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# Hot rocks and hot water - developing geothermals in south-west WA

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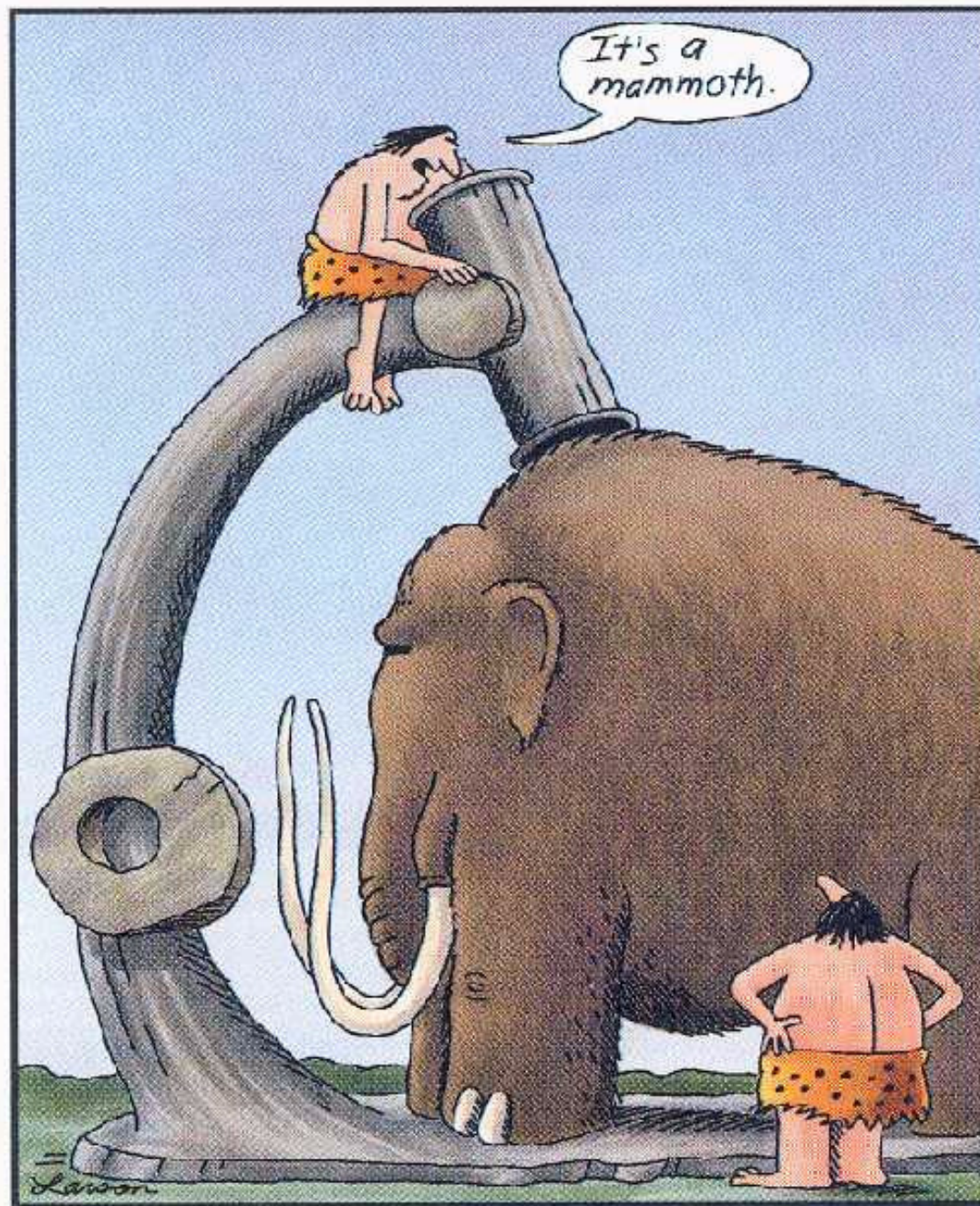
Future  
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# Sustainability in business

- Corporate responses to climate change
  - A bit of science
  - Potential for geothermals
  - Exploration and development
  - Tools and technology
  - Legislative frameworks
  - Joined-up thinking and interest rate rises
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Early microscopes

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# Greenhouse and global warming

- Greenhouse theory
    - Basis first proposed by in 1824
    - Greenhouse = earth's "blanket" - average temperature about 15°C; otherwise would be -18°C
  - Anthropogenic global warming theory late 1960's
    - UN and IMO lead debate late 1979
    - Intergovernmental Panel on Climate Change formed 1988
    - Rio 1992, Kyoto 1997 ...
  - Warming of climate is now unequivocal – global increases in air and ocean temperatures, melting of snow and ice, and rising sea level.
  - *The enhanced greenhouse effect is **empirically** and **theoretically** well-established.*
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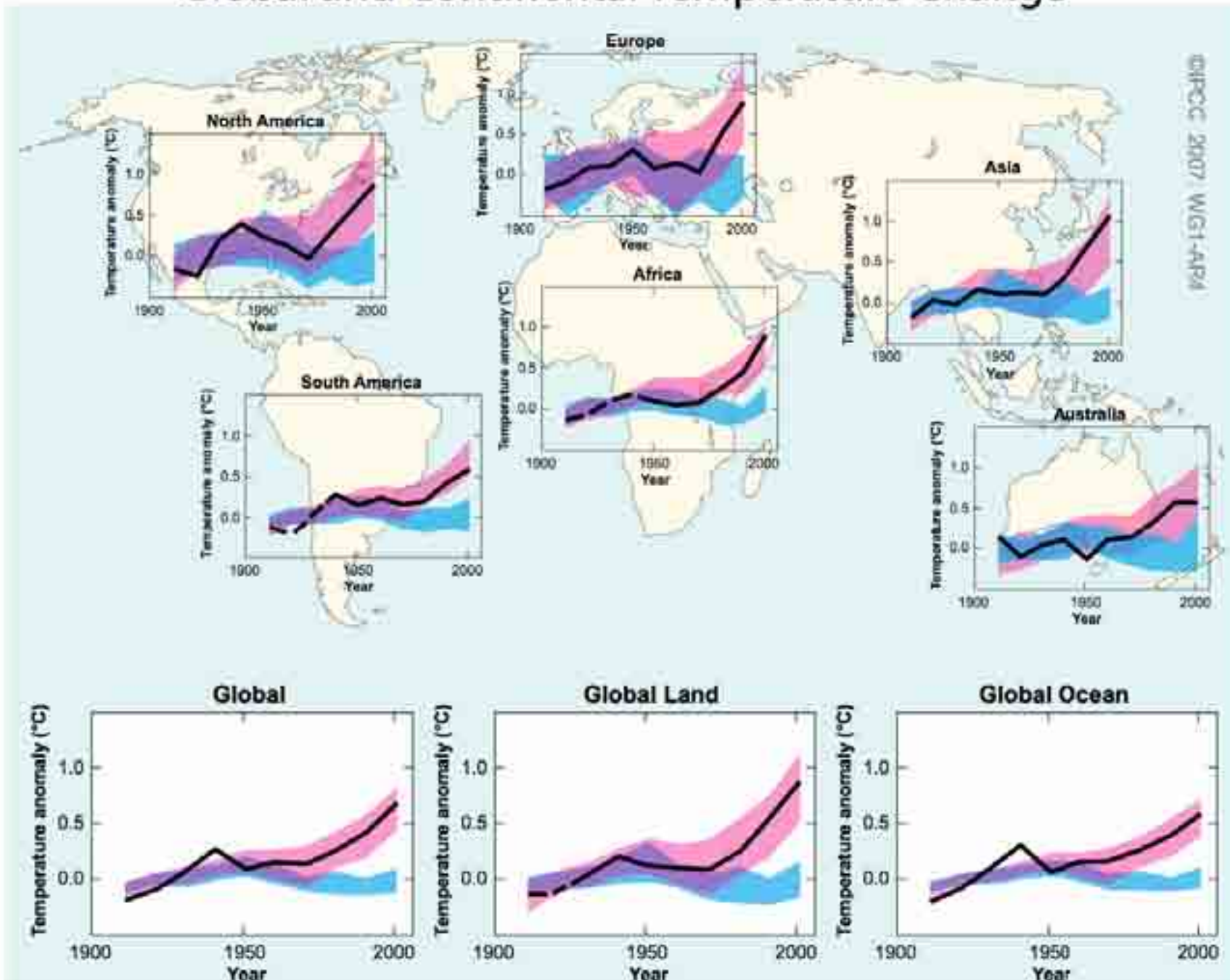


# Evidence of global warming

artwork  
"Hot with a chance of a late storm"  
by The Glue Society.

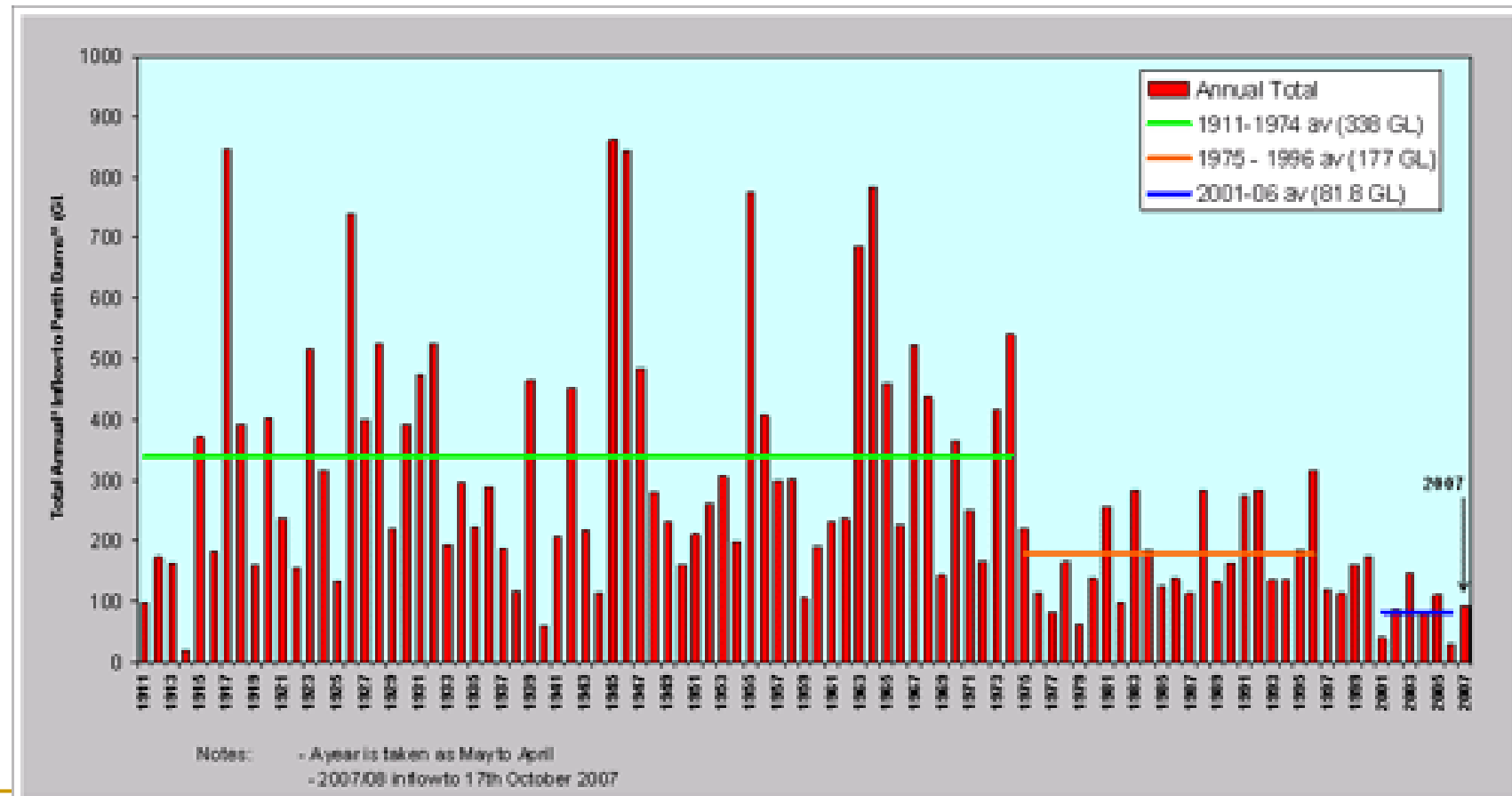


# Global and Continental Temperature Change



# About WA

- An example of abrupt climate change – drop in annual inflow to Perth's surface water sources.



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# About WA

- WA is arguably the first Western economy with measurable economic impact through climate change
  - WA SW has already suffered a 20% decline in rainfall in the last 30 years - effects on runoff more serious with 50% drop in stream flow to reservoirs - and a further 20% reduction predicted, and this is thought to have already started at the end of the 1990s.
  - Value of lost income in water sales in dams is estimated at \$1 billion in WA through water restrictions and additions to infrastructure (WaterCorp) - and almost another billion with Desal II.
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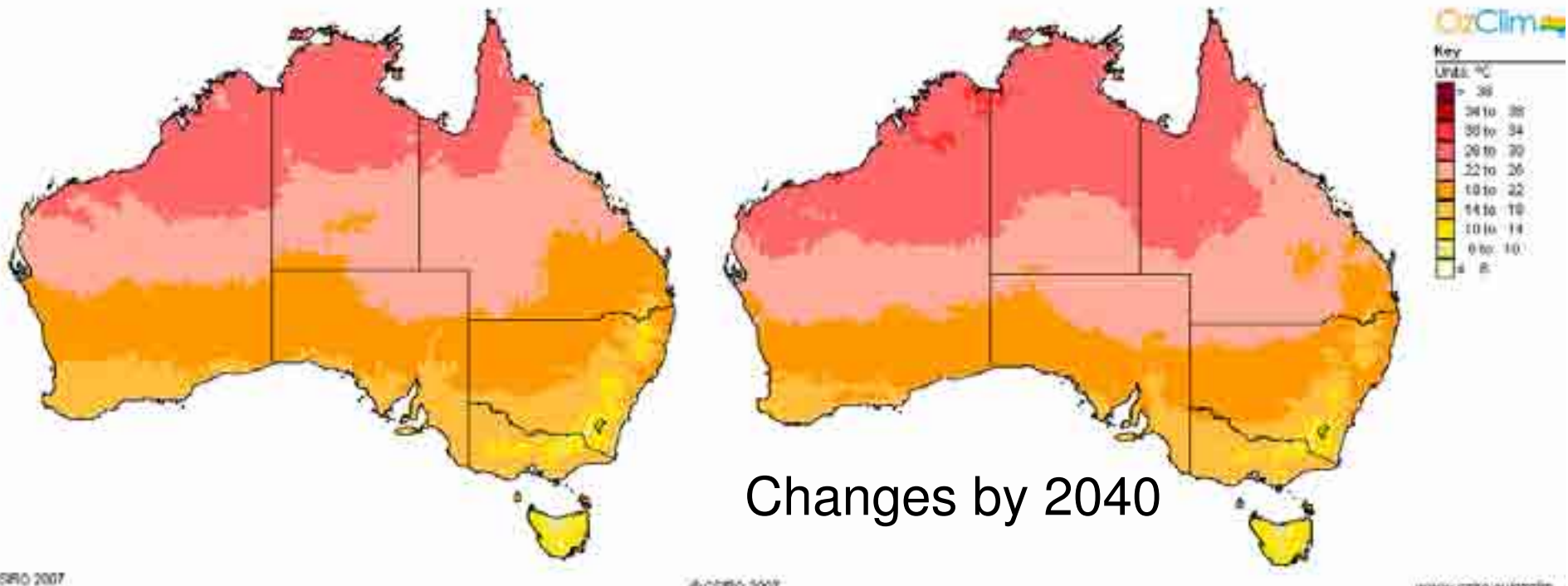


# About WA

- A warming of 1.0°C moves climate belts about 150 km south - a regional change of temperature of 2 °C is likely to have a serious impact on most life forms, and on most ecosystems and agricultural areas.

**Title:** Projected Mean Surface Temperature (°C) , in AUSTRALIA for the year 2040, Annual  
**Detail:** Model: IAP FGOALS\_g1.0, Emission Scenario: BRES marker scenario B1, Climate Sensitivity: low

**Title:** Projected Mean Surface Temperature (°C) , in AUSTRALIA for the year 2040, Annual  
**Detail:** Model: GFDL CM2.1, Emission Scenario: BRES marker scenario A1F1, Climate Sensitivity: high



# About WA

- With global warming and drying of the south coast in WA, areas with temperature increases  $> 2^{\circ}\text{C}$  combined with a decline in rainfall consistently below 400 mm will lead to the loss of many species of Proteaceae in WA's SW
  - including the iconic *Banksia* and *Dryandra*,
  - will die out.
- As will the animals that live on them.



# About WA

- Climate is a key determinant of agriculture and changes in climate will impact on all agriculture - both crops and livestock.
- Rising temperatures will cause a shift in budburst, shorter growing seasons, earlier harvest dates, lower crop quality.
- Wheat growing areas in SW WA seriously impacted and northern wheatbelt likely to disappear while production in the remainder greatly reduced, wiping out most of an industry worth more than \$2 billion.
- Tree crops are particularly sensitive because of longer lead times to reach production.



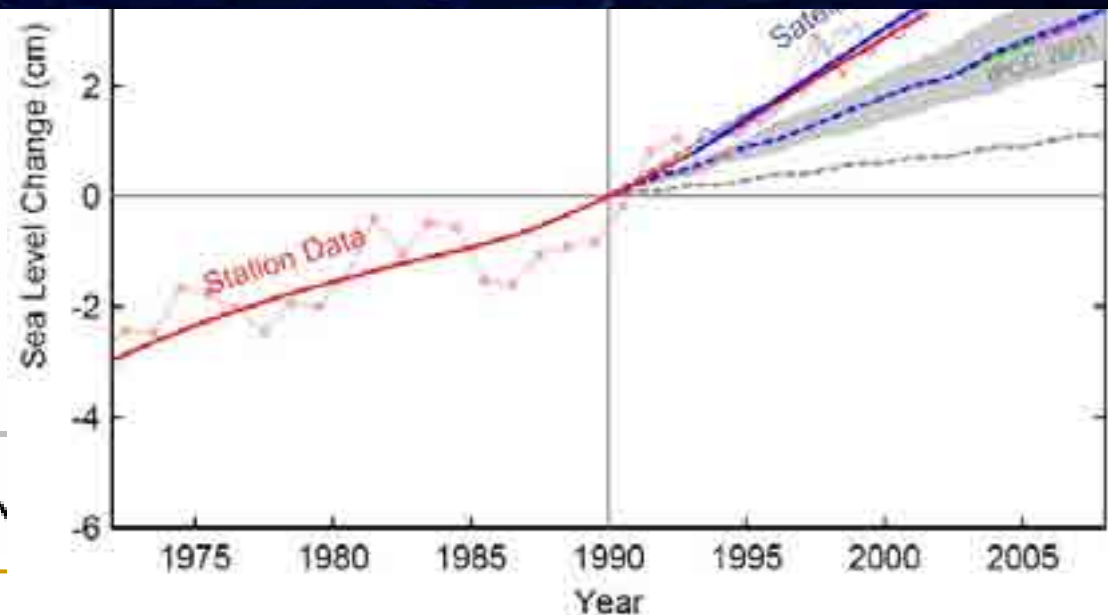
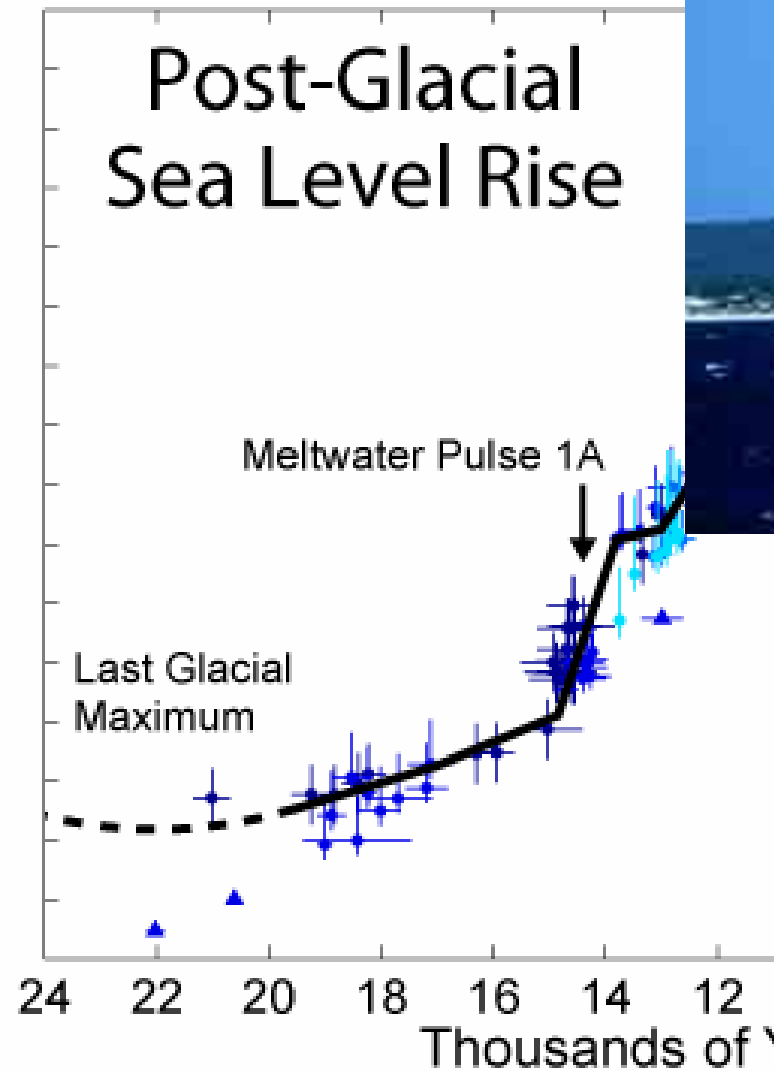
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## About WA

- Climate is a key influence in grape selection.
  - Shifting rainfall patterns and drier conditions will change the way vineyards operate and reduce the wine crop.
  - WA produces around 5% of all Australian wine, but produces about 25% of wine in super-premium and ultra-premium categories.
  - Margaret River climate will be closer to that of Perth, cabernet sauvignon and chardonnay will be lost and varieties suited to warmer climates such as shiraz.
  - Swan Valley will no longer be suitable for vines.
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# Sea level changes



# Sea level changes



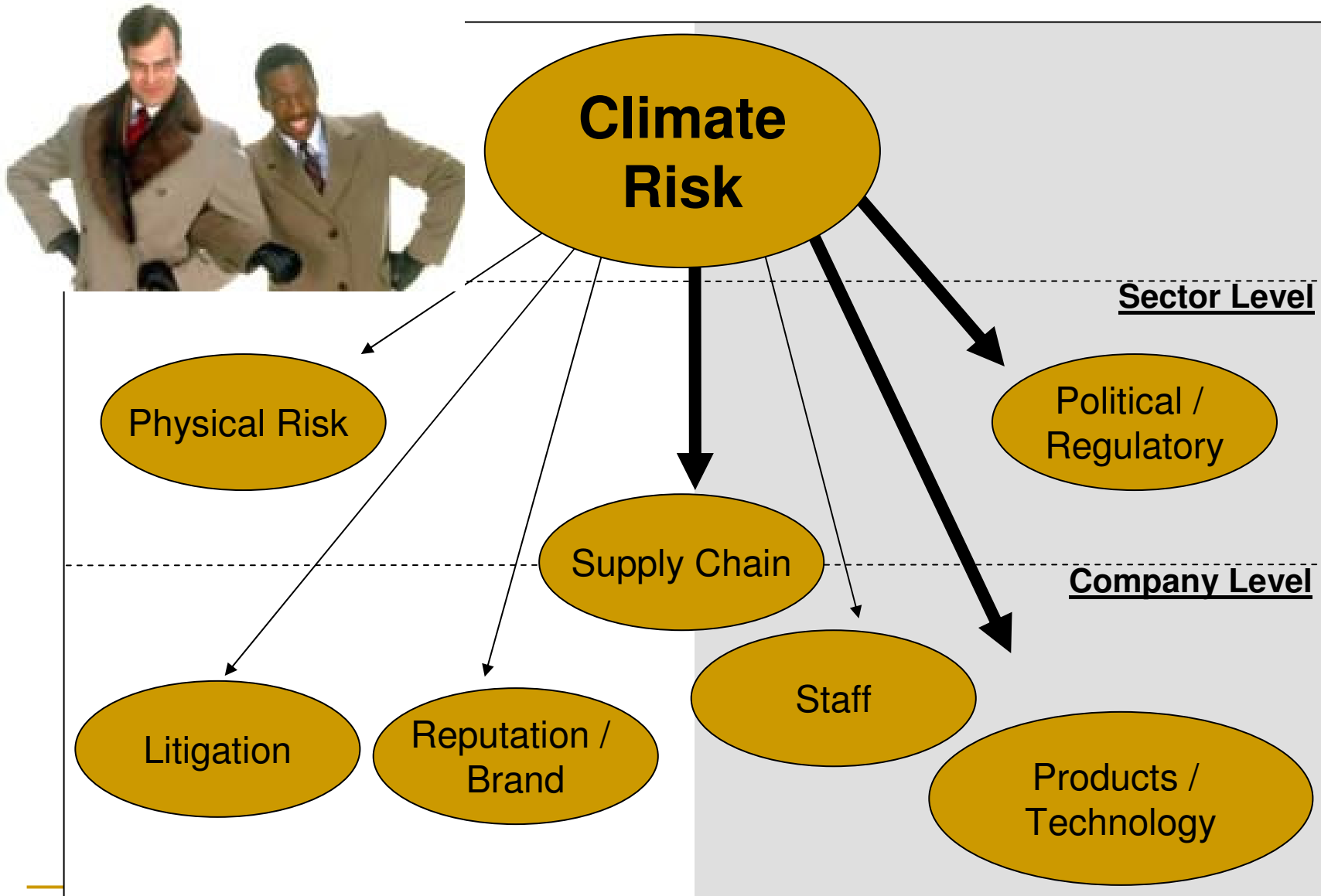
Mandurah  
at 1m sea  
level rise

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# Sustainability in business

- McDonald's Corp. is blogging on the environment.
  - Starbucks Corp. has a green-themed online game.
  - Hilton Hotels Corp. linked manager pay to green outcomes.
  - Many corporates say they have worked for decades on pro-environment strategies and corporate social responsibility - growing awareness of global warming among consumers is creating even greater change.
  - Businesses in green buildings report improved productivity, better staff retention, fewer sick days, millions of dollars in energy savings and a reduced environmental footprint.
  - Some companies that "go green" seen a 25% increase in trade with eco-shoppers and eco-traders, with a trend for green businesses to only deal with other green businesses.
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# Economic risk of change





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# Litigation

- Negligence is common law – if you have knowledge that something is at risk and fail to act, you are negligent.
  - Australian Securities Exchange (ASX) updated guidelines state companies are required to disclose whether they have policies to manage risks that might include environmental and sustainability issues.
  - More than any other issue, global warming is blurring the lines between corporate fiduciary duties, profitability and corporate social responsibility.
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# Responding to climate change

- The threat of dangerous climate change underscores the need to build a sustainable economy.
  - An effective response will change the way we use energy and in so doing, future proof our economy.
  - Action by government, business and the community must put in place measures that
    - ❑ reduce unnecessary use;
    - ❑ promote energy efficiency across life cycles;
    - ❑ reduce our reliance on increasingly expensive fossil fuels; and
    - ❑ promote the production of energy through renewable generation.
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# Responding to climate change

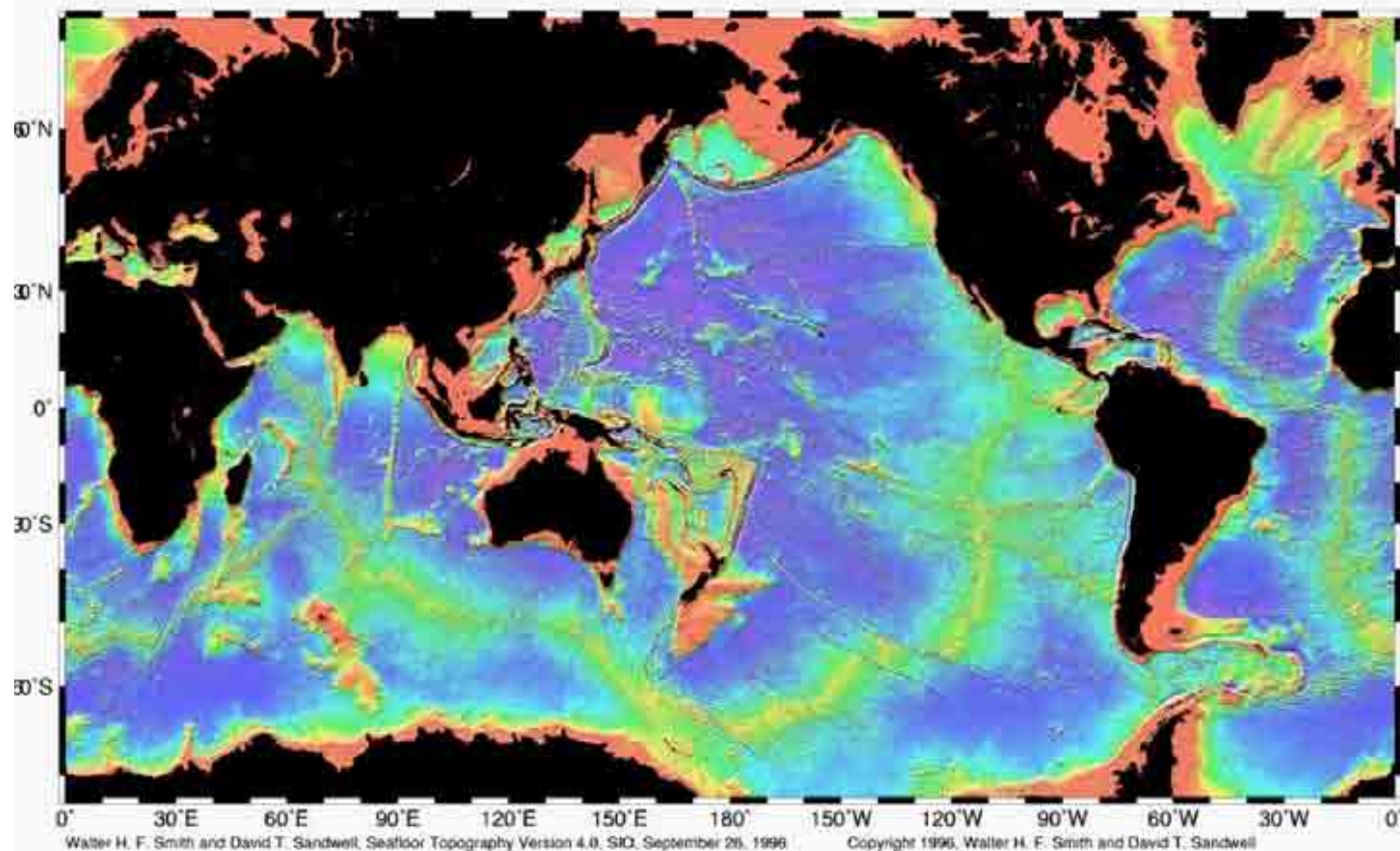
- Responding to climate change will create opportunities, establish new businesses, and create new jobs.
  - Renewable energy generation is generally more labour intensive, and more broadly distributed across regions.
  - Better employment factor of renewable energy projects can lead to growth of local communities in rural WA.
  - Inadequate housing energy efficiency standards and vehicle fuel efficiency standards make energy and fuel bills higher, impacting on the household budget and mortgage affordability and driving inflation.
  - Any economic analysis must fully assess the benefits to the community – that's a part of sustainability.
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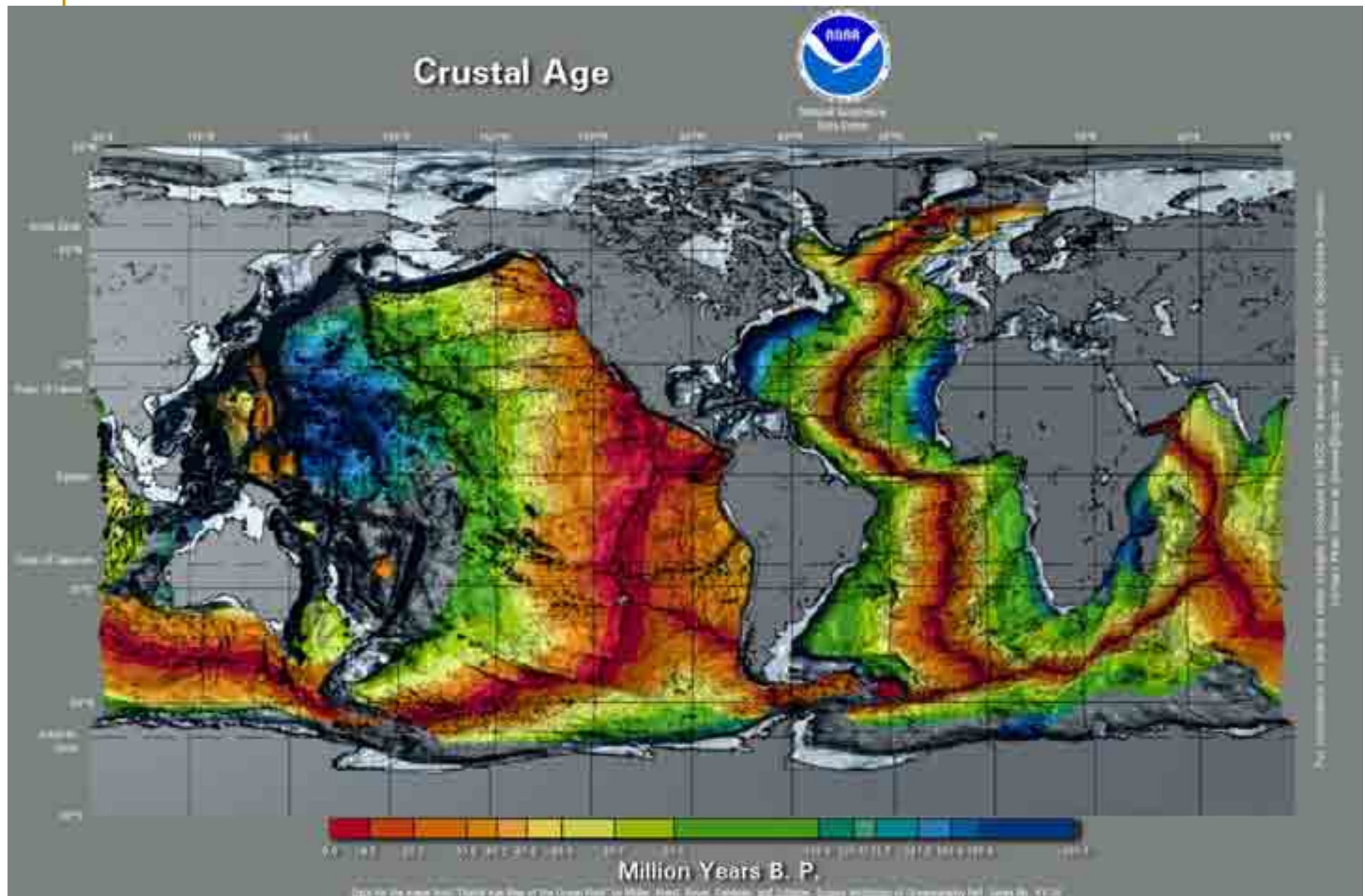
# What is geothermal?

- Interior of the earth a vast source of heat estimated at around 7000 °C
  - Heat from slow decay of radioactive elements in the earth's interior.
  - Heat source is sufficient to drive the earth's plate tectonic systems, which are responsible for earthquakes and volcanic activity.
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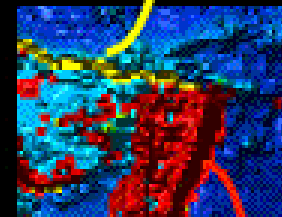
# Sea floor spreading



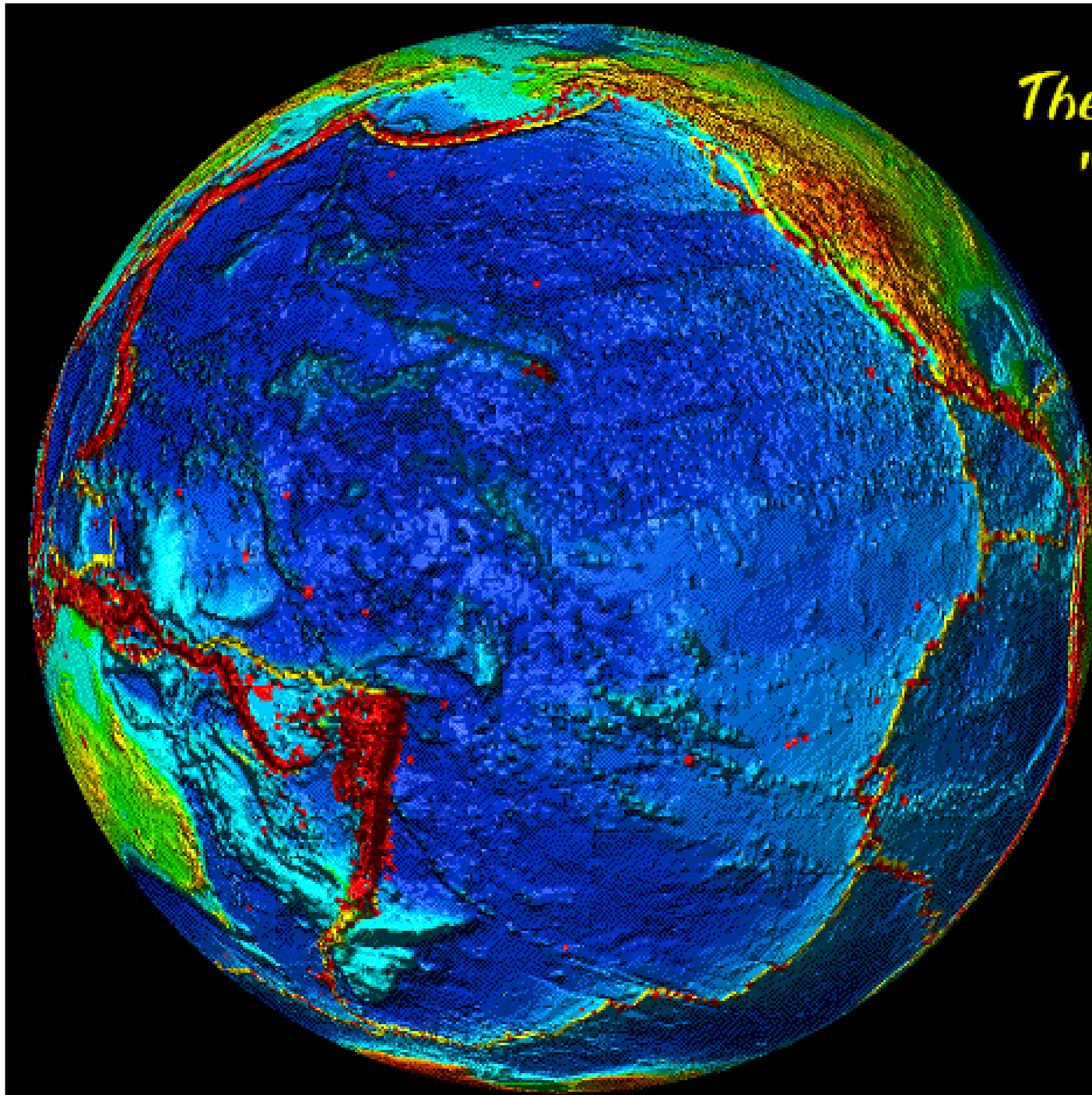


# *The Pacific "Ring of Fire"*

Crustal Plate  
Boundary

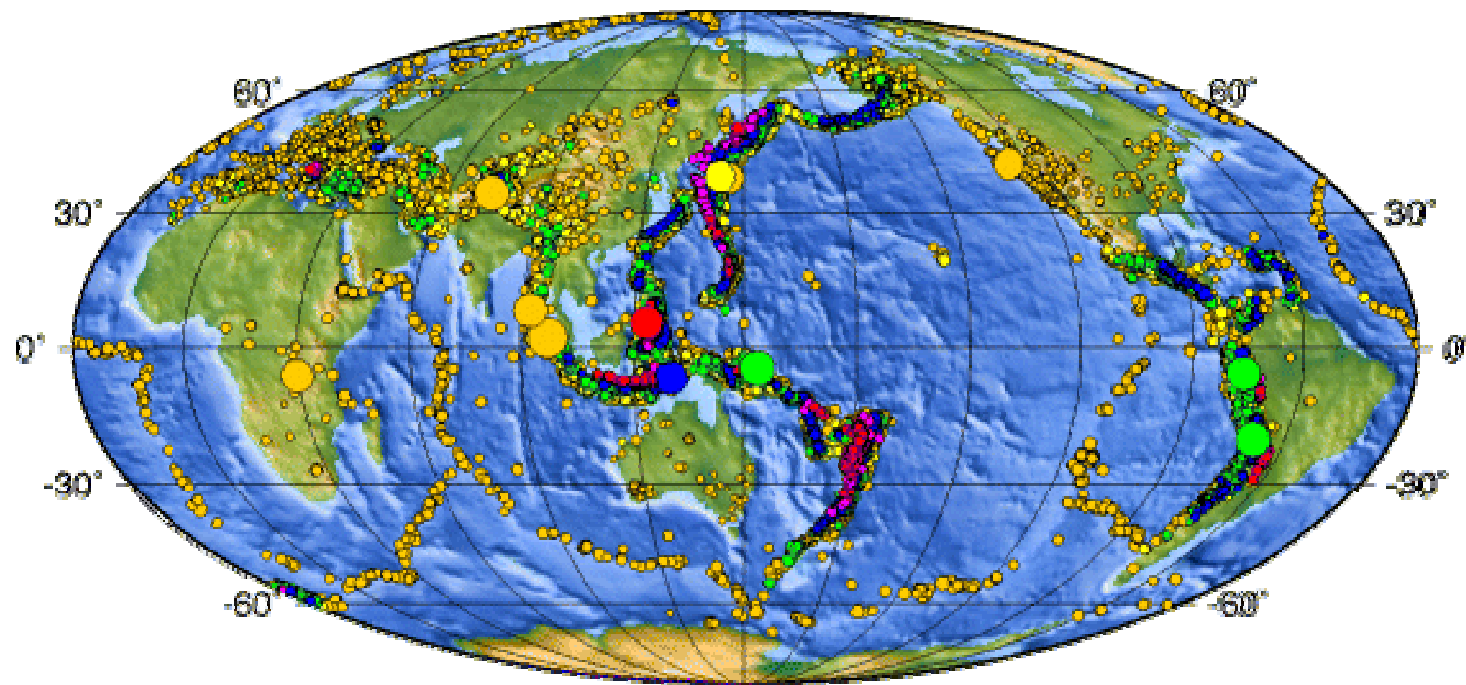


Epicenters of  
Earthquakes,  
Magnitude  $\geq 5$   
since 1980



# Plate tectonic change

Earthquakes in 2005, Located by the NEIC



USGS National Earthquake Information Center Website 16 03/20/16 MST 2006





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# Potential for geothermals - world

- Geothermal installations tap heat either for electrical generation or direct use of the heat.
  - Around 8000MW of electrical generating capacity has been installed in 24 countries worldwide
  - About 15,000 MW direct heat applications in 71 countries for residential or commercial sectors - space heating, water heating, greenhouse and aquaculture, food dehydration, laundries, and textile processes.
  - Most plants in geologically active areas where shallow upwellings of molten rock interact with groundwater, creating pressurised hot springs or steam geysers.
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# Potential for geothermals - Australia

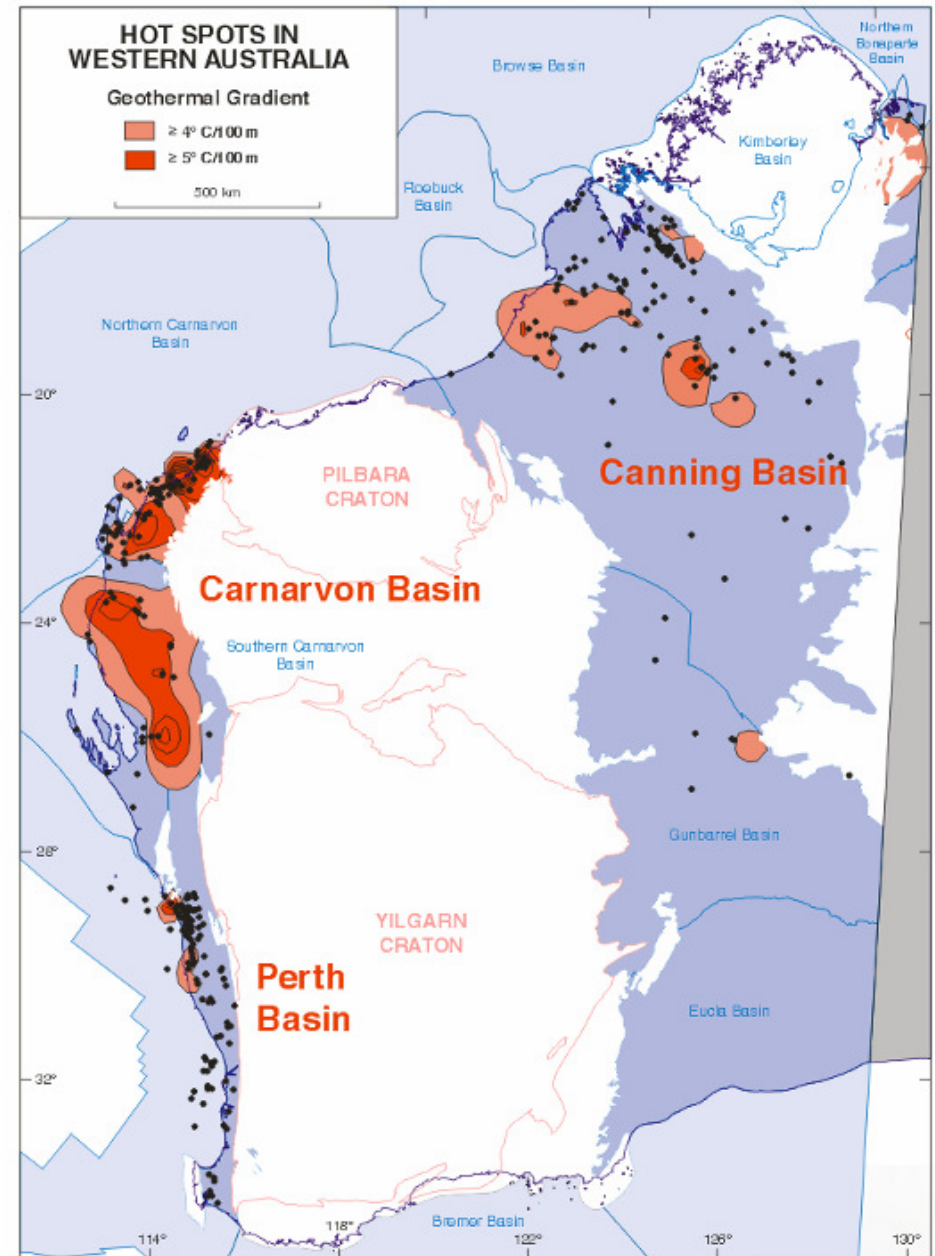
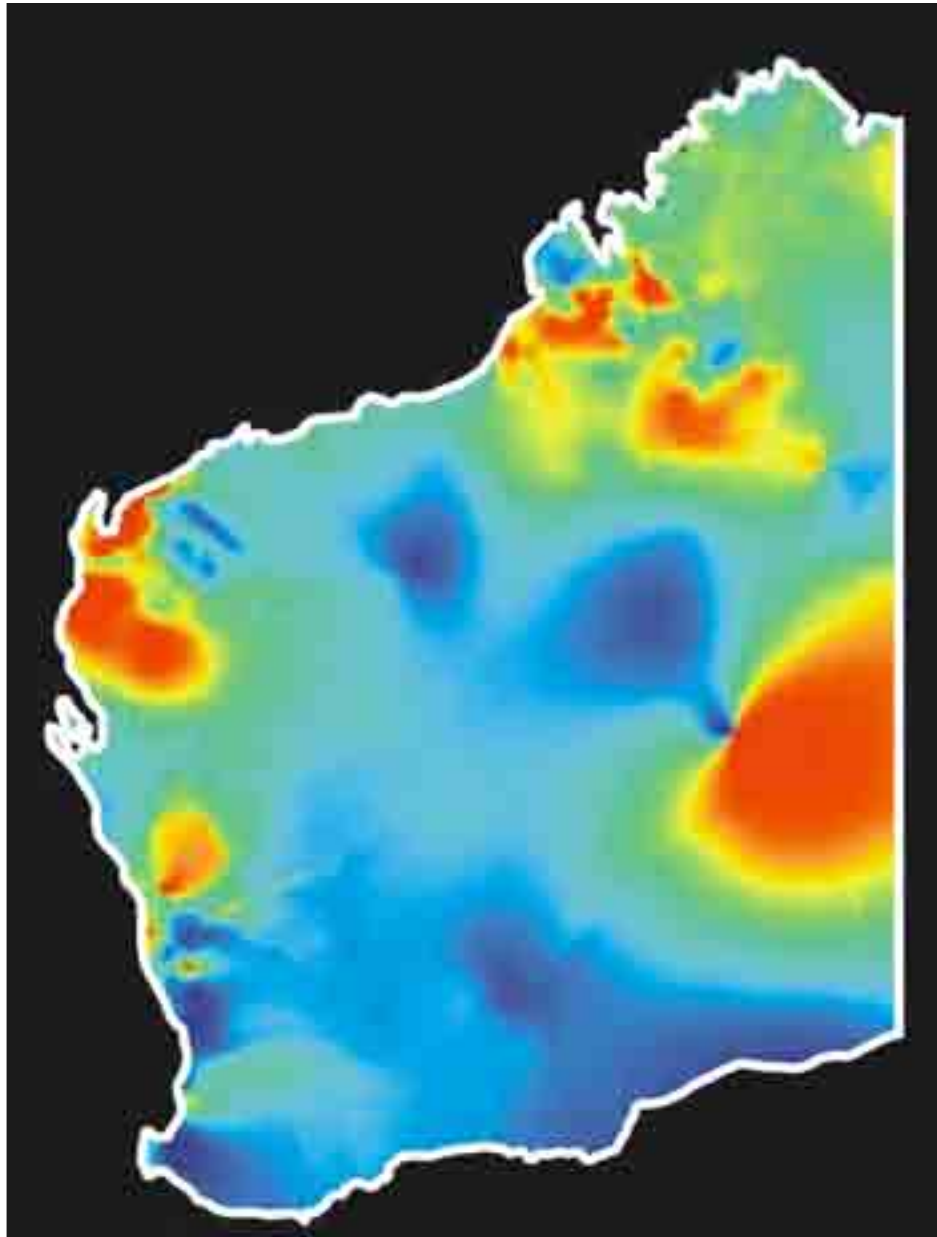
- Australia's relative geological stability means there are no foreseeable applications for 'hydrothermal' power station in Australia.
  - But, in recent years a different kind of geothermal application has been proposed for Australia and elsewhere: Hot Dry Rock (HDR) technology (or Enhanced Geothermal Systems).
  - 1 cubic KM at 200 °C will produce 10 MW for 20 years
  - Geoscience Australia estimate more than 1.2 million petajoules - 20 000 x Australia's primary energy use.
  - Most advanced pilot project under development in South Australia's Cooper Basin.
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# Potential for geothermals - Australia

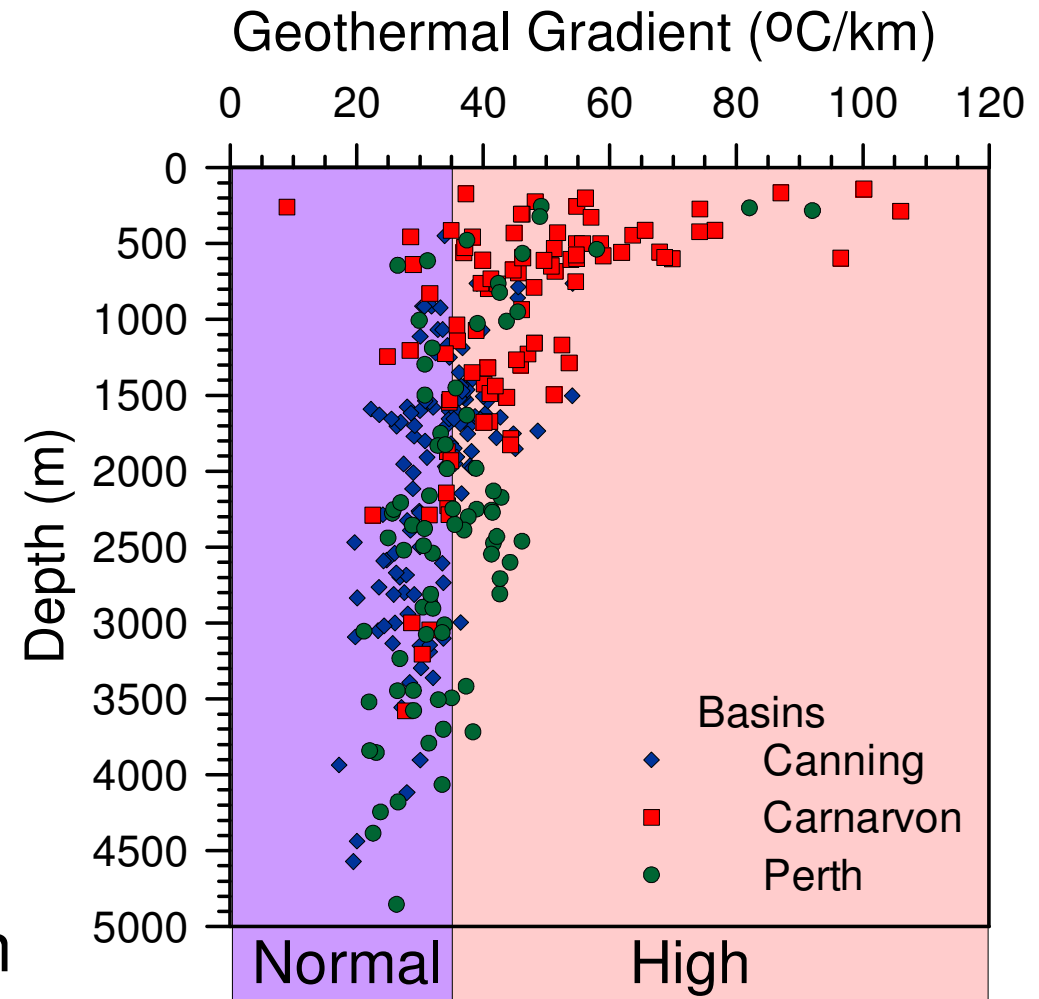
- Australia-wide, 27 companies have applied for 166 geothermal licences.
  - Between 2002 and 2012 these companies are currently expected to invest more than A\$650 million in exploring-for and undertaking proof-of-concept projects in their licenses.
  - In WA, we are awaiting legislation for security of resource.
  - Western Australia possesses significant hot rocks resources in the Murchison, Pilbara, West Kimberley and Ngaanyatjarra regions.
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# Potential for geothermals - WA



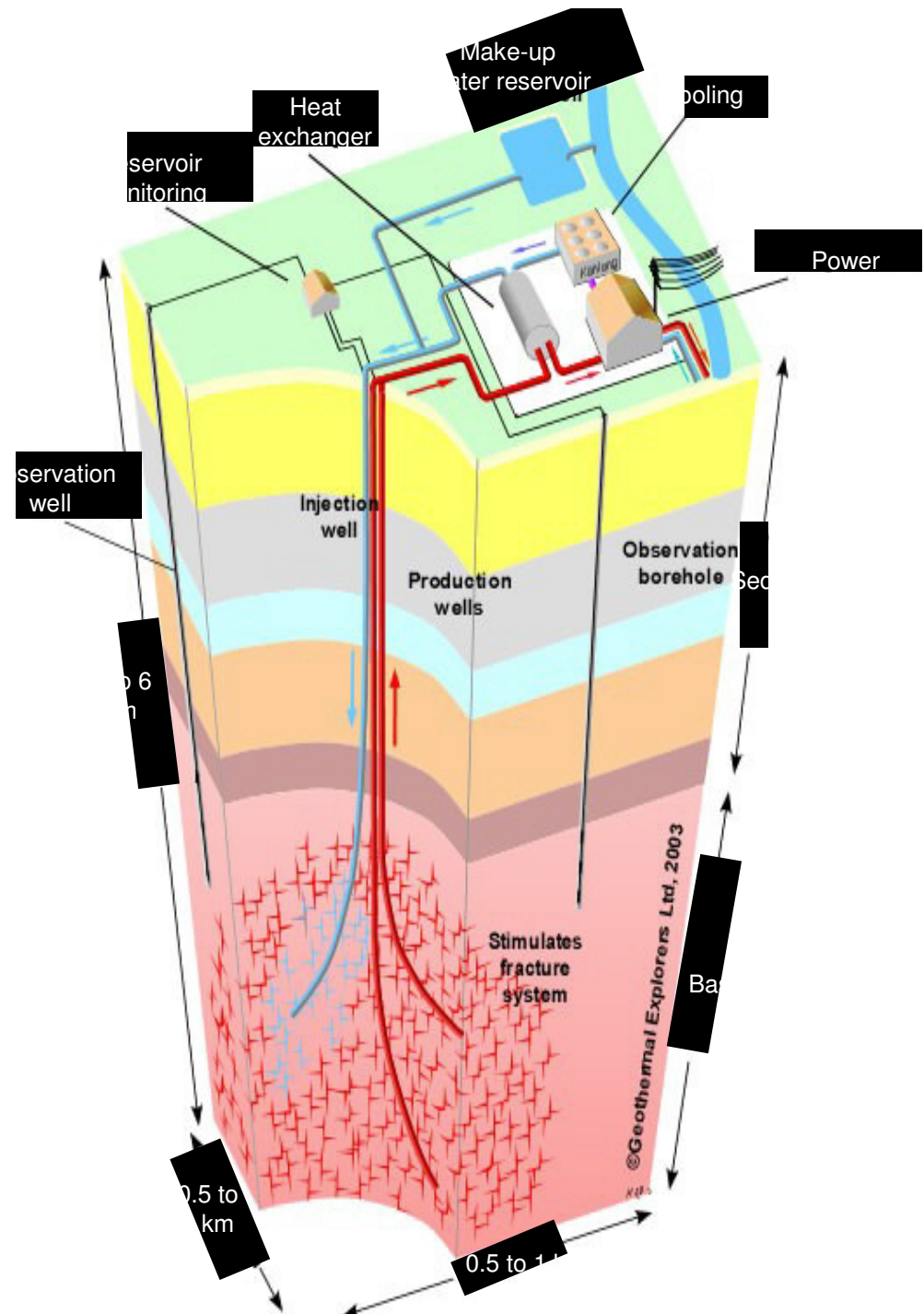
# Exploration and development

- Low temperature  
**<150 °C**
- High temperature  
**>150 °C**
  - Commercial production of electricity
- High geothermal gradients than normal  
**(17—35 °C/km)**  
indicate high heat flow
- Gradients **>35 °C/km**  
are present in Western Australia



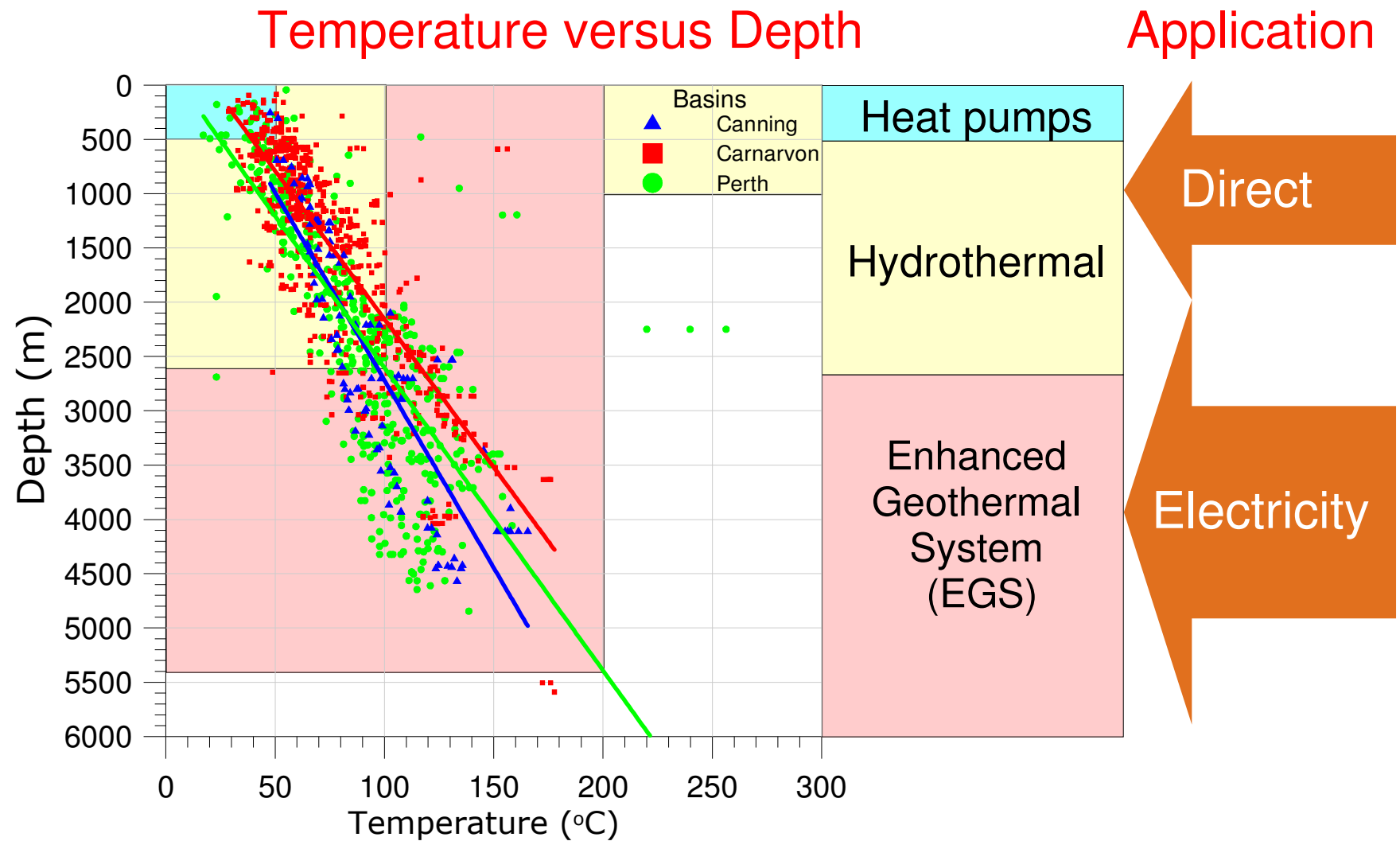
# Technology

- Geothermal energy present everywhere, but only technically and economically feasible when:
- At shallow depths, usually  $< 3$  km, but possibly as deep as 6 to 7 km;
- High porosity and fracture permeability to produce thermal waters either naturally or engineered,
- Short distance power generating facility.





# Technology



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# Technology

- Since mid 2004, four of the five pools at Challenge Stadium have been heated using geothermal energy.

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# Legislative frameworks - Australia

- NSW and Tas - mining legislation
  - Vic, Qld and NT - stand alone legislation
  - Vic Act based on petroleum legislation
  - NT drafting underway
  - SA - *Petroleum Act 2000*
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## Legislative framework - WA

- Options were stand alone or amendment of Petroleum Act 1967
  - Petroleum Amendment Bill 2007
  - Petroleum and Geothermal Energy Resources Act 1967
  - Definitions - of geothmal energy, and geothermal energy resources
  - Crown ownership - requirement for permit to explore, royalties
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# Legislative framework - WA

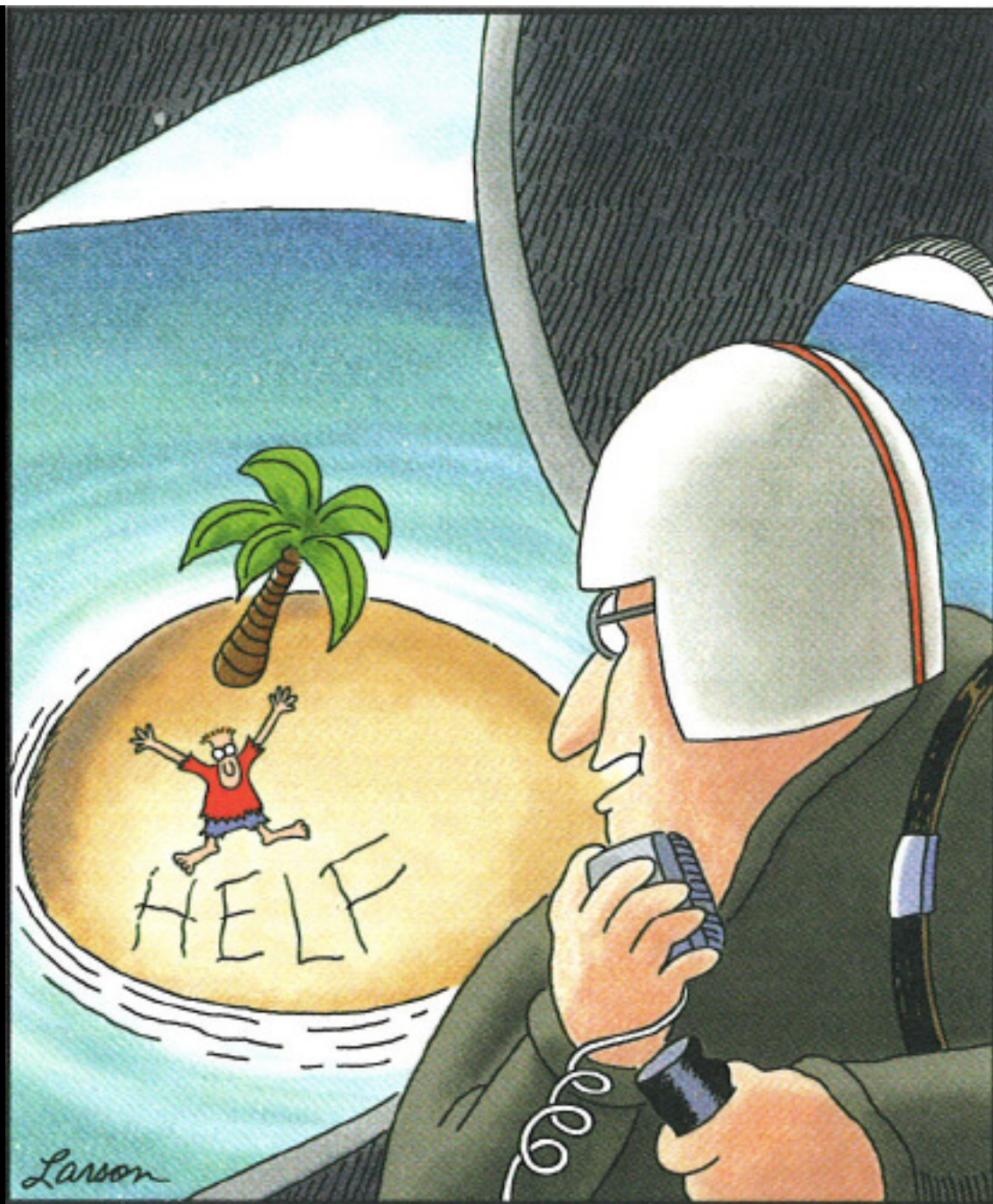
- Drafting issues:
  - Water rights
  - Native title
  - Title overlap between petroleum and geothermal
  - Applies petroleum OSH Schedule
  - Commercial and non-commercial geothermal operations
    - Non-commercial = small scale, internal use: no royalty
  - Introduction to WA Parliament
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# The latest news



■ <http://www>





"Wait! Wait! Cancel that. ... I guess it says 'help.'"

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The inconvenient truth - time has run out  
for solutions that are simply convenient.

Dr Ray Wills

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