location, and often the early lifetime, of the project itself.

Australia, by contrast, has adopted many guidelines and bulletins requiring miners to include discussion of past or future seismic events being either natural (through earthquakes) or mining-induced, as both can affect open cut and underground mining operations.[12] A number of organisations in Australia currently undertake research, education and consulting in this field in addition to providing advisory and monitoring services to the mining industry[13].

An illustration of the multidisciplinary approach required for the study of induced-seismicity is shown in Figure-3.

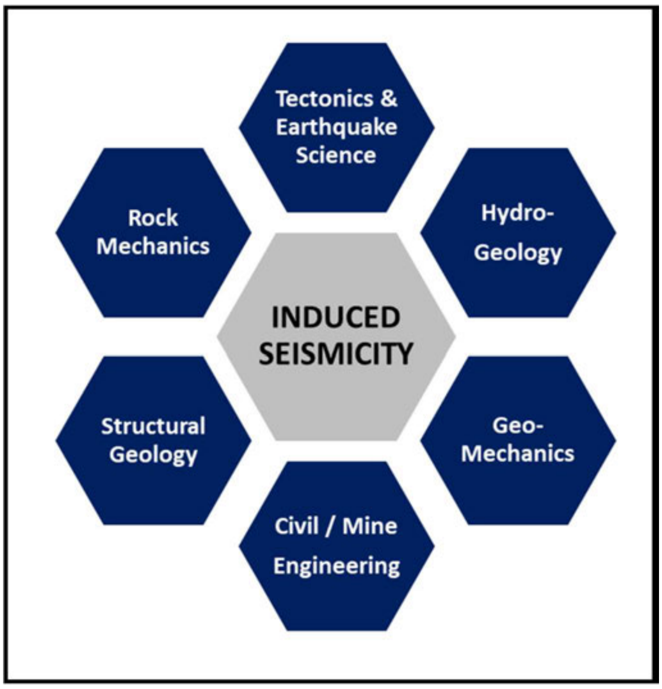


**Figure 3 – Component Disciplines of Induced-Seismicity**

[12] *https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://minex.org.nz/wp-content/uploads/2023/12/Nov-Seismic-Emergency-Response-and-Preparedness.pdf&ved=2ahUKEwjq7r7C1dWTAxUUTmwGHbH8JPMQFnoECB0QAQ&usg=AOvVaw0mZWdz8EleH4jVa6lVzOvY* (accessed 09/03/2026)

[13] Eg: https://ancold.org.au/ and: https://www.src.com.au/about-us/

In an attempt to determine whether NZ has experienced addional unrecognised cases of human-induced seismicity, I have undertaken screening investigations on several large-scale projects in six industry sectors and across the country (See Table-1)

**Table-1: List of Projects in Author's Current Screening Study of Induced-Seismicity**

| Industry Sector | District |
|---|---|
| Fracking | Taranaki |
| Coal Mining | Southland<br>Grey District<br>Buller<br>Huntly |
| Hard Rock Mining | Otago<br>Thames |
| Water Reservoir Impoundment | Auckland<br>Waikato<br>Wairarapa<br>Tasman<br>Waitaki<br>Central Otago<br>Dunedin |
| Aquifer Withdrawal | Canterbury Plains |
| Coventional Oil & Gas Production | Taranaki |
| | |

Theabove case studies include one on the Macraes gold mine in East Otago, which has findings of particular relevence to the proposed Bendigo-Ophir mine, as discussed below.

## Observations from the Macraes mine

The Macraes gold mine in East Otago offers an ideal analogue for considering the potential for induced-seismicity from the proposed Bendigo-Ophir mine. Both have low levels of natural background seismicity and recognised active, potentially active and inactive faults close-to and within the mine footprint. The prevailing tectonic stress regimes for both is compressional, which makes them theoretically susceptible to seismicity triggered from large pit excavations reducing the confining vertical stress in the shallow crust to the point of inducing rock-failure.

A first step in looking for signs of induced seismicity is usually to analyse recorded quakes in the area. In the absence of dedicated seismic monitoring data from Macraes, use has been made of the publicly available GeoNet earthquake catalogue[14]. The GeoNet catalogue utilises a relatively sparse geophone array and consequently has limited resolution. More sophisticated geophone arrays have been occasionally deployed in parts of the South Island for general research, and are planned to be analysed later.

Figure-4 shows the regional setting of the area studied.

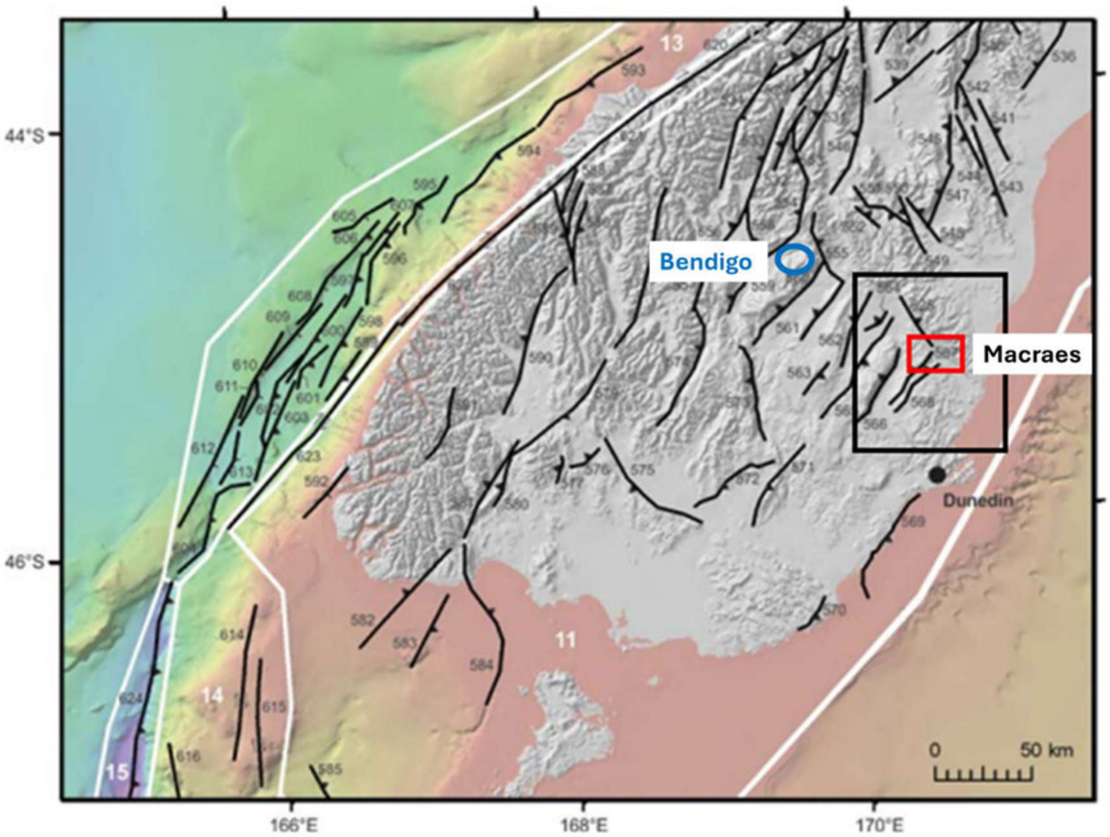


**Figure-4: Regional Setting showing main tectonic domains (white polygons) and active faults as black lines (after: Litchfield N, et. al., GNS SR 2012-019). The Macraes Study area is a c.20km by 20km area (outlined in red) centred on the mine site. The black rectangle shows the c.100km by 100km area used to calibrate Macraes seismicity against regional seismicity. The Bendigo Project location is shown in blue.**

[14] https://doi.org/10.21420/0S8P-TZ38

Figure-5 shows GeoNet's catalogued quakes in the Macraes area. No quake events were recorded from within the Macraes area before excavation of the Frasers Pit commenced in 1991.

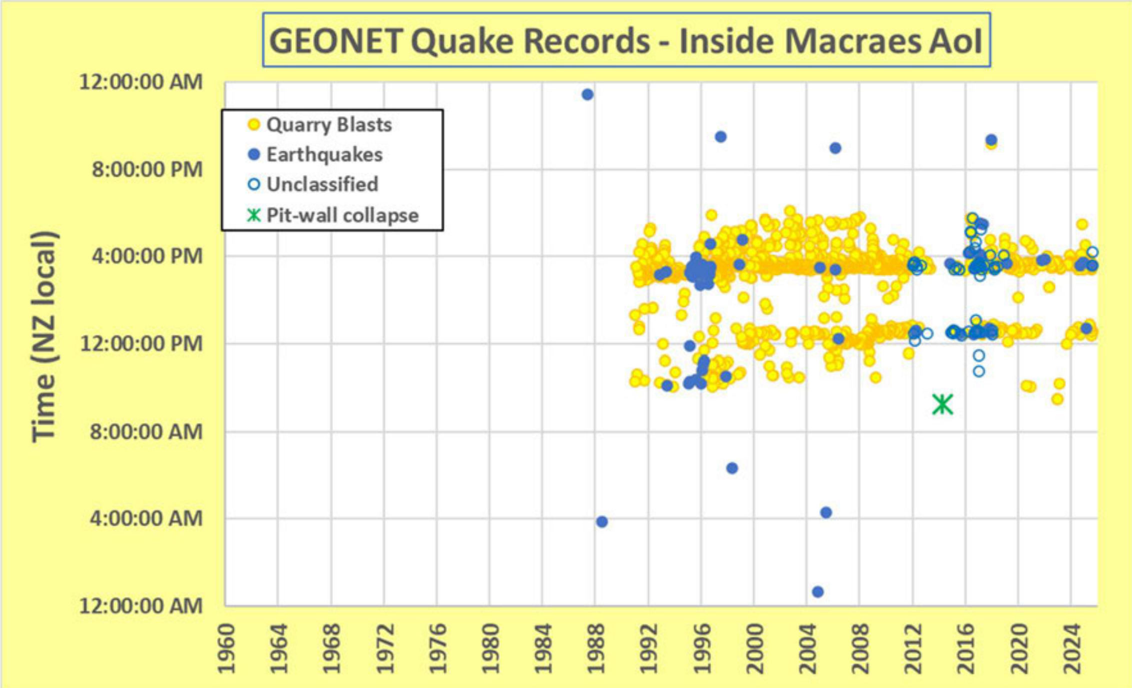


**Figure-5: Time Series of GeoNet Quake Events Recorded from within the Macraes Area of Interest**

Quake events (yellow dots in Figure-5) are almost certainly correctly classified by GeoNet as being 'quarry-blasts' and have very shallow (or surficial) epicentres. Nearly all occur within the scheduled blasting window of 9am to 5.30pm.

Many events catalogued as 'earthquakes' (blue dots in Figure-5) or 'unclassified' (blue circles) also occur during the permitted blasting window but have epicentre depths mostly in the 5km to 15km range and deepening towards the east, which is the dip-direction of the mineralised Hyde-Macraes shear zone (the ore-bearing zone in the Frasers underground mine. Equivalent to the Thomson Gorge Fault Zone at Bendingo).

Catalogued 'earthquakes' outside the permitted blasting window are unlikely to be blast-related, but examination of blast records and quake moment-tensor analyses are planned in order to better distinguish between quarry blasts, penecontemporaneous mining-induced seismic events and natural earthquakes.

A shallow seismic event (green star in Figure 4) corresponds with a reported major pit-wall collapse in 2014[15] following heavy rainfall.

Numerous other significant pit-slope failures and ground movements at the Frasers Pit are described in a 2024 report produced for Oceana Gold by PSM[16]. However, that

[15] Otago Daily Times [https://www.odt.co.nz/news/dunedin/massive-slip-closes-macraes-mine]
[16] https://www.orc.govt.nz/media/jrendyh2/appendix-7-psm-2024b-macraes-phase-4-consenting-project-element-432-open-pit-stability-assessment-for-frasers-tsf.pdf

report implies these to be localised stress-relief features with no reference to the involvement of tectonic stresses.

Another possible indicator of mining-induced seismicity at Macraes, and not directly mentioned in the PSM report, is the progressive development of surface ruptures, along the surface trace of the Macraes Fault (Figs-6 & -7).


**Figure-6: Aerial photograph of mine showing surface trace of Macraes Fault**


**Figure-7: West Wall of Fraser's Pit, showing progressive ground rupturing (arrowed).**

## Implications of Macraes for the Proposed Bendigo Project

As mentioned earlier, determining the risk of mining-induced seismicity requires integrating a broad range of geotechnical, geological and engineering factors. Such integration is not clearly evidenct in the Applicant's Supporting Technical Reports.

A comparison of PSM Ltd's geotechnical reports for both Macraes[17] and Bendigo[18] (when available) might shed light on the likely degree of pit and mine instability to be expected for the currently proposed Bendigo mine development concept.

---

[17] https://www.orc.govt.nz/media/jrendyh2/appendix-7-psm-2024b-macraes-phase-4-consenting-project-element-432-open-pit-stability-assessment-for-frasers-tsf.pdf

[18] PSM Consult Pty Ltd (PSM) Bendigo-Ophir Gold Project Pre-Feasibility Geotechnical Assessment Report PSM5131-003R DRAFT, dated 31 July 2024

### 3c) Recovery of toxic and/or valuable by-products.

The Applicant states the Project "will benefit from the application of modern and technically advanced commercial processing and mine implementation practices, as well as from leading standards of progressive mine rehabilitation and management of environmental effects"[19]. However, there is no mention of removal or recovery of valuable, toxic and/or critical minerals stated to be expected in the mining waste solids and liquids[20] and summarised below:

| Element or Compound | Toxicity in Drinking Water* | On NZ's Critical Mineral List? |
|---|---|---|
| Cadmium (Cd) | EXTREME (MAV > 0.001mg/L) | - |
| Antimony (Sb) | HIGH (MAV > 0.01mg/L) | YES |
| Arsenic (As) | HIGH (MAV > 0.01mg/L) | YES |
| Chromium (Cr) | HIGH (MAV > 0.01mg/L) | YES |
| Lead (Pb) | HIGH (MAV > 0.01mg/L) | - |
| Nickel (Ni) | HIGH (MAV > 0.01mg/L) | YES |
| Selenium (Se) | HIGH (MAV > 0.01mg/L) | YES |
| Uranium (U). | HIGH (MAV > 0.01mg/L) | - |
| Cyanide (CN) | MEDIUM (MAV > 0.1mg/L) | - |
| Manganese (Mn) | MEDIUM (MAV > 0.1mg/L) | YES |
| Copper (Cu) | LOW (MAV > 1mg/L) | YES |
| Molybdenum (Mo) | - | YES |
| Strontium (Sr) | - | YES |
| Zinc, (Zn) | - | YES |

* Source: Water Services (Drinking Water Standards for New Zealand) Regulations 2022

The recovery of mineral waste from tailings, whilst sometimes undertaken long after mine closure, offers maximum overall benefit when done contemporaneously with mining.

The ringfenced economics of recovering critical and/or toxic accessory waste minerals may be negative in the Bendigo Project, but the total direct and indirect economic benefits should nontheless be evaluated along with the environmental, heath and legacy benefits

[19] Application document A.08 Section 1 Introduction (PDF, 1 MB) – Page 6
[20] Application document B.06 Mine Waste Management Limited Mine Impacted Water Overview Report (MWM 2025) (PDF, 1 MB)

# 4. Concluding Remarks

Firstly, the currently proposed mine development concept is too preliminary and potentially misleading to be a suitable basis for the numerous resource consent approvals being sought

Secondly, the Project risks from mining-induced seismicity are significant and potentially far-reaching in view of:

- The existing earthquake risks and vulnerabilities of the region.
- The known, and potentially unknown, active and potentially-active faults in the immediate mine permit area;
- Indications of mining-induced seismicity at the Macraes gold mine, which resembles Bendigo in terms of similar tectonics, geological structure and mixed open & underground mine-development;
- The more heterolithic, anisotropic and weaker schist rocks apparent at Bendigo compared to Macraes; and
- The likelihood of mining-induced seismicity becoming exacerbated and more widespread by cumulative effects from the Applicant's anticipated mine expansion and future mining in surrounding tenements.

Once sufficient appraisal data is obtained, I consider the Applicant must engage a competent and experienced agency with capability to undertake the required multidisciplinary work to assess the induced seismicity risks of the Project.

Intuitively, I consider the adverse tectonic and rock-mechnical conditions at the site may favour a much reduced open-pit component to the Project that would offer additional benefits by greatly reducing the volume of waste-rock to be quarried, carried and stacked.

This, together with recovery of toxic and valuable tailings components, would greatly reduce the footprint of the mine which could be expected to reduce its lasting burden to the environment, heritage, aesthetics and community values.