The Need for an Industry Guideline for Geothermal Reserves Determination

Jim Lawless

(Sinclair Knight Merz - SKM)

Acknowledgement

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Greg Ussher: SKM
Jim Randle: Polaris Geothermal Inc
Allan Clotworthy: now at Lihir Gold Ltd

Having Sound Reserves Definitions is Increasingly Important For Geothermal

- Lenders and Stockmarket investors
  - Traditional requirement for resource potential analysis
  - Increasing numbers involved in geothermal financing
  - Transparently and rapidly evaluate exposure, assess risks
- Quantifying Resource and Project Value through the development cycle
  - Tracking resource proving through the exploration and development program
  - For many listed companies, this is critical for funding the development activity
- New Technologies and Resources Emerging
  - HDR, HFR, EGS, low temperature

A Common Language for Reserves Definition

- Maintain Investor Confidence
  - Consistency
  - Transparency
  - Reliability
- Support Geothermal Development
  - Track project value (hopefully growth !!) through exploration
  - Facilitate more efficient financing

Reserves Definition in Other Industries

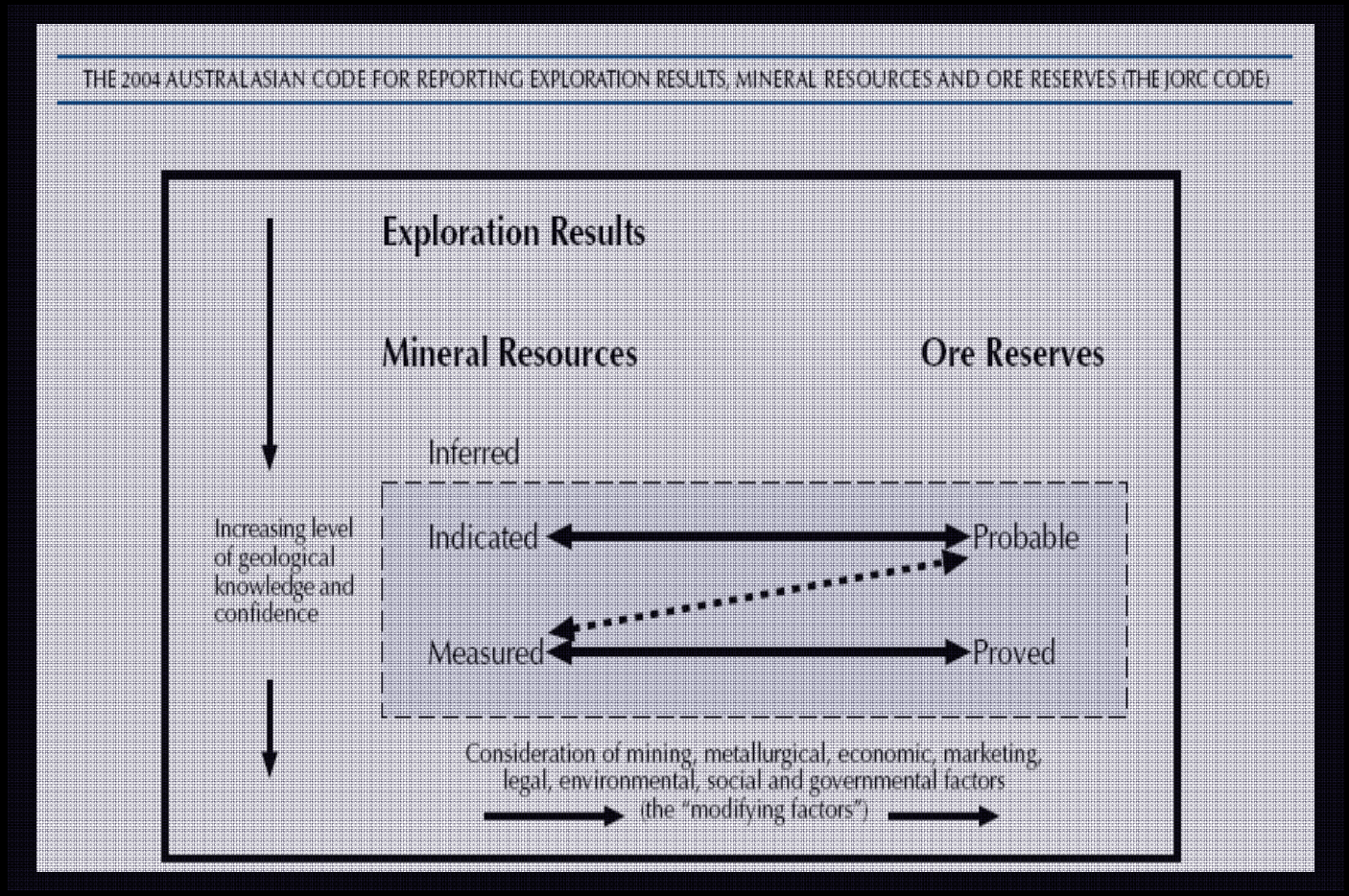
- Oil & Gas
  - Long history of application
  - A variety of standards being used, but similar components
  - Common themes
- Minerals
  - Very common standard used in Canada + Australia
    - e.g JORC Code by AusIMM
- Common Themes
  - Driven largely by Industry Professional Organisations
  - In association with market regulators
  - Two-Dimensional Categorisation

Two Dimensional Categorisation

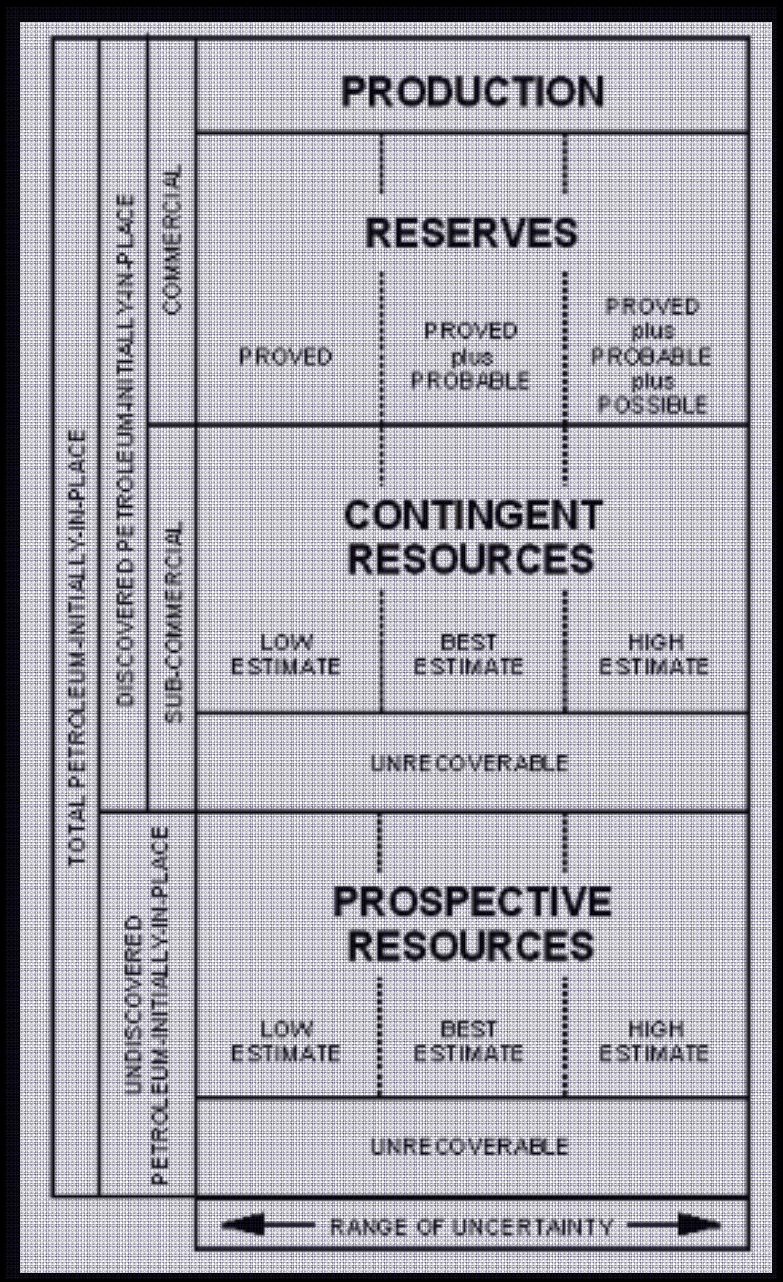
- "Geological" Knowledge and Confidence
  - The resource characteristics
  - How reliably they are defined
  - Typically : "Proven – Probable – Possible"

- Commercial Extractability
  - What can be commercially extracted - now
  - What may be extracted under more favourable conditions
  - Typically "Reserve (commercial) - Resource (sub-commercial)"

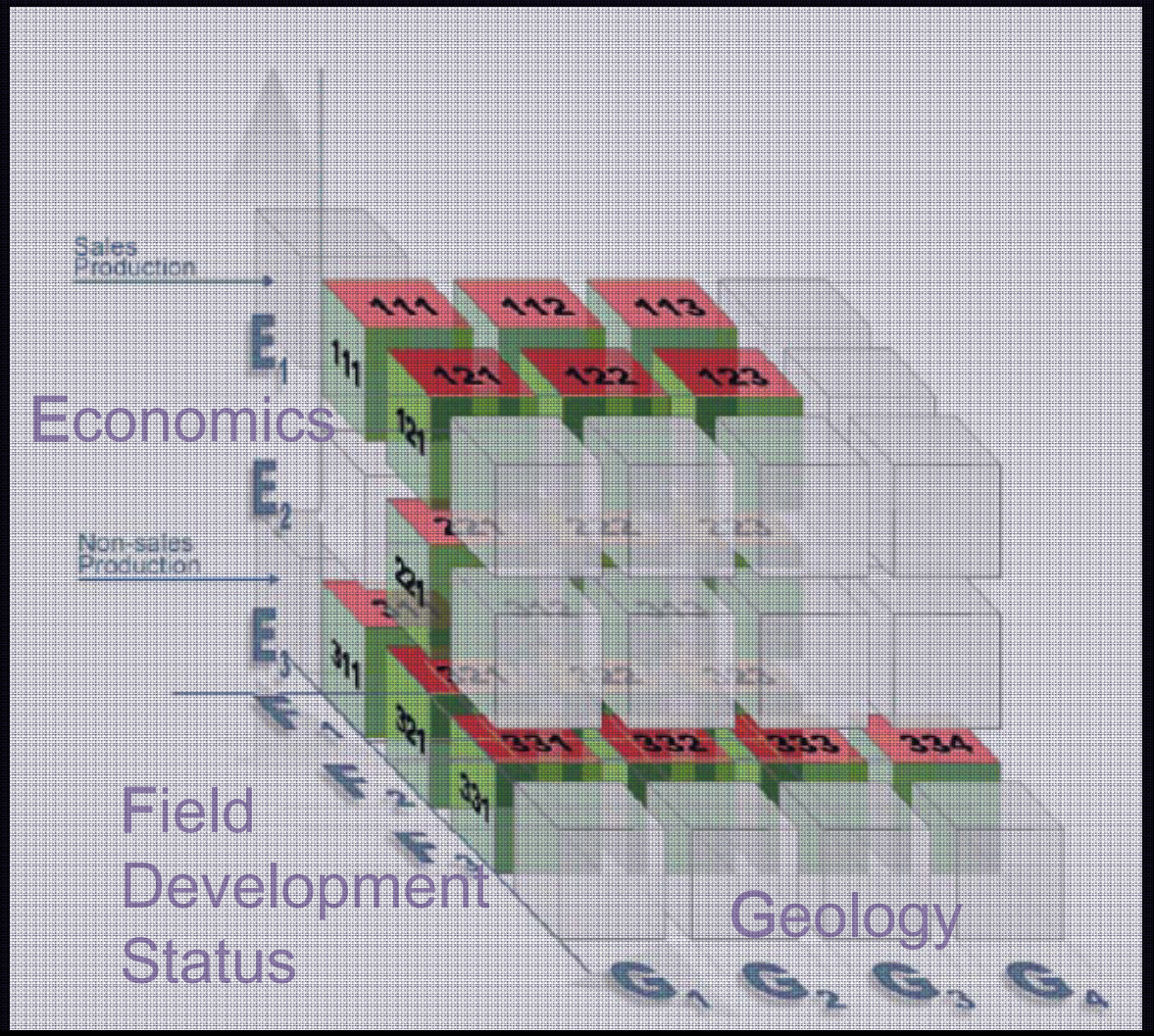
Canadian Institute of Mining (CIM) and Australian Joint Ore Reserves Committee (JORC) Code for Minerals



SPE – Oil & Gas


PRODUCTION
RESERVES
PROVED
PROVED plus PROBABLE
PROVED plus PROBABLE plus POSSIBLE
CONTINGENT RESOURCES
LOW ESTIMATE
BEST ESTIMATE
HIGH ESTIMATE
UNRECOVERABLE
PROSPECTIVE RESOURCES
LOW ESTIMATE
BEST ESTIMATE
HIGH ESTIMATE
UNRECOVERABLE
RANGE OF UNCERTAINTY
TOTAL PETROLEUM-INITIALLY-IN-PLACE
DISCOVERED PETROLEUM-INITIALLY-IN-PLACE
COMMERCIAL
SUB-COMMERCIAL
UNDISCOVERED PETROLEUM-INITIALLY-IN-PLACE

United Nations UNFC 2004

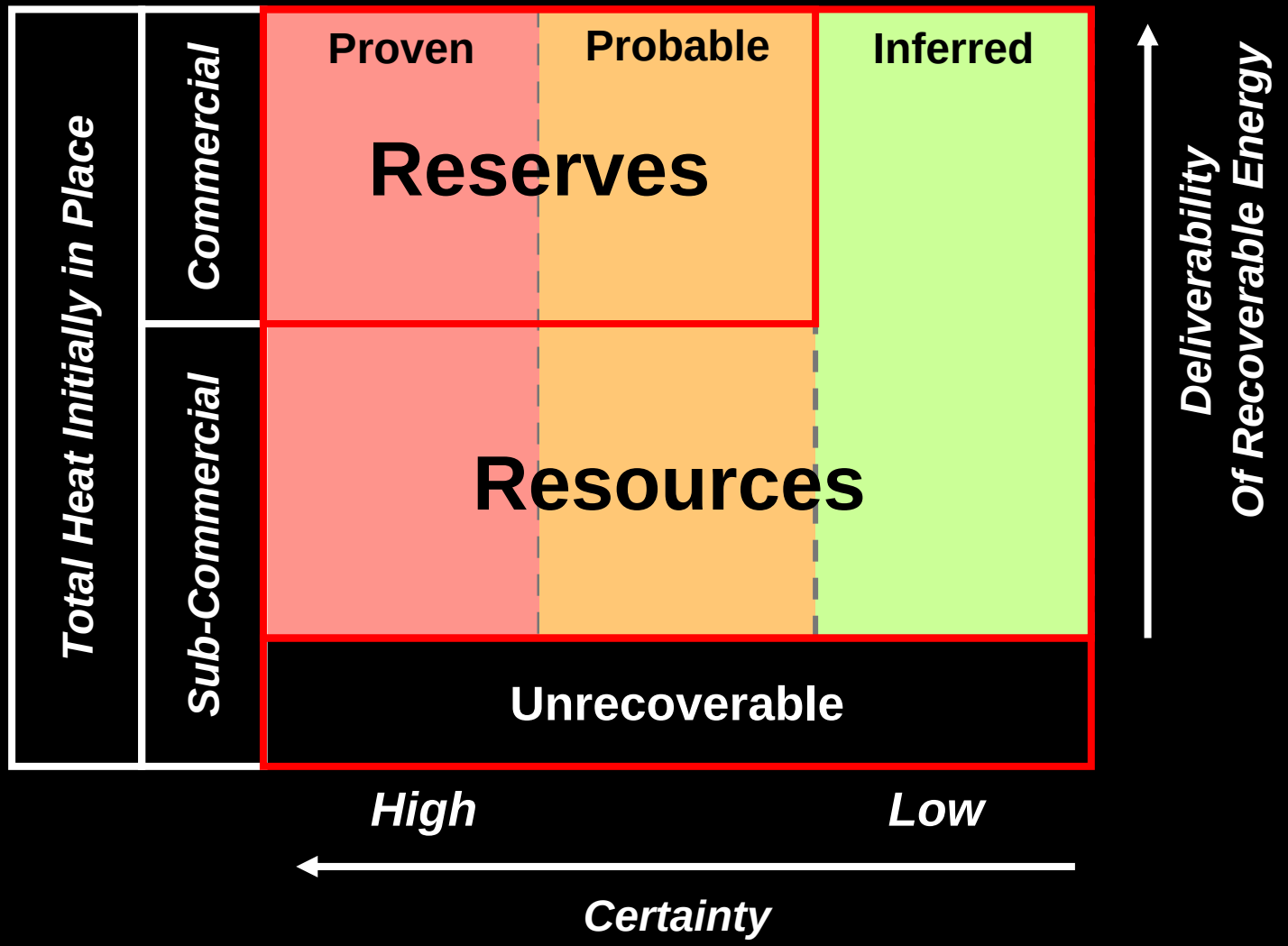


Key Requirements

- Deliver clear understanding of certainty and reliability of data
- Pragmatically deal with commercial criteria
- Can be applied for all geothermal resource types

- Next step: develop Guidelines for implementation

A Possible Classification



Certainty Classifications

- Proven
  - Sampled by wells
  - Deliverability demonstrated
  - “No surprises” expected in future drilling
- Probable
  - Less reliably characterised
  - Temperature indicated by geochemistry or nearby wells
  - Area defined by geophysics / temperature gradient mapping
- Inferred
  - Less direct indications of area, depth and character
  - Sound reason for indicating resource - geochemistry

Commercial Criteria

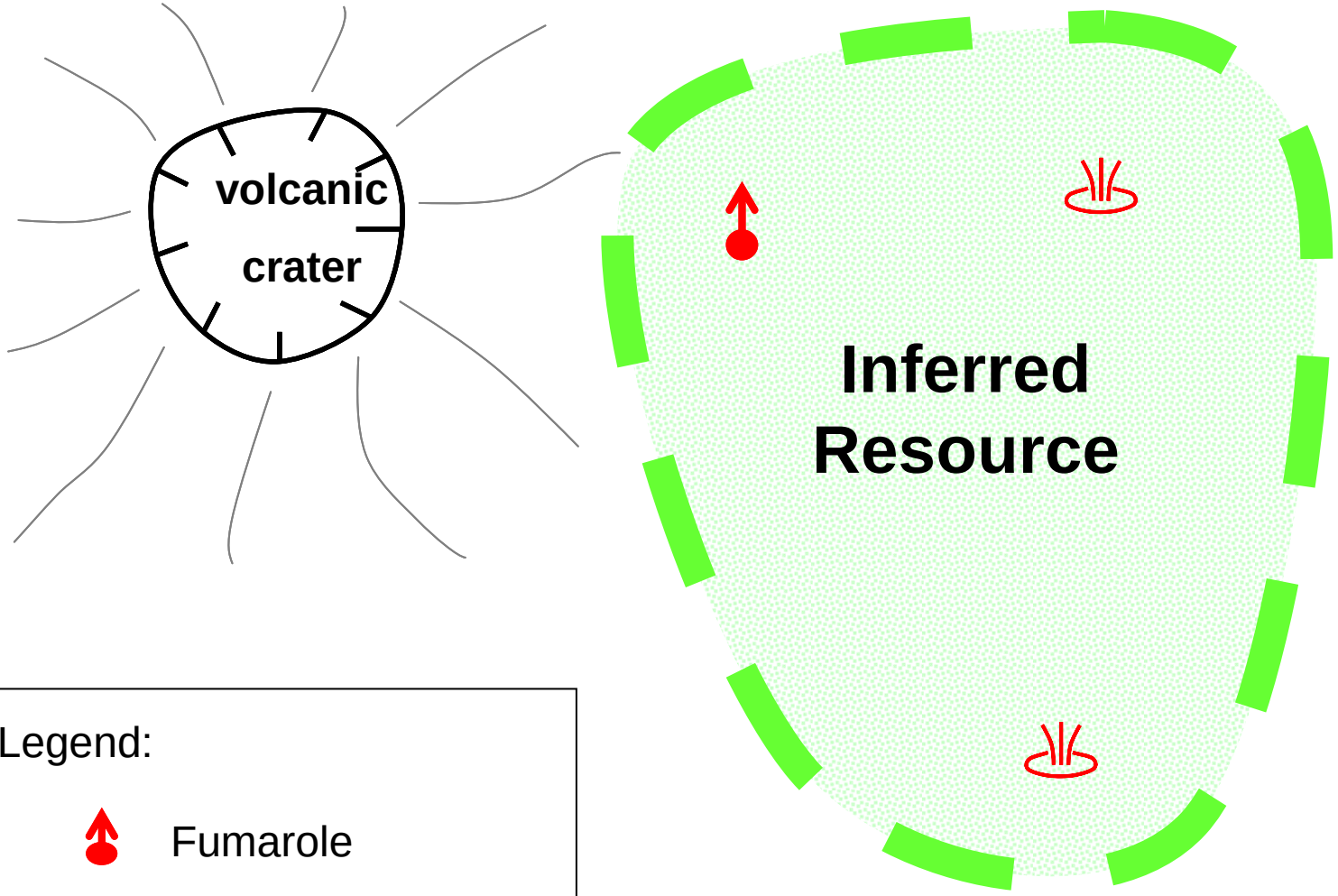
- An extra issue for geothermal generation is that the product, electricity, has severe limitations on its transportability
- Hence unlike minerals and oil, which have a definable international $ value, the value is **country-** and even **site-specific**
- This affects:
  - The economic drilling depth and hence the reservoir volume
  - The cut off grade
  - The plant type that is affordable and hence the efficiency
- A meaningful resource estimate must therefore state the assumed power price and technology

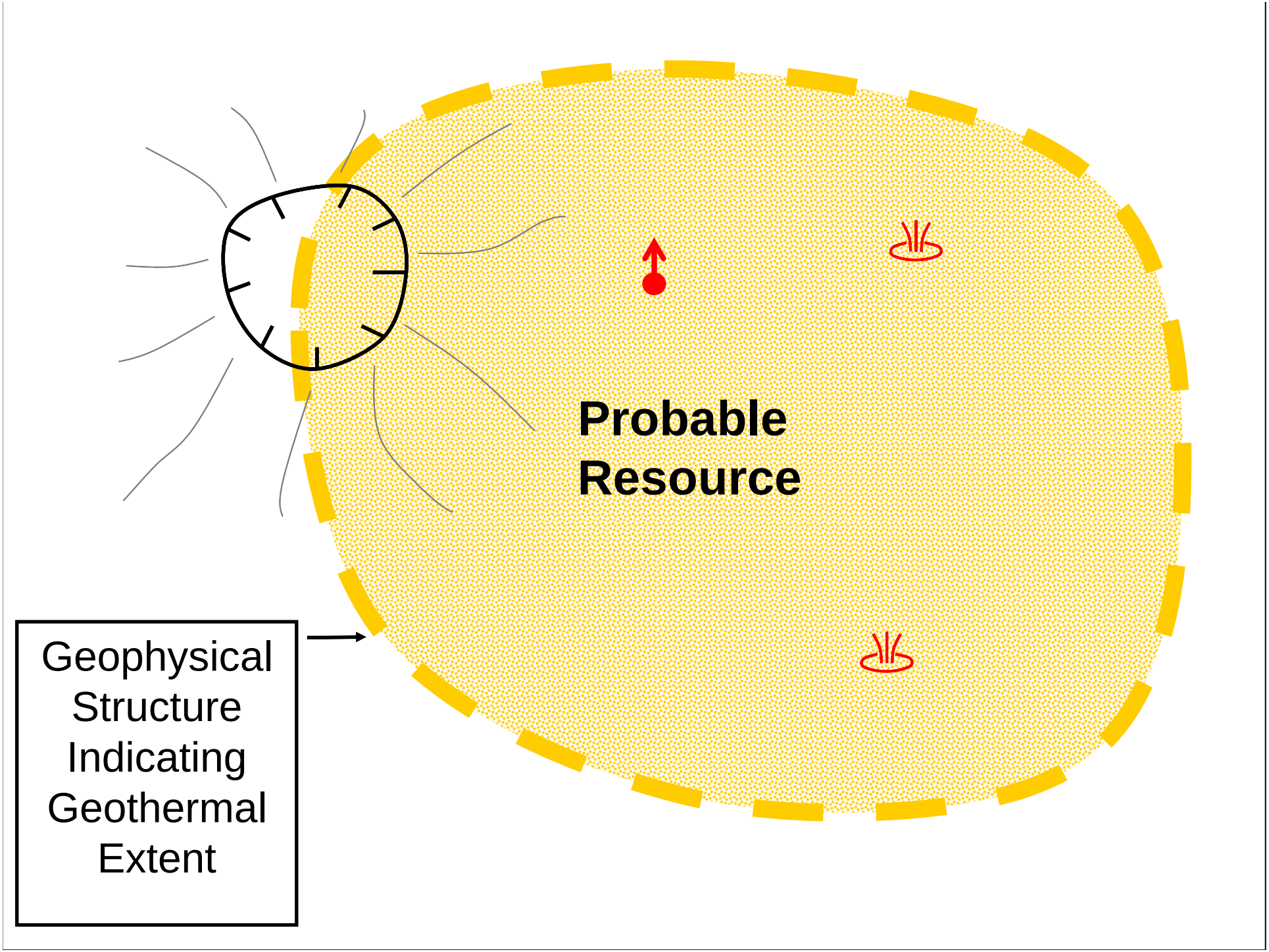
Mutnovksy 50 MWe Power Plant, Russia,

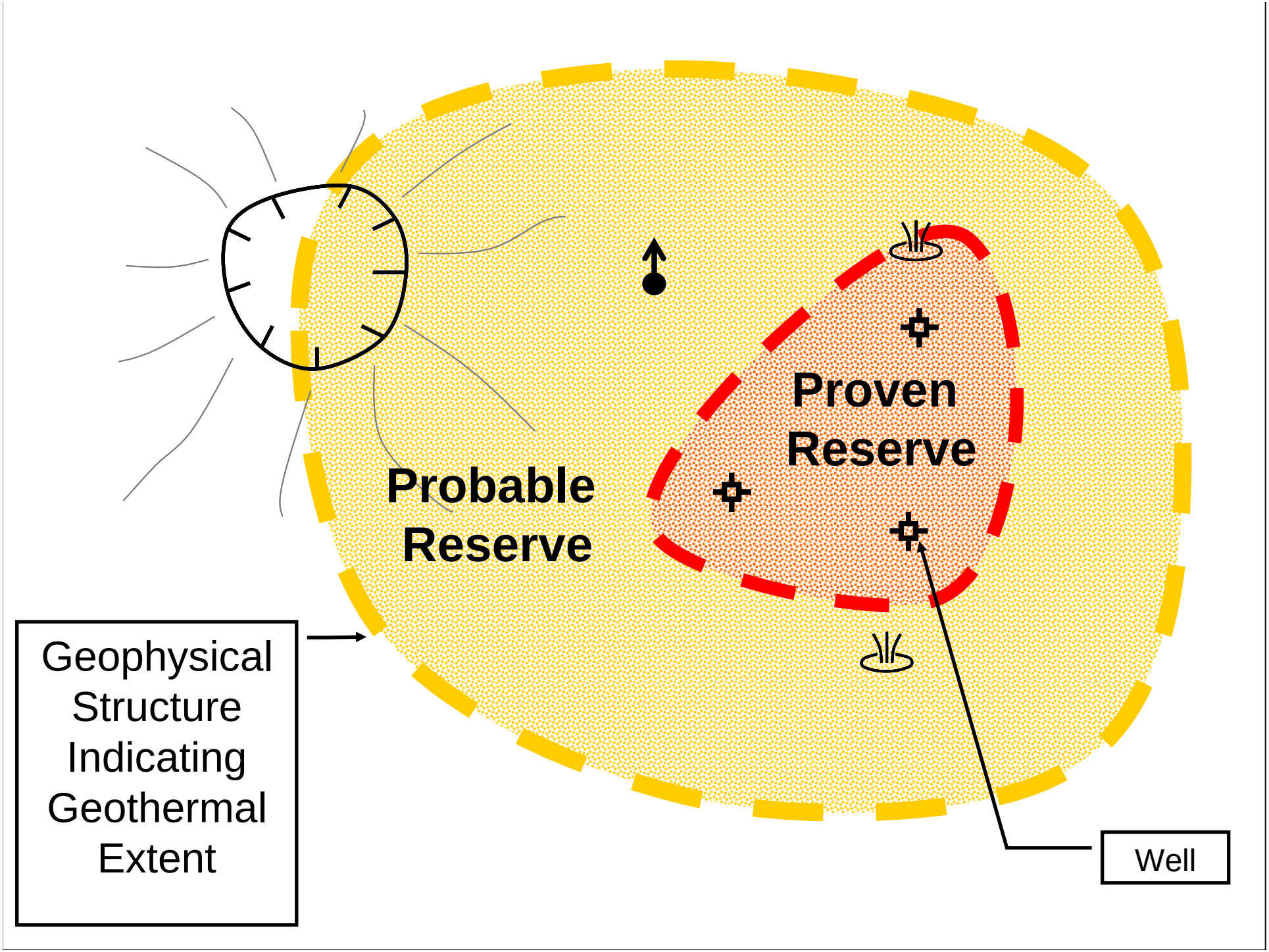
Upper Mahiao plant, the Philippines

Commercial Extractability

- Reserves
  - Commercially Extractable
    - Use generally accepted criteria for initial assessments
    - Refined by pre-feasibility or feasibility assessments
  - In context of a ***Stated Target Type of Development***
  - Can use Well Deliverability as a practical measure
- Resources
  - Could be commercially extractable in foreseeable future
  - Technology identified, not yet economic or technically proven


volcanic
crater
Inferred
Resource
Legend:
Fumarole
Cl spring


Probable
Resource
Geophysical
Structure
Indicating
Geothermal
Extent


Proven
Reserve
Probable
Reserve
Geophysical
Structure
Indicating
Geothermal
Extent
Well

Practical Application

- Guidelines for definition criteria
  - Representing the reliability of exploration data
- Use deliverability to indicate Commercial Extractability
  - Define areas / volumes that are extractable
  - Define temperature limits below which deliverability would be come un-commercial –
    - the extraction base temperature
- Guidelines for Energy Calculation
  - Stored heat calculations
  - Numerical models
  - Accommodating Recharge
  - Efficiency of energy conversion / utilisation

Conclusions

- Formalisation of Energy Reserves Descriptions
  - Will encourage investor confidence
  - Support projects during development stages
  - Encourage R&D to increase reserves through commercialisation of new technology
- This could get forced on the Geothermal Industry
  - Potential for TSX, ASX etc to act unilaterally
- We should act
  - Better that the geothermal community drives this process
  - GRC and IGA are logical organisations to lead the process
    - Together with major developers, regulators, market operators, lenders
    - No comparable organisation in Australia ?