



Potential Application of UNFC Classification to Geothermal Resources

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<http://energy.usgs.gov/other/geothermal/>

U.S. Department of the Interior
U.S. Geological Survey



Brief Background on Geothermal Classification

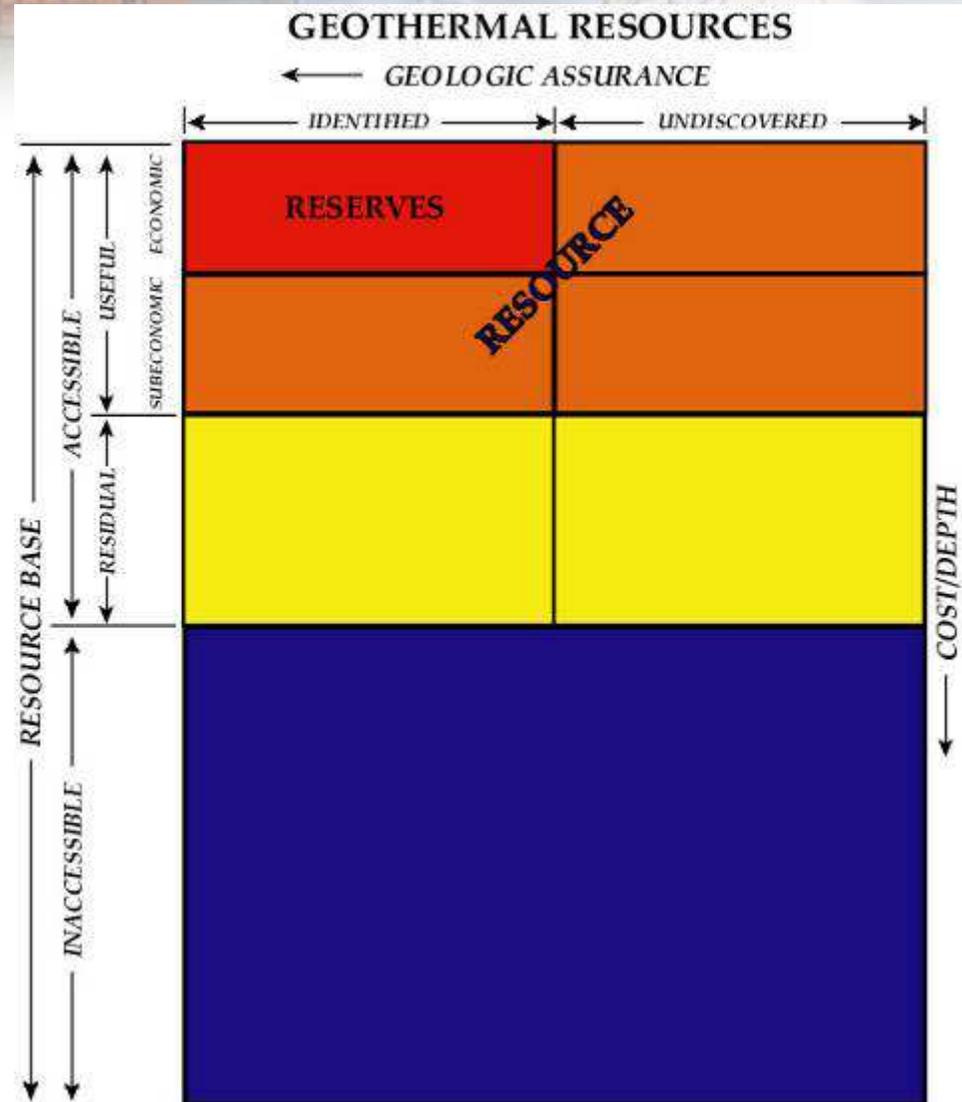
- USGS geothermal resource classification developed by Muffler and Cataldi (1978), which was derived in part from USGS terminology applied in mineral and petroleum assessments (McKelvey diagram)
- This approach formed the basis for guiding the scope and describing the results of geothermal resource assessments, including recent USGS assessments
- Fundamental divisions are **resource base**, **resource** and **reserve**
- Following USGS mineral resource classifications, the geothermal resource could be further categorized as **inferred**, **indicated**, or **measured**
- An important distinction to note regarding geothermal is that in contrast to other geologic resources (e.g., mineral deposits, petroleum) thermal recharge rates can be high enough to significantly alter assessment results under different exploitation scenarios. Consequently, results incorporate a standard production lifetime (e.g., MWe for 30 years)

USGS Resource Assessment Concepts

Reserve – Geothermal energy that can be extracted legally and economically.

Resource – Geothermal energy that is technically recoverable and can be added to Reserves at some future time.

Resource Base – Thermal energy in the crust in specific area.



Modified from Muffler and Cataldi (1978)

Some Additional Approaches

GeothermEx (Schlumberger subsidiary) – Characterizes reserve estimates by equating risk with results of Monte Carlo simulations

Proved Reserves = P90

Probable Reserves = P50 (or Mode) – P90

Possible Reserves = P10 – (Probable + Proved)

Australian and Canadian Geothermal Energy Association Reporting Codes – Based on need to provide guidelines for publicly traded companies (and derived from Mineral and Petroleum reporting codes as well as earlier USGS terminology)

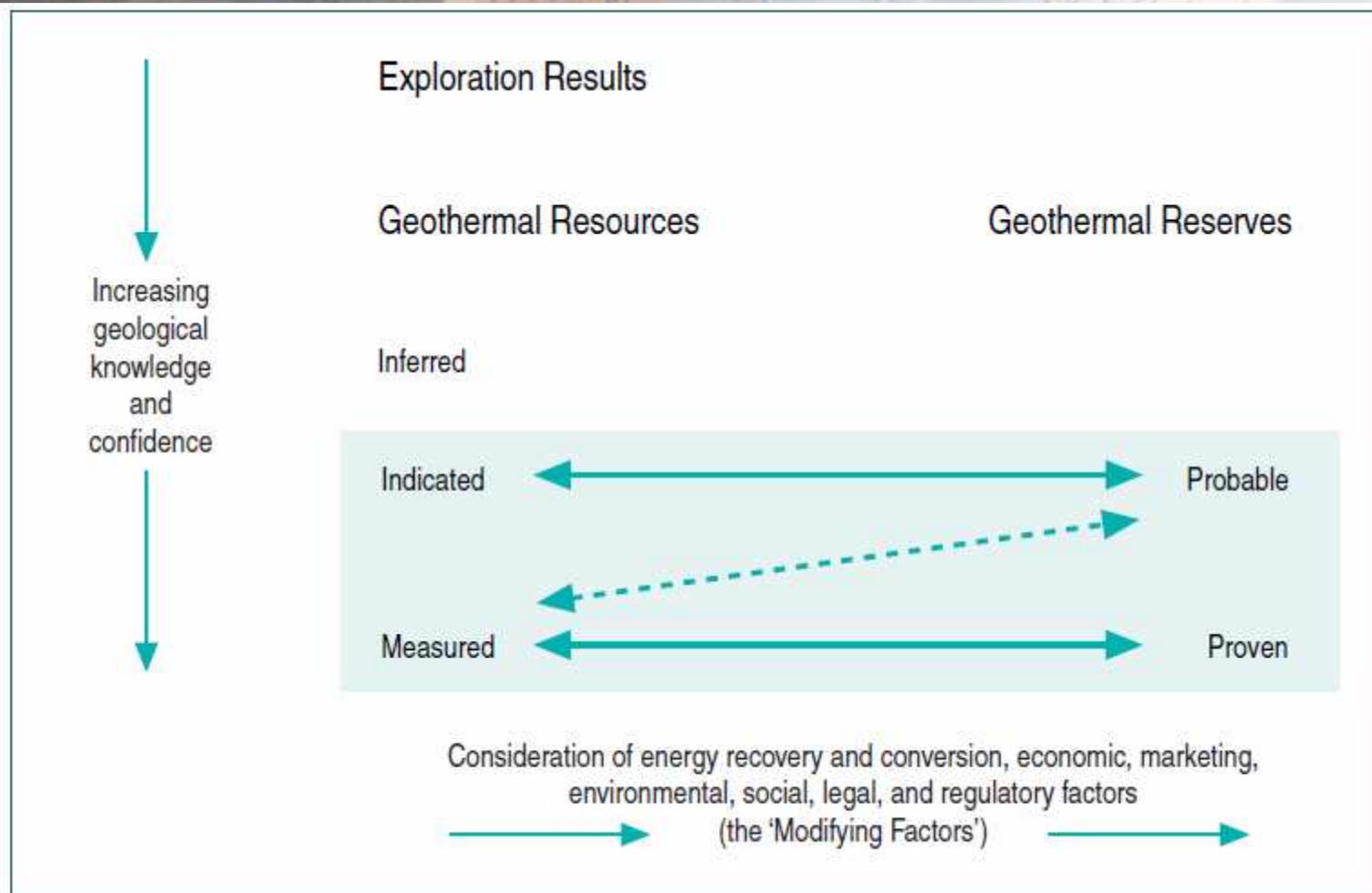
Inferred, Indicated and Measured Resources

Probable and Proved Reserves

Less quantitative in requirements. Based on availability of certain types of data interpreted by “competent person” (“practising geothermal professional”)



Australian and Canadian Protocol Terms



More Approaches

Geothermal Energy Association (United States) – Relies on self-reporting by industry members following specified standards

Possible Resource (Phase I and II)

Delineated Resource (Phase III)

Confirmed Resource (Phase IV)

(Phase III and IV GEA resource categories correspond to traditional reserve definitions)

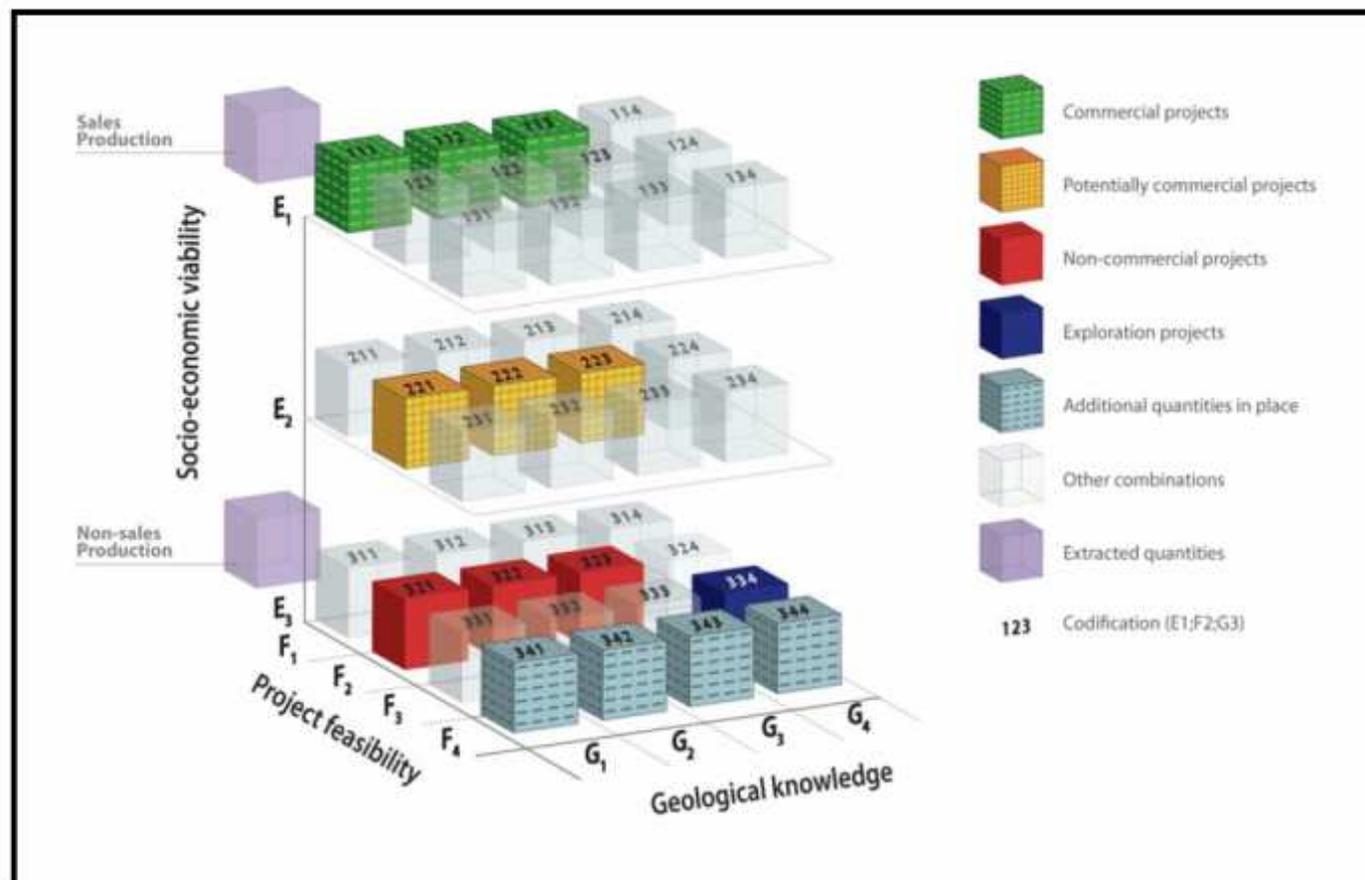
USGS 2008 Resource Assessment – Proposed new resource classes

- **Prospective** – Identified geothermal system but no quantitative constraints on temperature or volume
- **Potential** – Identified geothermal system with reservoir temperature determined from in situ measurements and/or chemical geothermometers. Volume estimates constrained by temperature gradient hole drilling or other geological/geophysical observations. Uncertainties in these estimates quantifiable.
- **Confirmed** – Reservoir penetrated by exploration drilling and successful production test conducted confirming both temperature and permeability
- **Producing** – Reservoir currently under production for electric power or direct use applications



Adopting UN Framework Classification Concepts

Can geothermal fit into the UNFC framework and is there a benefit to working in 3-dimensions? **Yes to both questions**





Adopting UN Framework Classification Concepts - 2

Can geothermal fit into the UNFC framework and is there a benefit to working in 3-dimensions? **Yes to both questions**

- Many geothermal prospects characterized by technological challenges and/or other factors (e.g., land status) affecting feasibility that are unrelated to simple economics. Older McKelvey cannot distinguish between these, which are lumped together on vertical axis. UNFC “F” and “E” categories will allow this.
- The four proposed stages of geological knowledge (G_1 through G_4) could be aligned with the four proposed USGS categories **Prospective, Potential, Confirmed, and Producing**, although there will be a requirement to clearly delineate the geological knowledge supplied by active production of a geothermal field and the associated high level of feasibility. (In other words, is there any way to have highest geologic confidence yet low feasibility or economic viability?)

Thank You



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