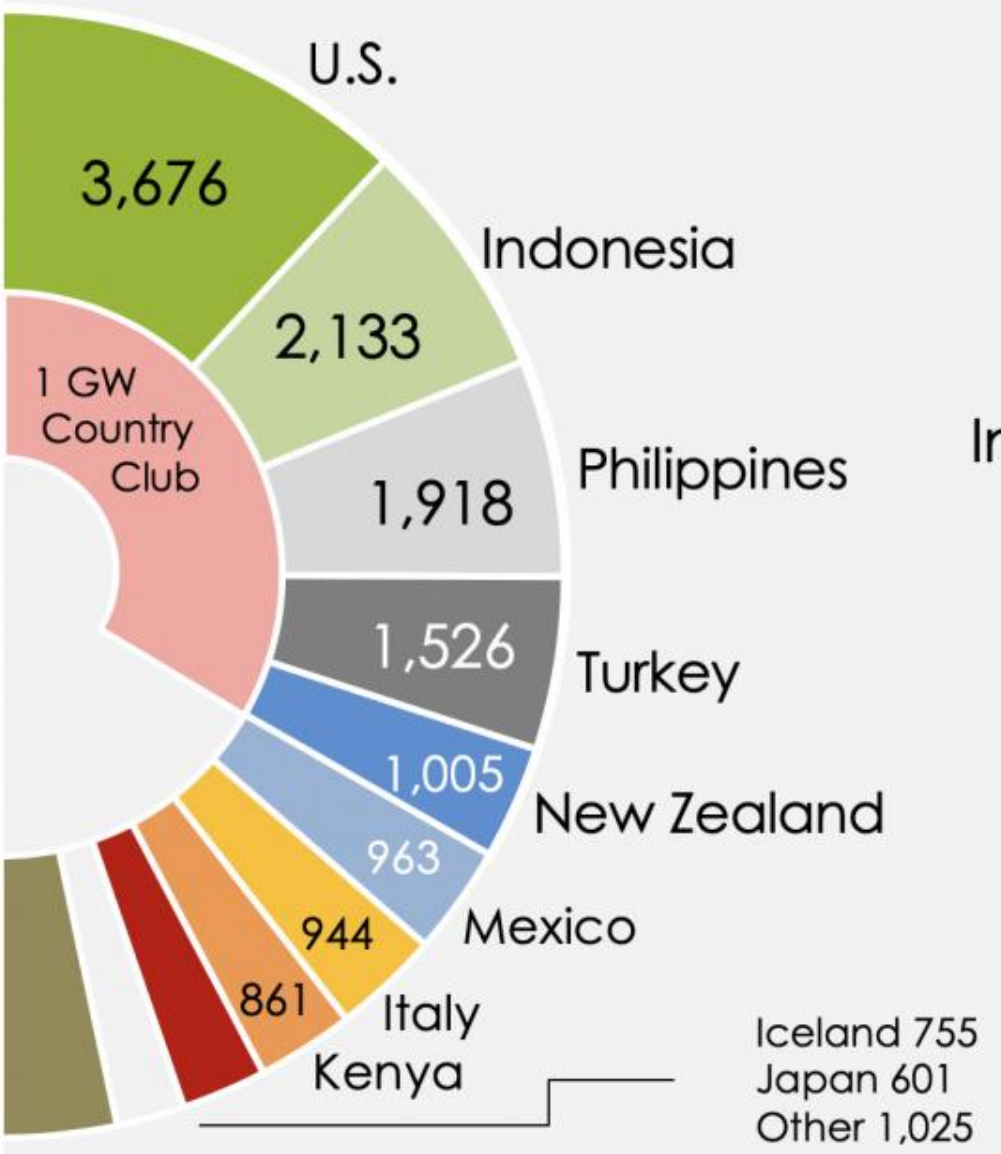
Energia geotérmica

Planta para geração de energia elétrica (Nesjavellir, Islândia)

Usos da energia geotérmica

- Eletricidade hidrogeotermal (*hydrogeothermal electricity*)
- Rocha quente seca (*hot dry rock – HDR*)
- Aquecimento/resfriamento geotérmica (*geothermal heat pump*)



Top 10 Geothermal Countries 2019

Installed Capacity in MWe
Year-End 2019

Total 15,406 MW

THINK GEOENERGY

Source: ThinkGeoEnergy Research (2020)

Produção de eletricidade geotérmica no mundo

País	Capacidade instalada (MW)	Porcentagem da produção nacional
EUA	3086	0,3%
Filipinas	1904	27%
Indonésia	1197	3,7%
México	958	3%
Italia	843	?
Nova Zelândia	628	10%
Islândia	575	30%
Quênia	167	11,2%
Costa Rica	166	14%
Nicarágua	88	10%
Rússia	82	?

Holm (2010)

International Geothermal Association

Fluxo de calor terrestre (Watt/m^2)

Crosta continental: 46-77 mW/m^2
Crosta oceânica: 50-170 mW/m^2

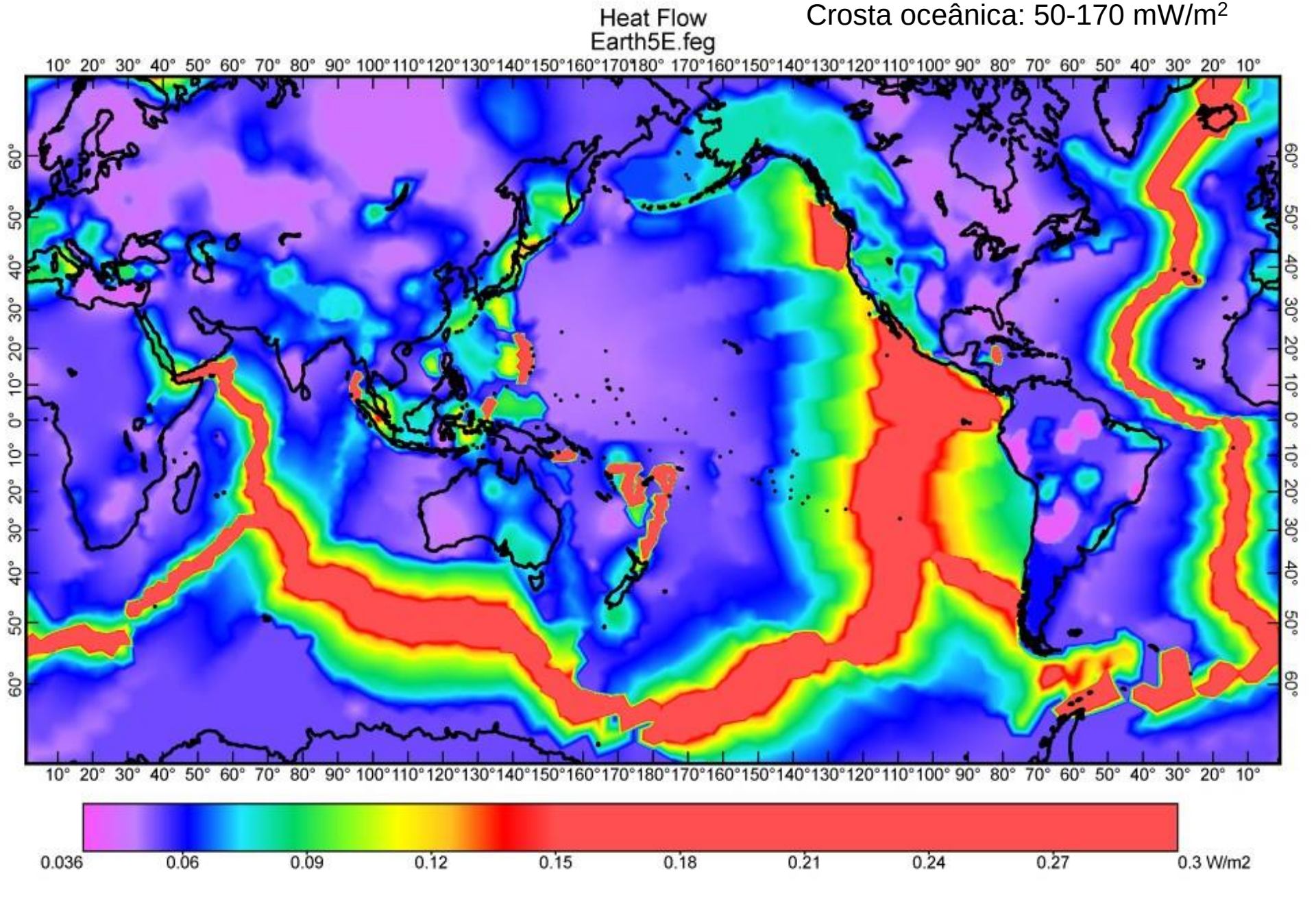
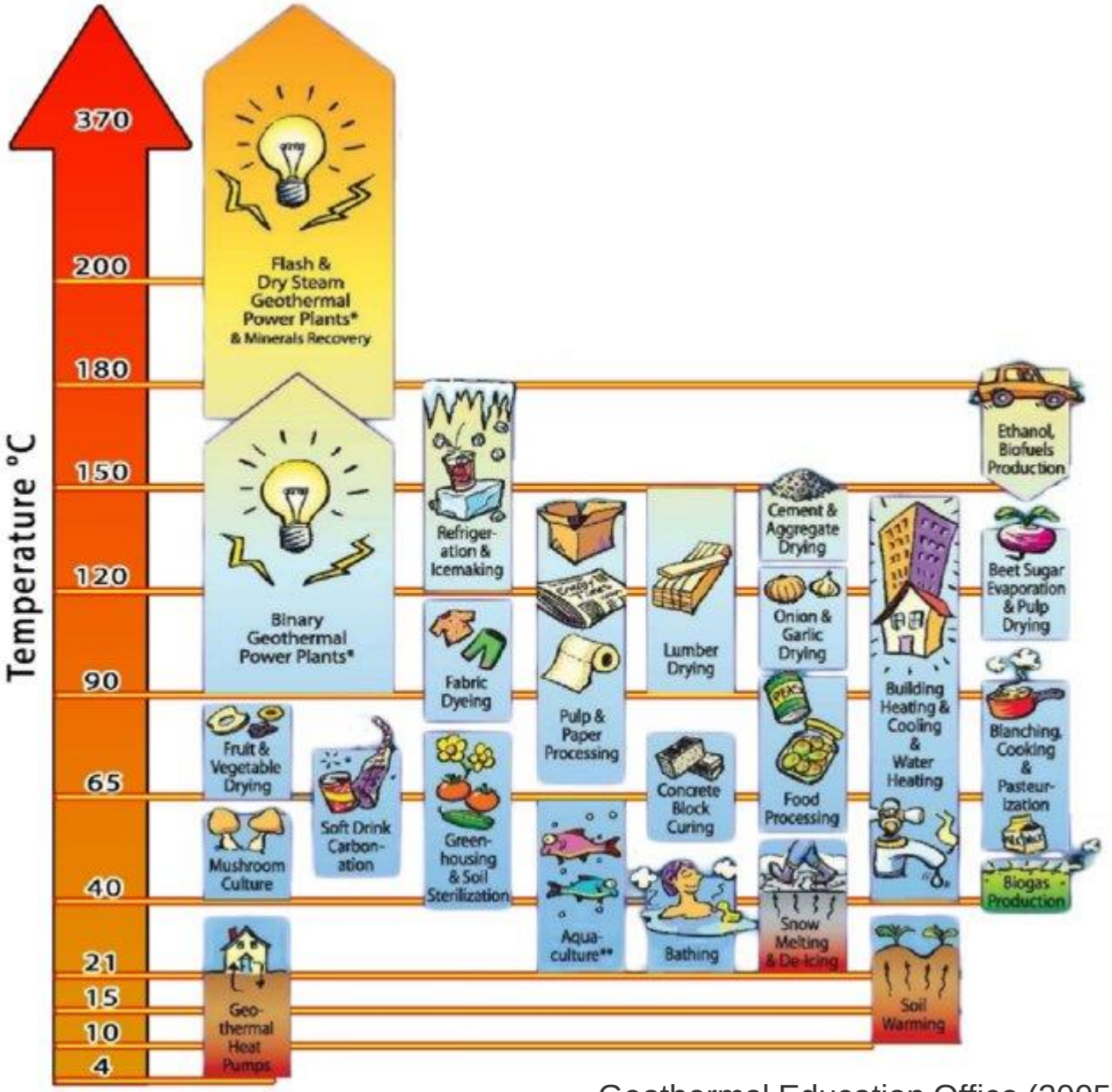


Diagrama de Lindal (1973)



Geothermal Education Office (2005)

Joshin'etsukogen National Park

Innovation & Investment

Pilot lobster production facility in Iceland used geothermal groundwater

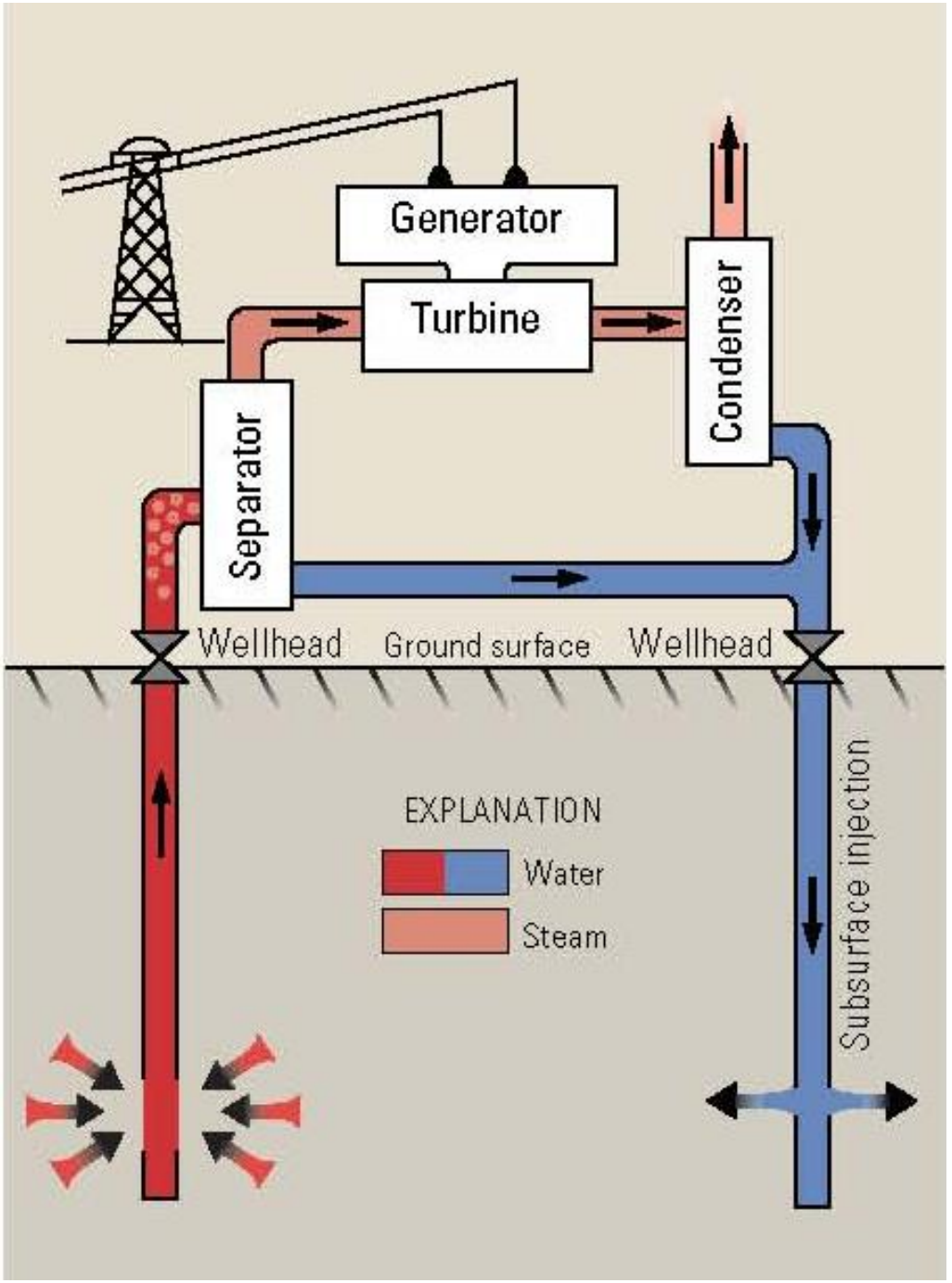
Friday, 2 May 2014
By Asbjørn Drengstig and Ragnheidur Thorarinsdottir

Project revealed knowledge in terms of genetics, physiology, biology and water quality

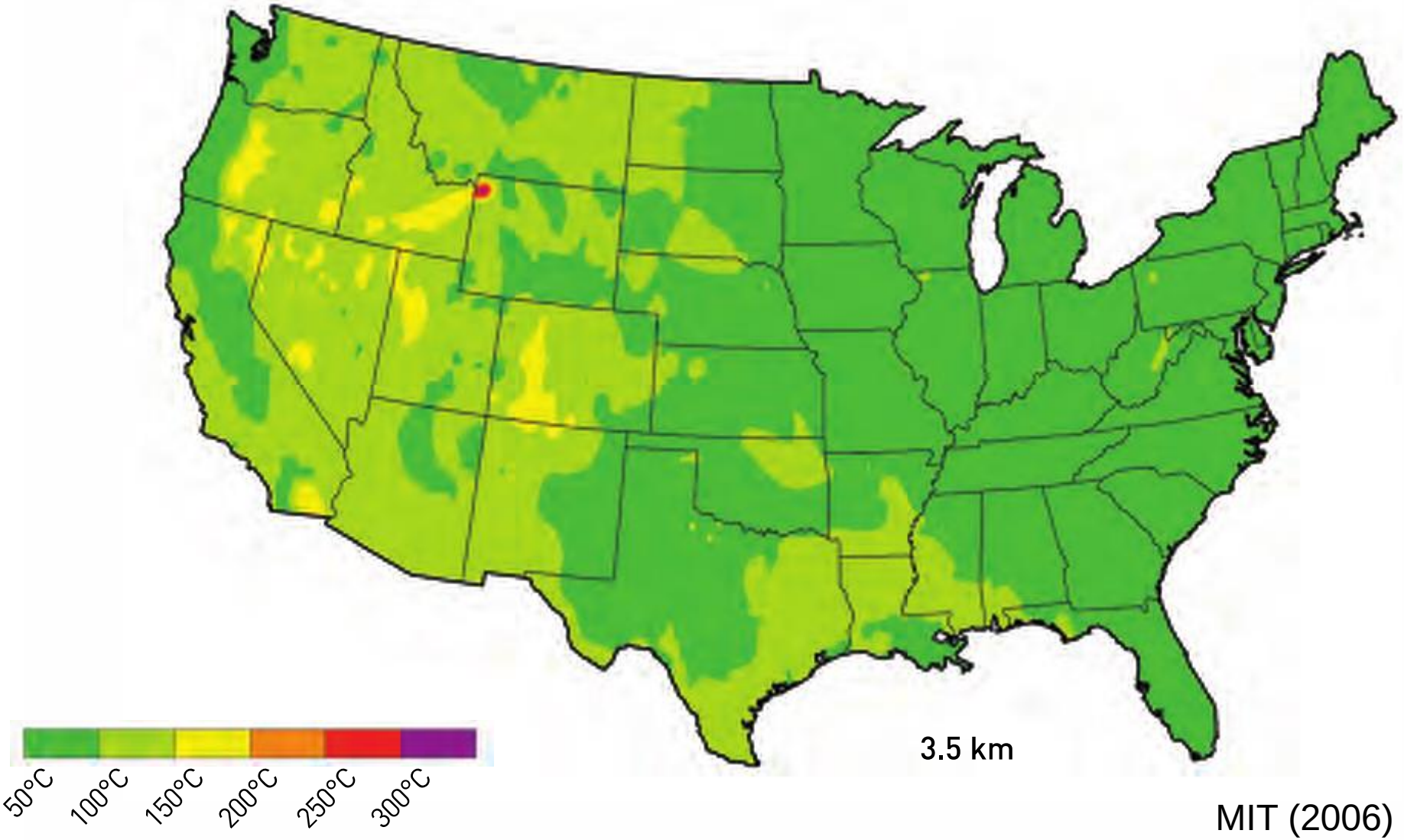
Fish farming and greenhouses currently use about 8 percent of Iceland's geothermal energy. Further development of lobster farming could further utilize the renewable energy resource.

Produção de eletricidade

Flash steam (Temperatura >180^{o}C)

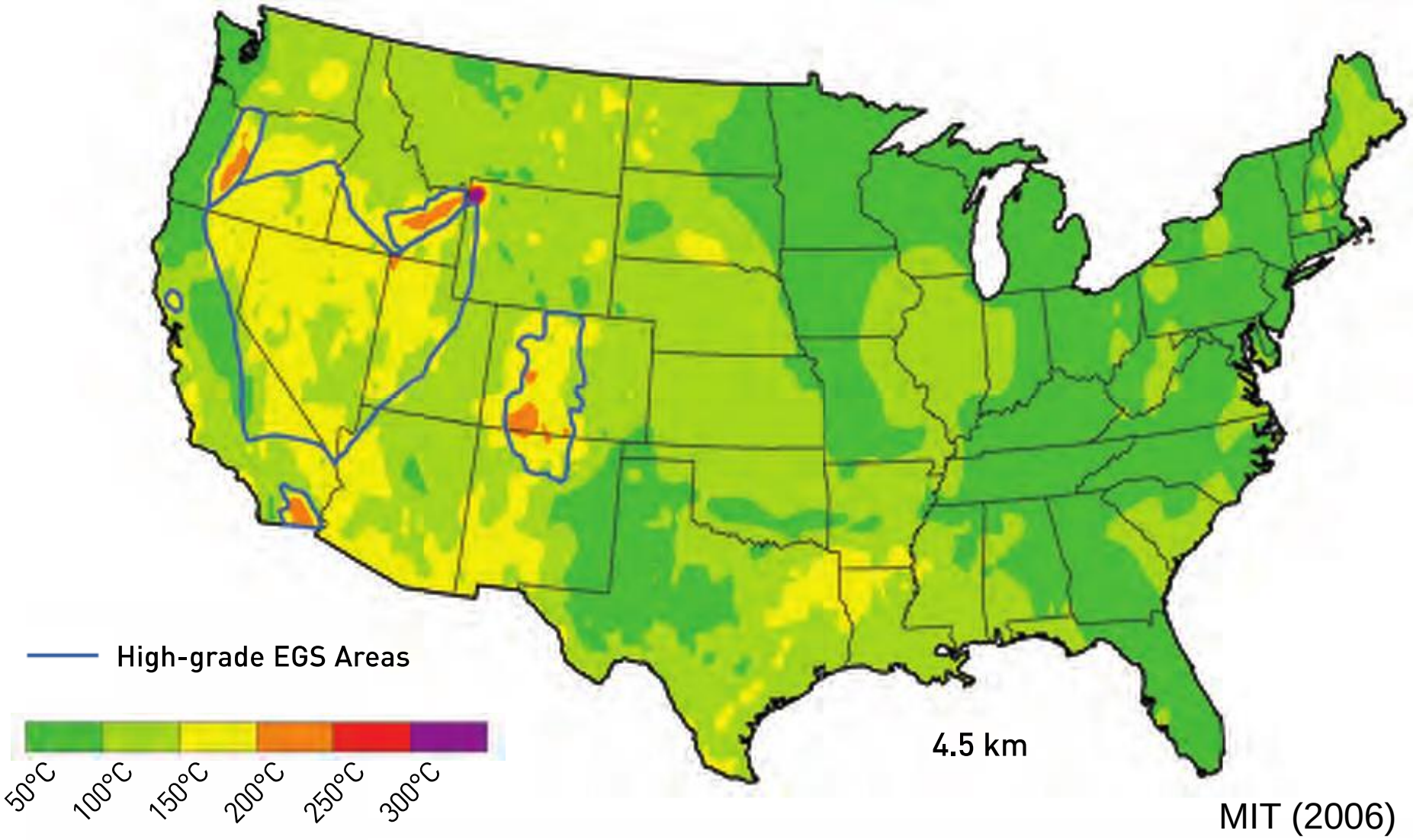


Temperatura vs. profundidade (EUA)



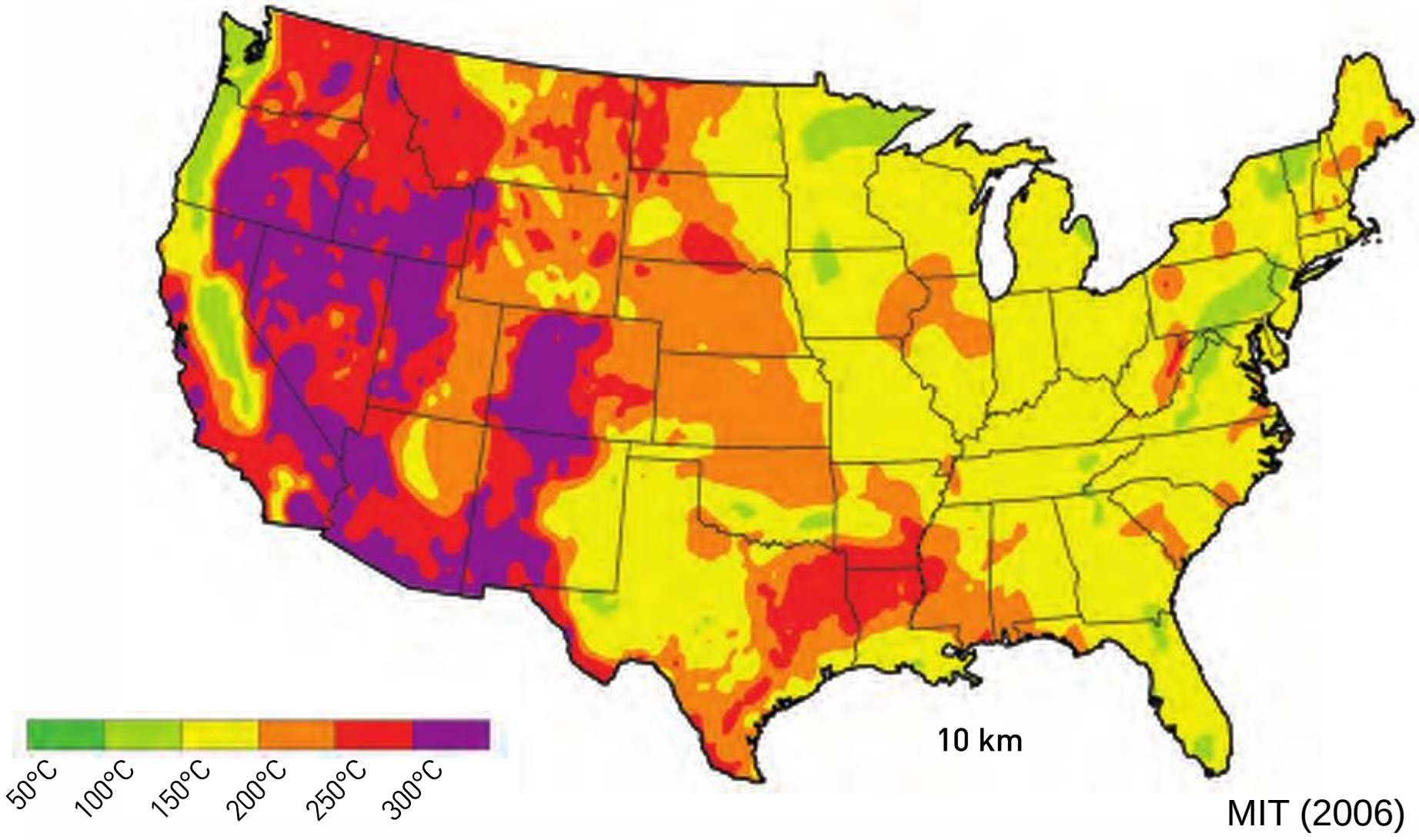
MIT (2006)

Temperatura vs. profundidade (EUA)



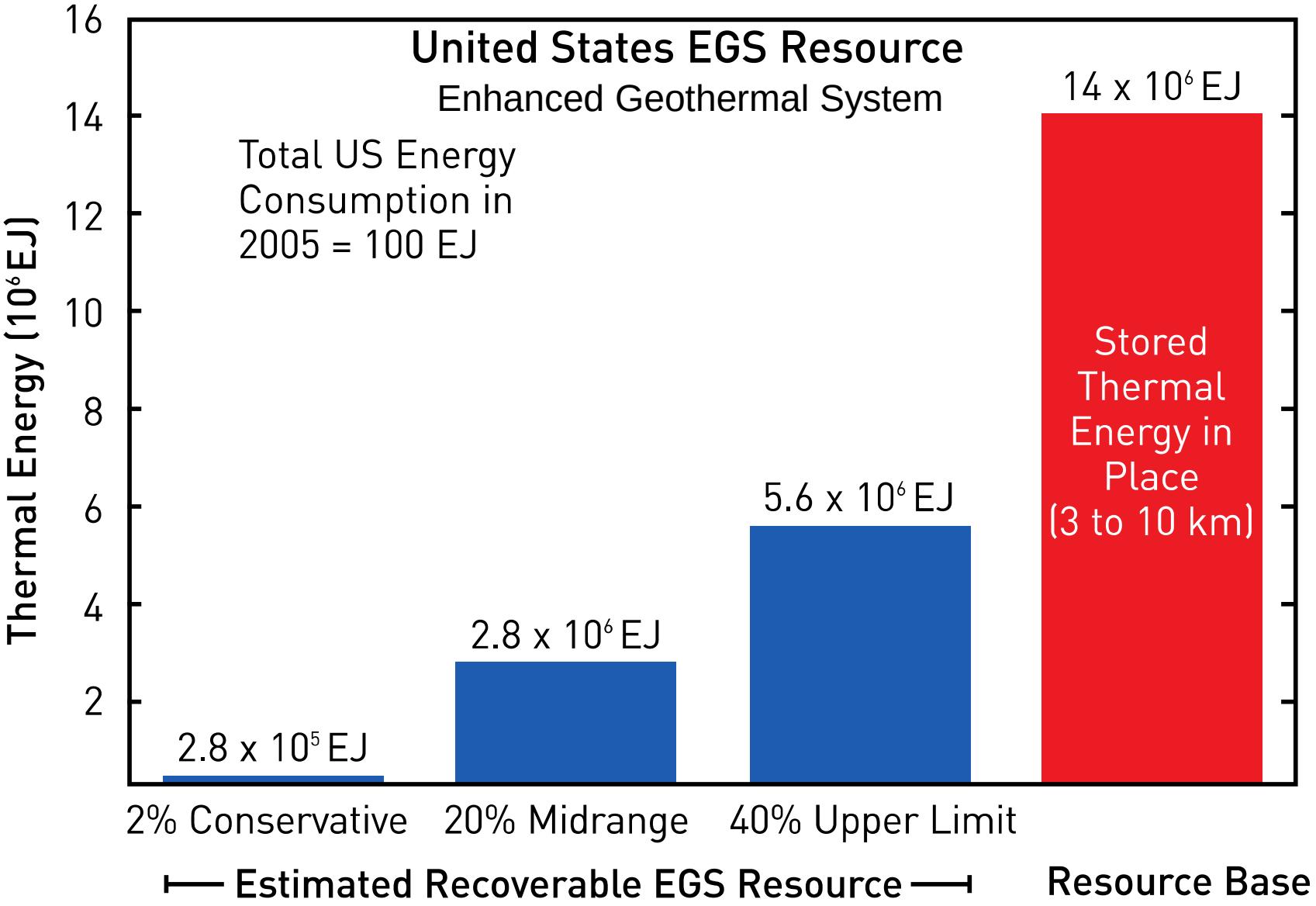
MIT (2006)

Temperatura vs. profundidade (EUA)



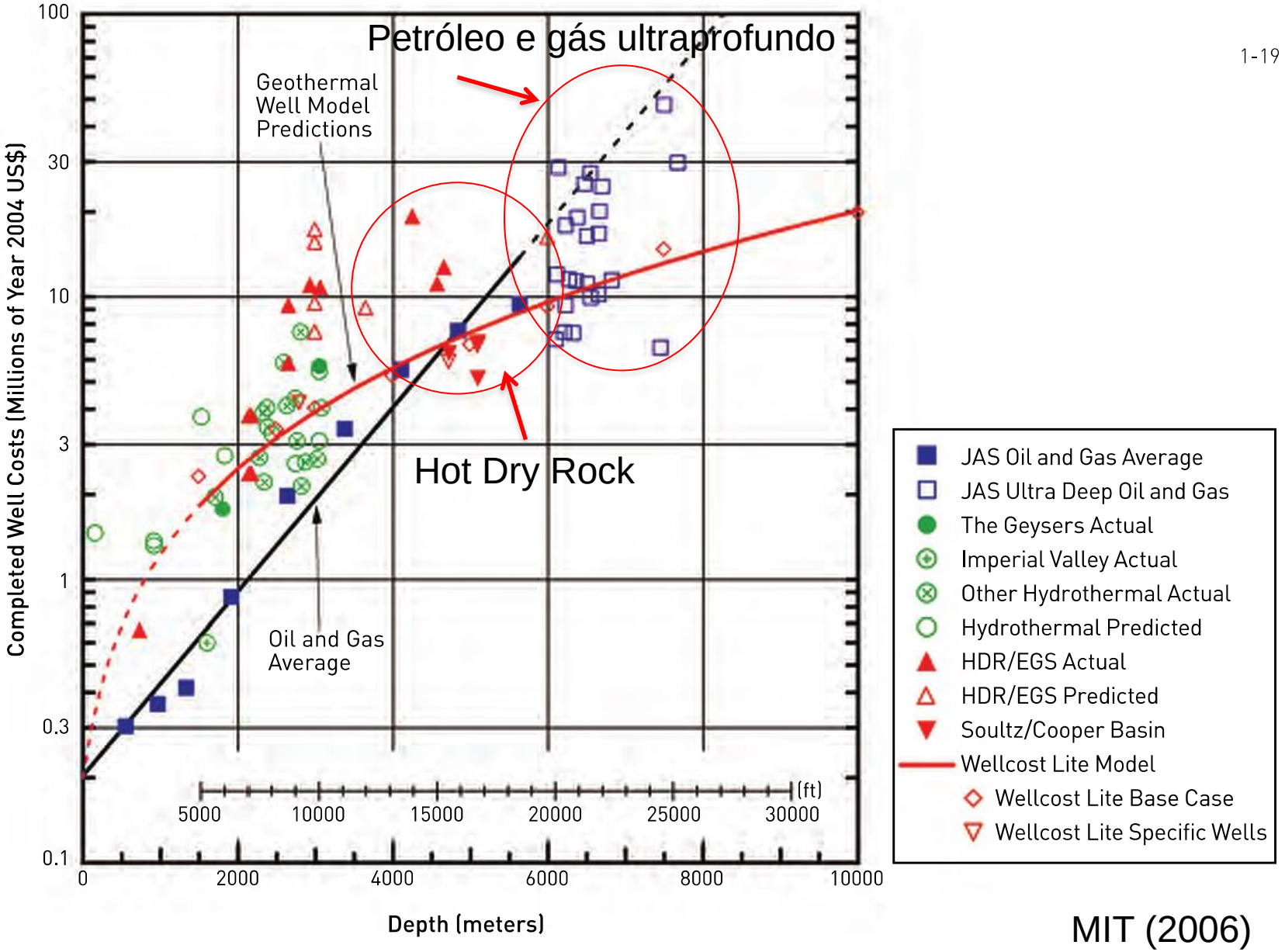
MIT (2006)

Potencial geotérmico (EUA)

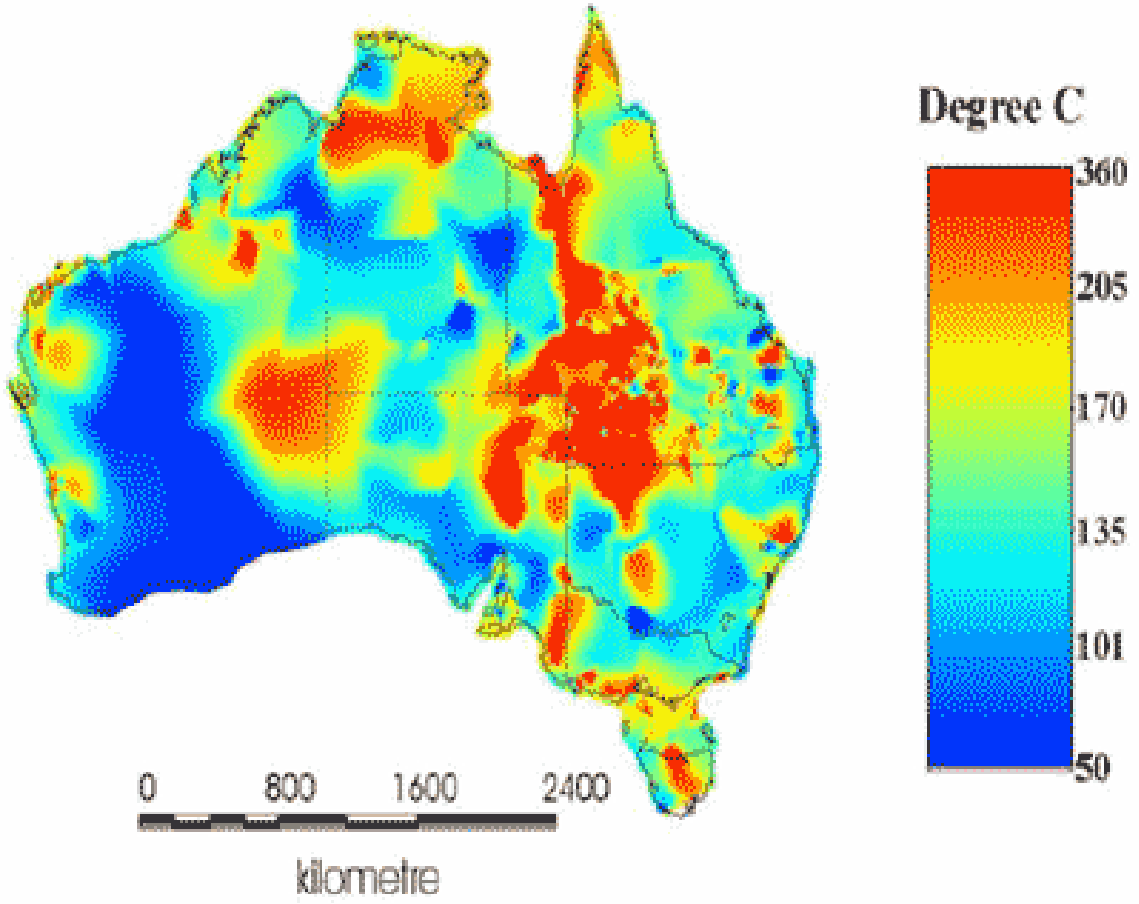


MIT (2006)

Custo da perfuração de poços (HDR)

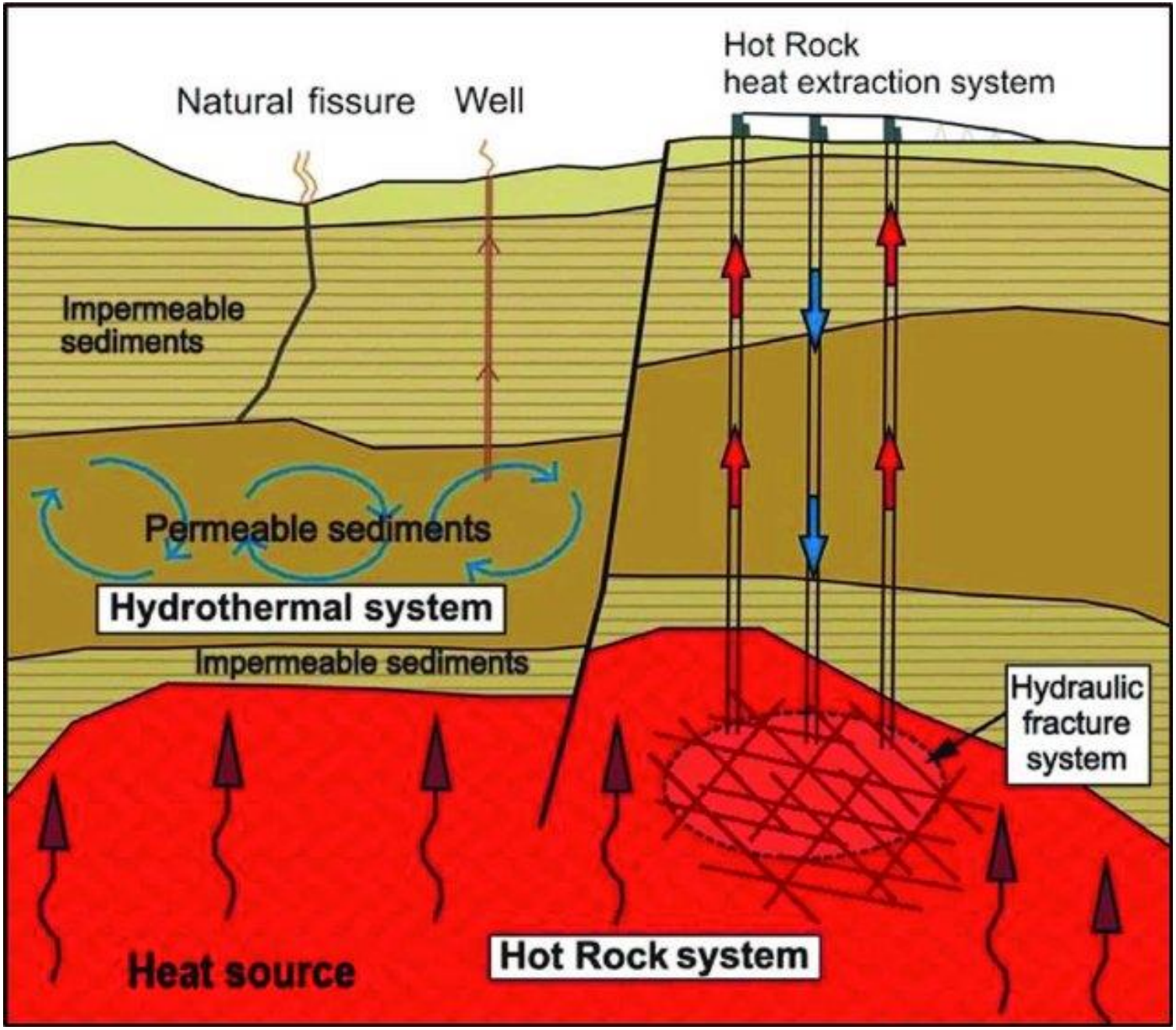


MIT (2006)



Temperature estimate @5km depth

http://cleanenergyaus.com.au/

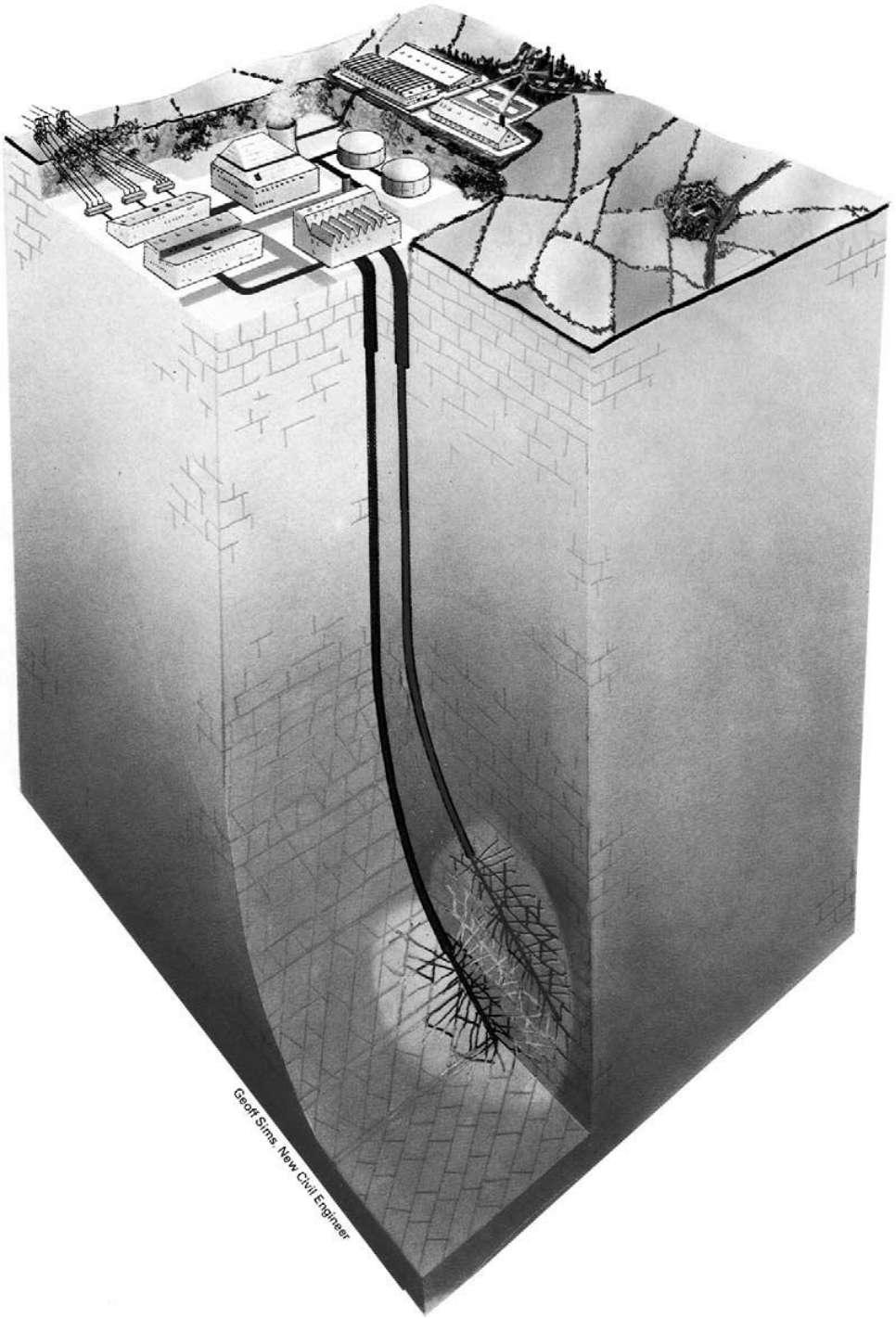


Garcia & González-Zarate (2018)

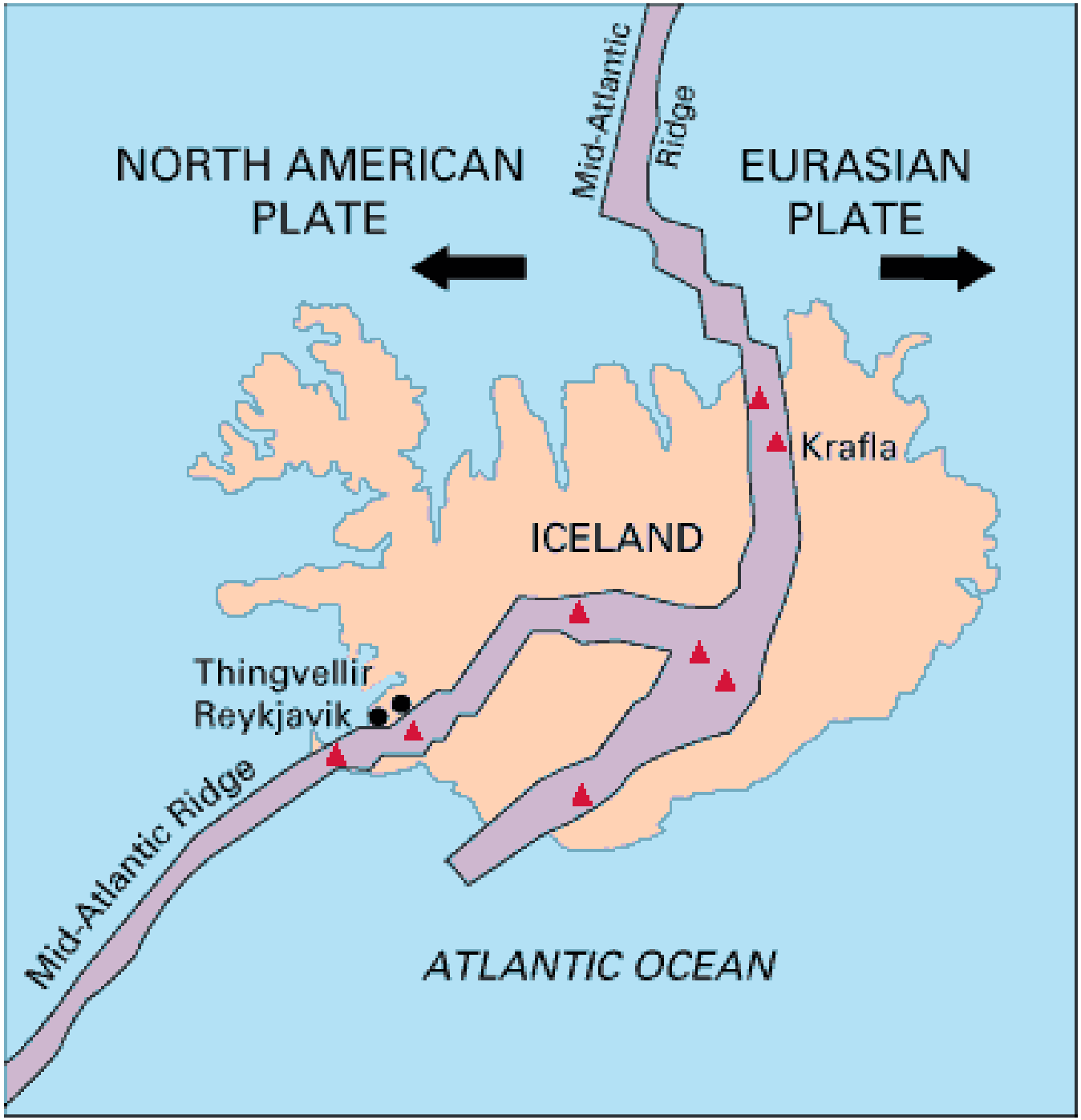
Projetos experimentais

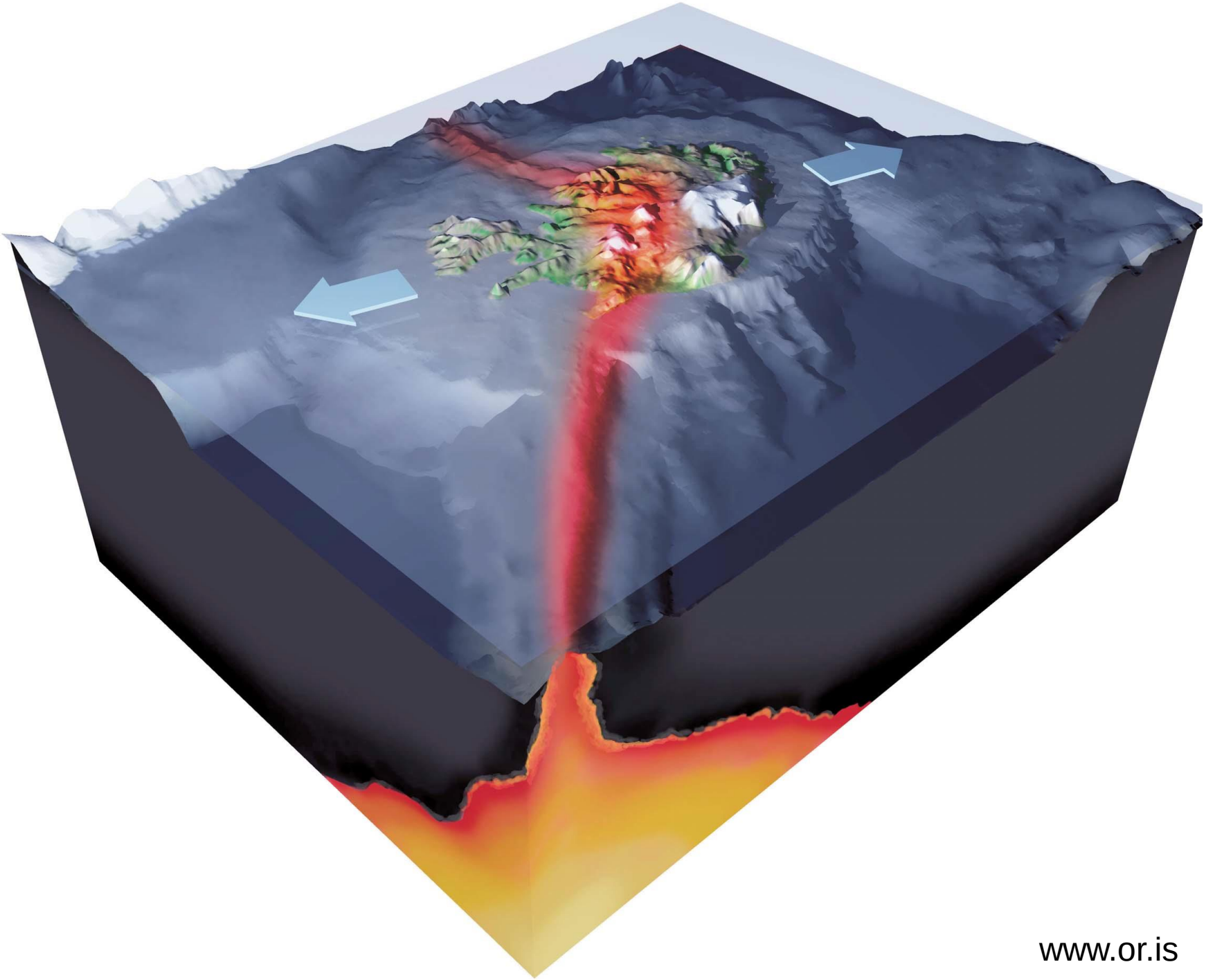
Hot dry rock (HDR)

Corpos magmáticos (US Magma Energy Extraction Program)

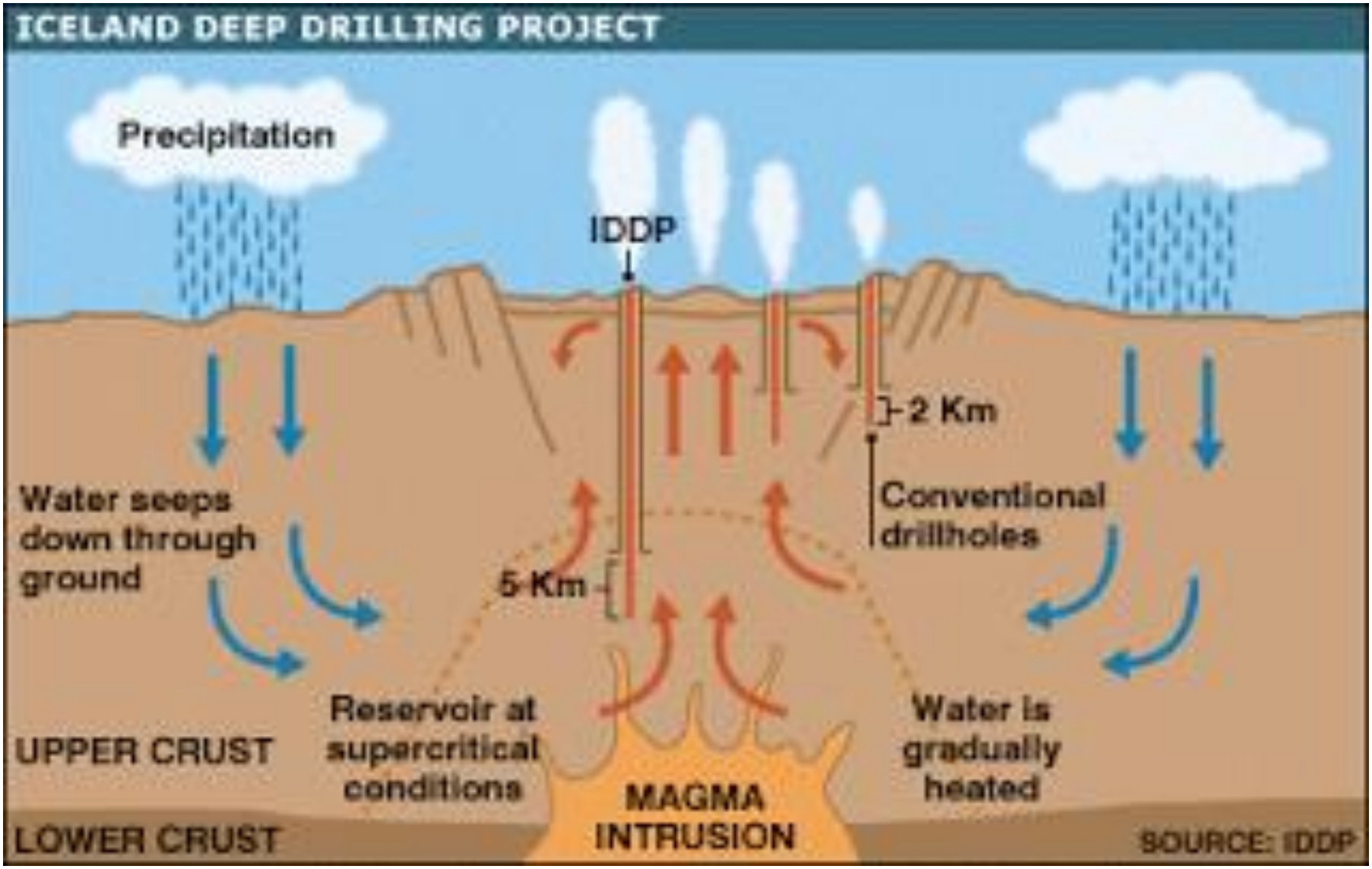


Iceland Deep Drilling Project - IDDP (ICDP)


NORTH AMERICAN PLATE
Mid-Atlantic Ridge
EURASIAN PLATE
Krafla
ICELAND
Thingvellir
Reykjavik
Mid-Atlantic Ridge
ATLANTIC OCEAN



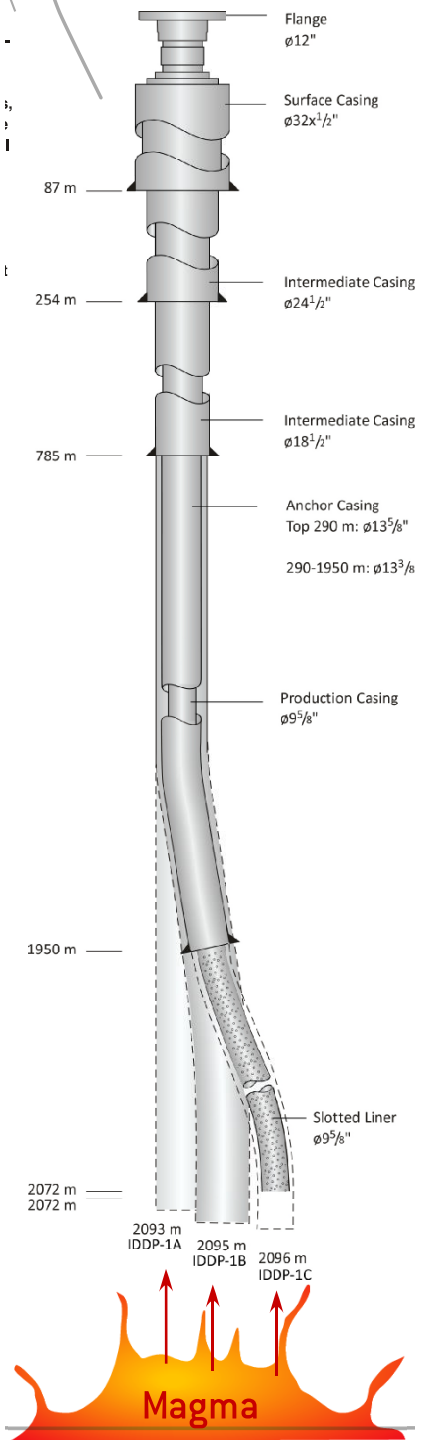
www.or.is


ICELAND DEEP DRILLING PROJECT
Precipitation
IDDP
2 Km
Conventional drillholes
Water seeps down through ground
5 Km
Reservoir at supercritical conditions
Water is gradually heated
UPPER CRUST
MAGMA INTRUSION
LOWER CRUST
SOURCE: IDDP

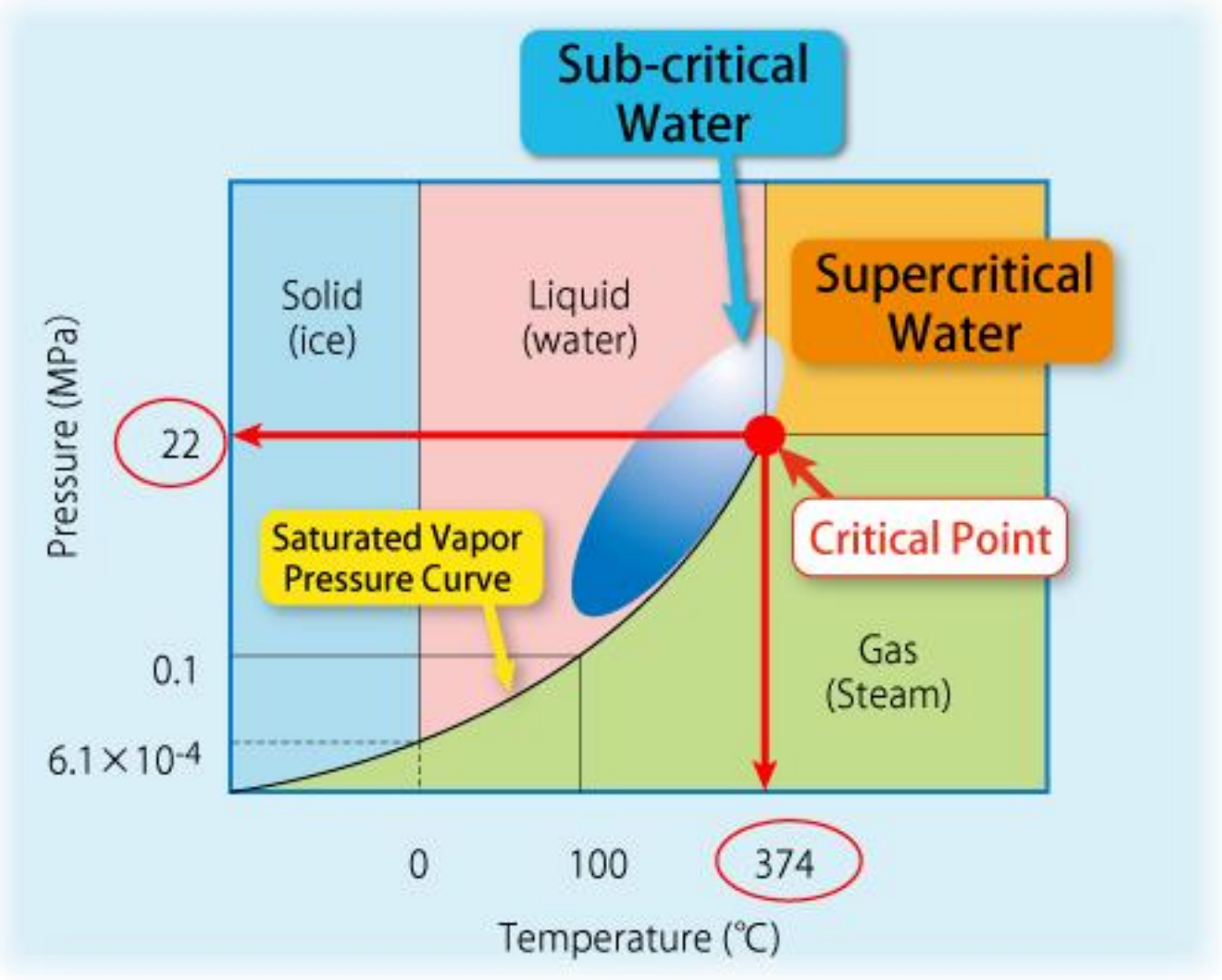
Nesjavellir

iddp.is

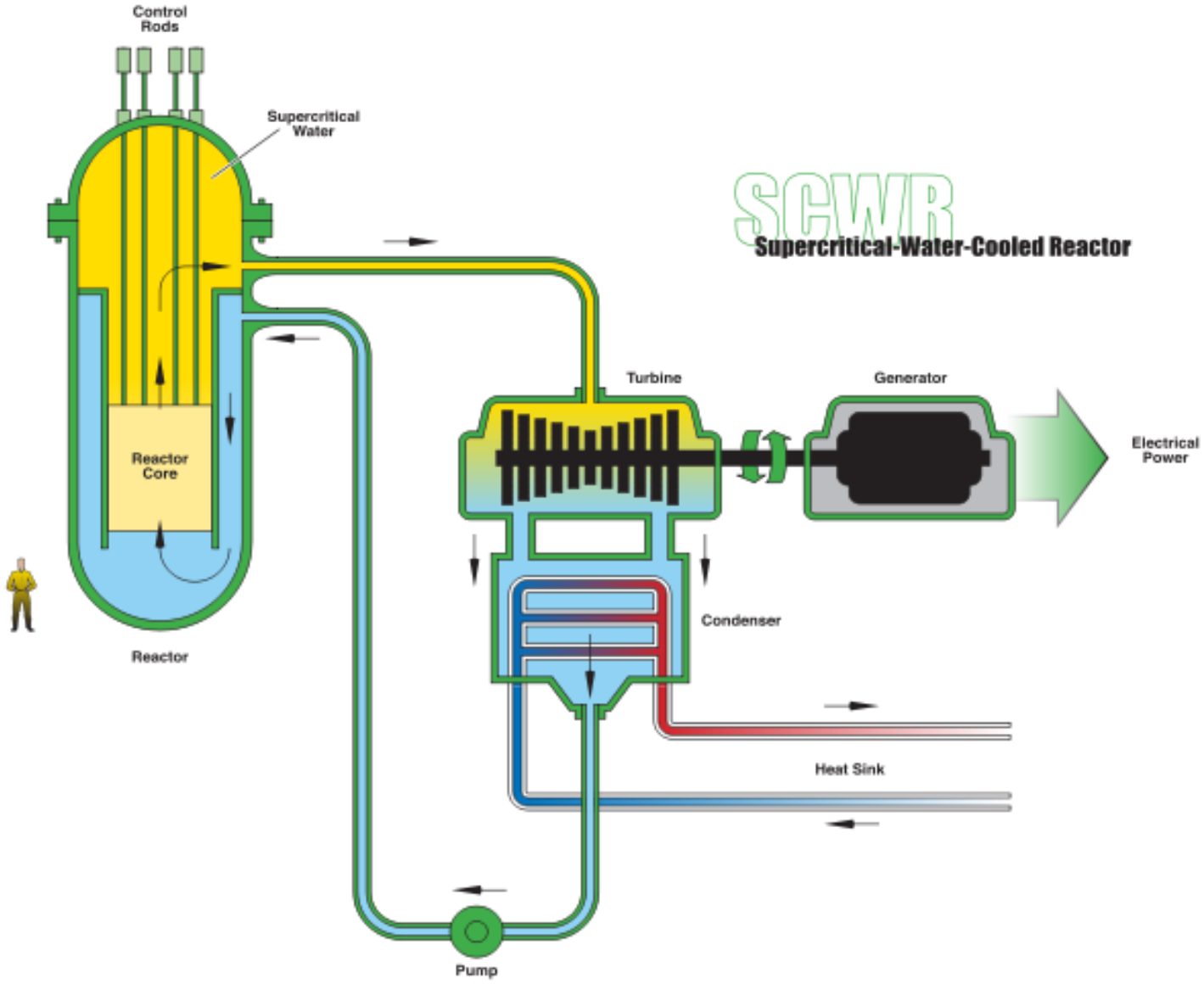
IDDP-1 flowing superheated clean transparent steam 410 °C hot at 40 bar pressure during continued flow test – August 2011.



Fluido supercrítico (água)



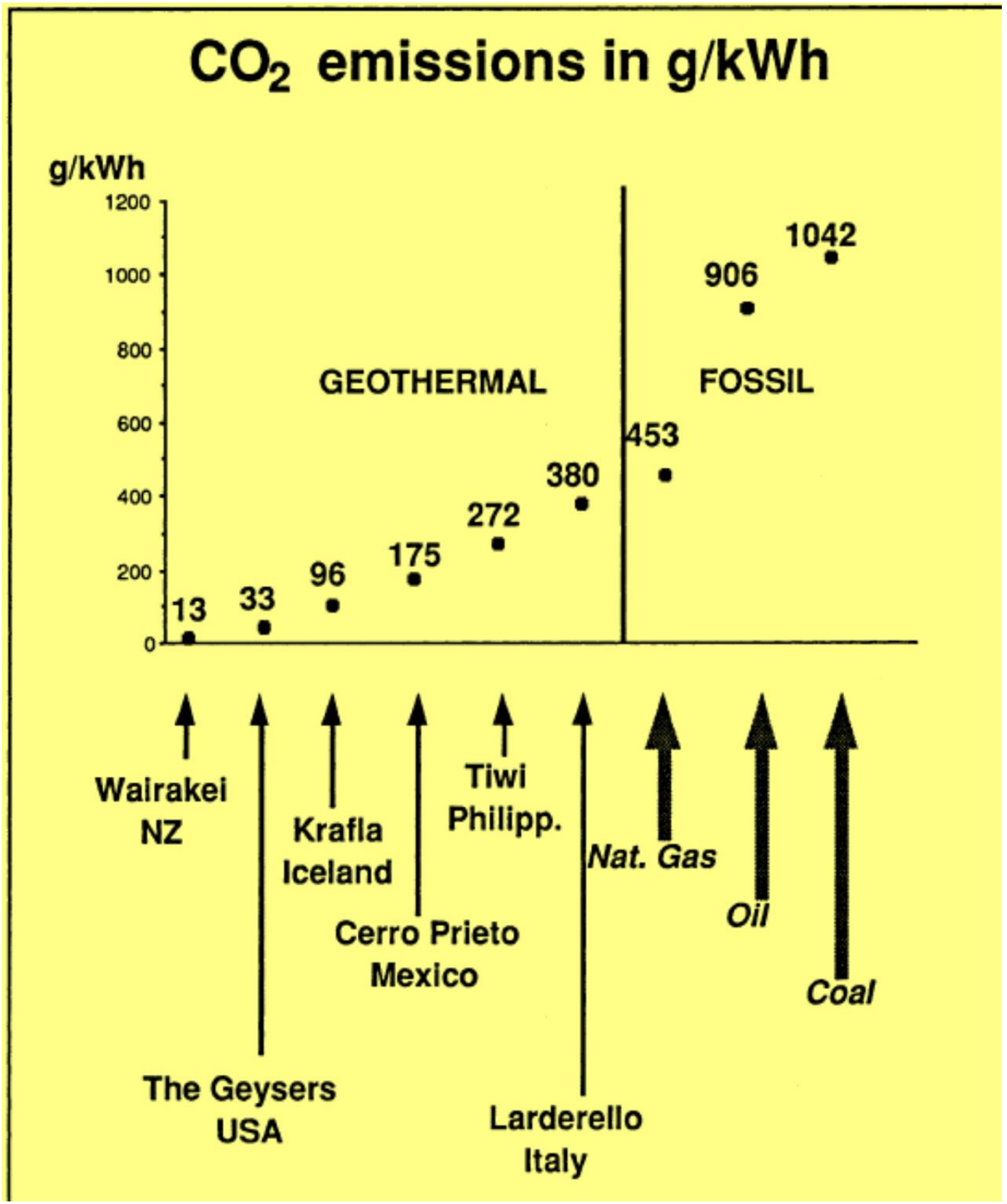
Reator de fluido supercrítico



Impactos ambientais

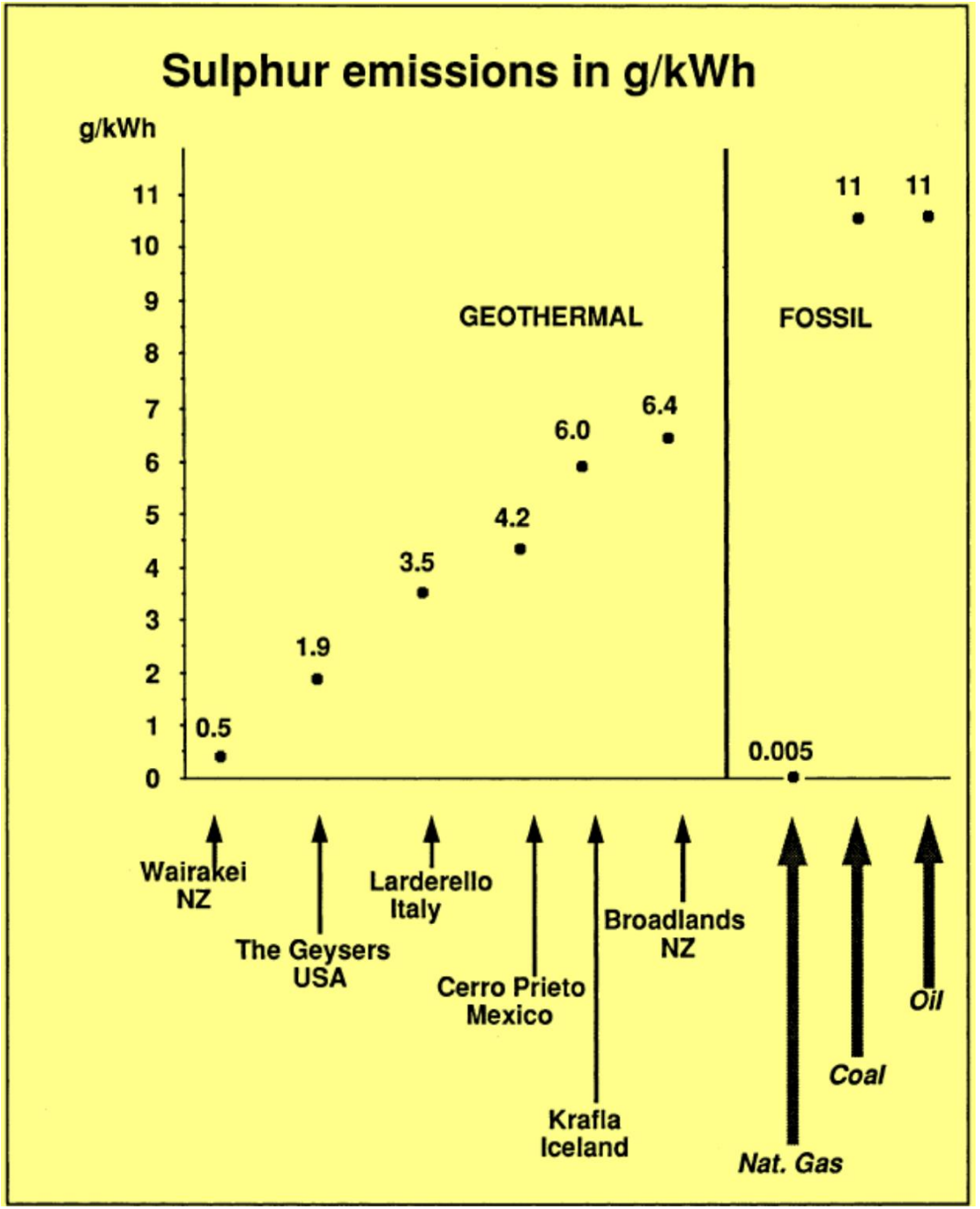
- Poluição do ar (H_2S, NH_3, CH_4, N_2 e H_2)
- Emissão de radônio
- Poluição de águas superficiais e solos (íons em solução – ex. As, B)
- Subsidência
- Sismos induzidos
- Uso da água

Emissão de CO_2



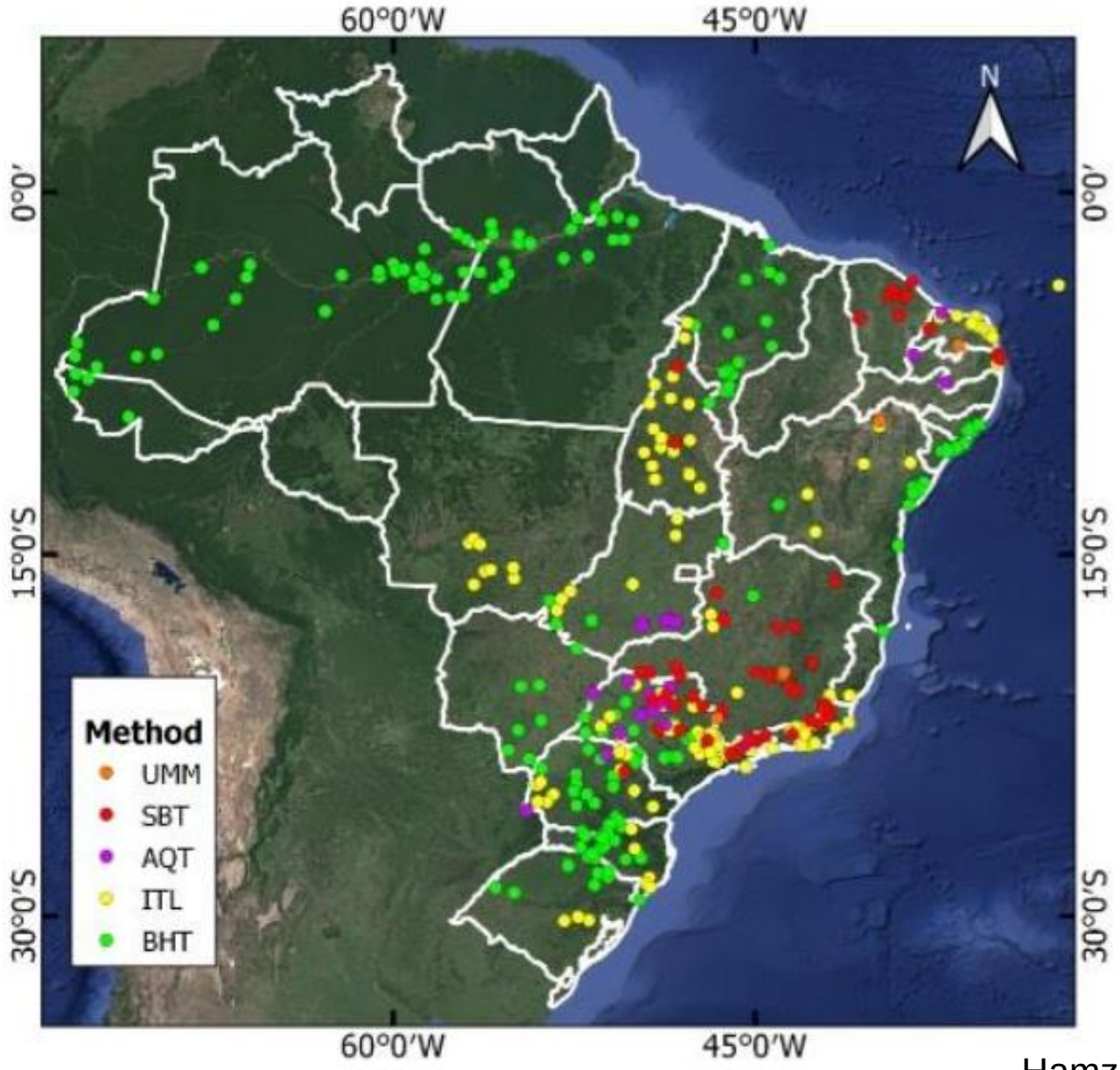
Barbier (2002)

Emissão de enxofre



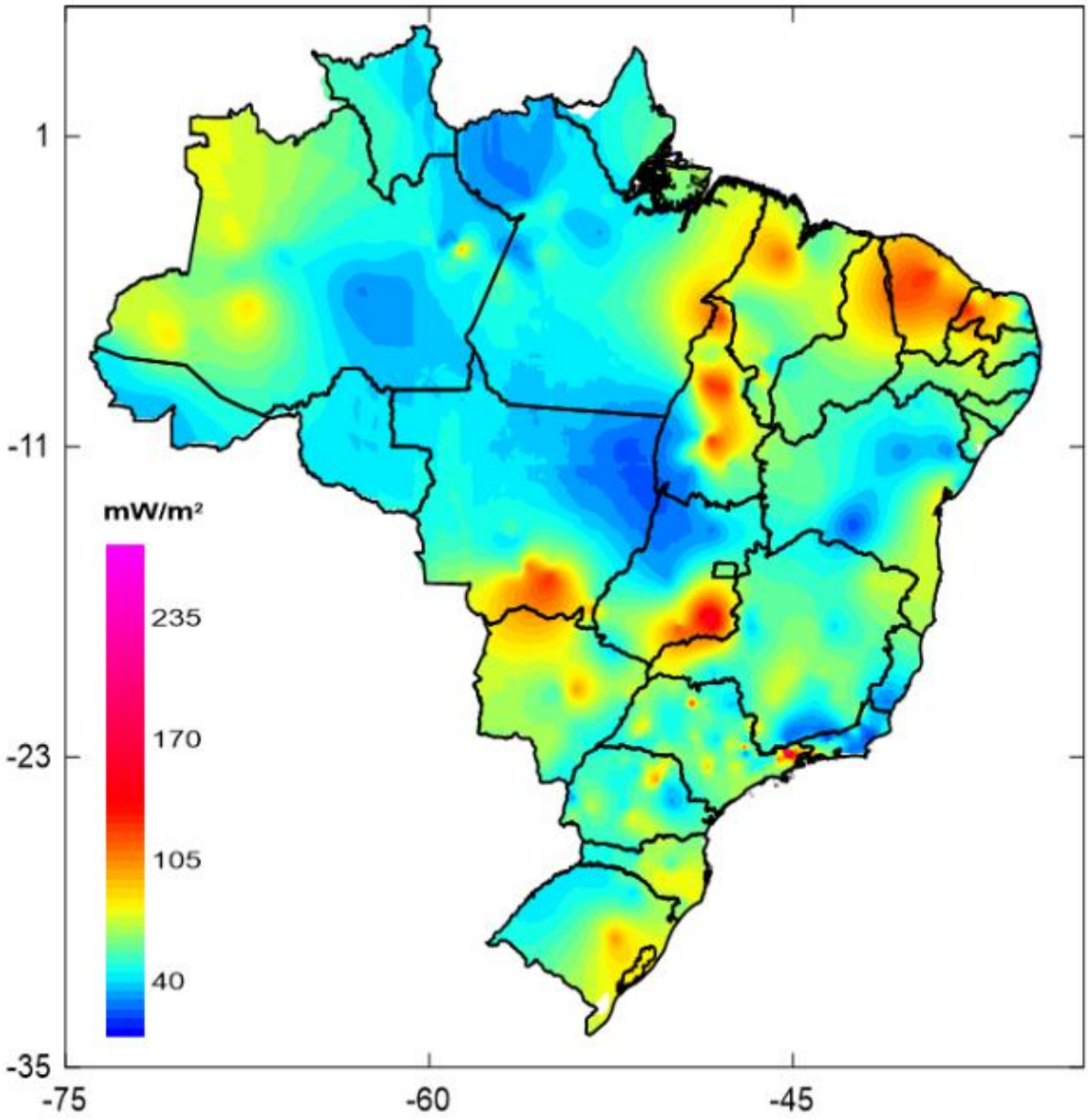
Barbier (2002)

Potencial geotérmico do Brasil

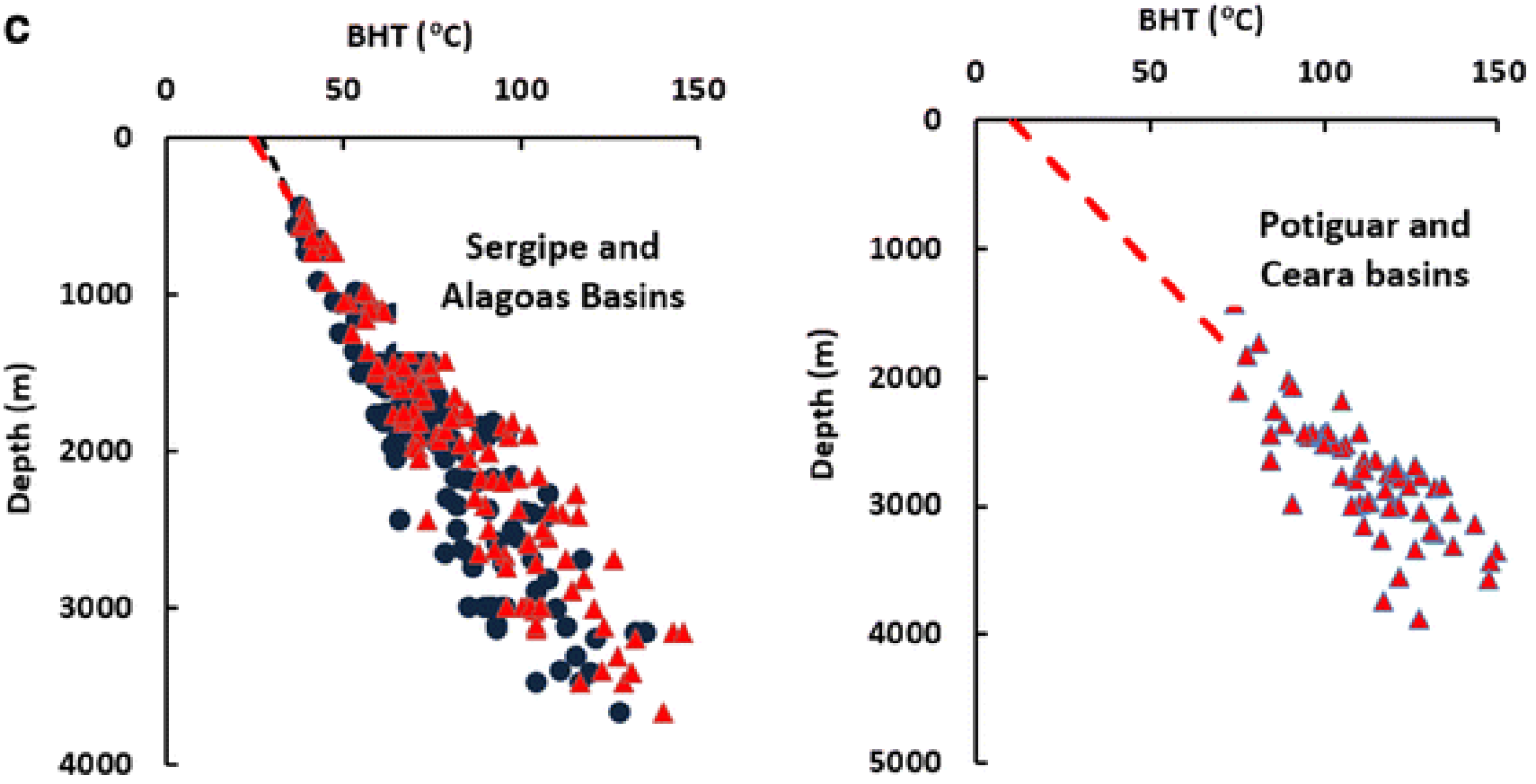


Hamza et al. (2020)

Fluxo térmico (mW/m^2)

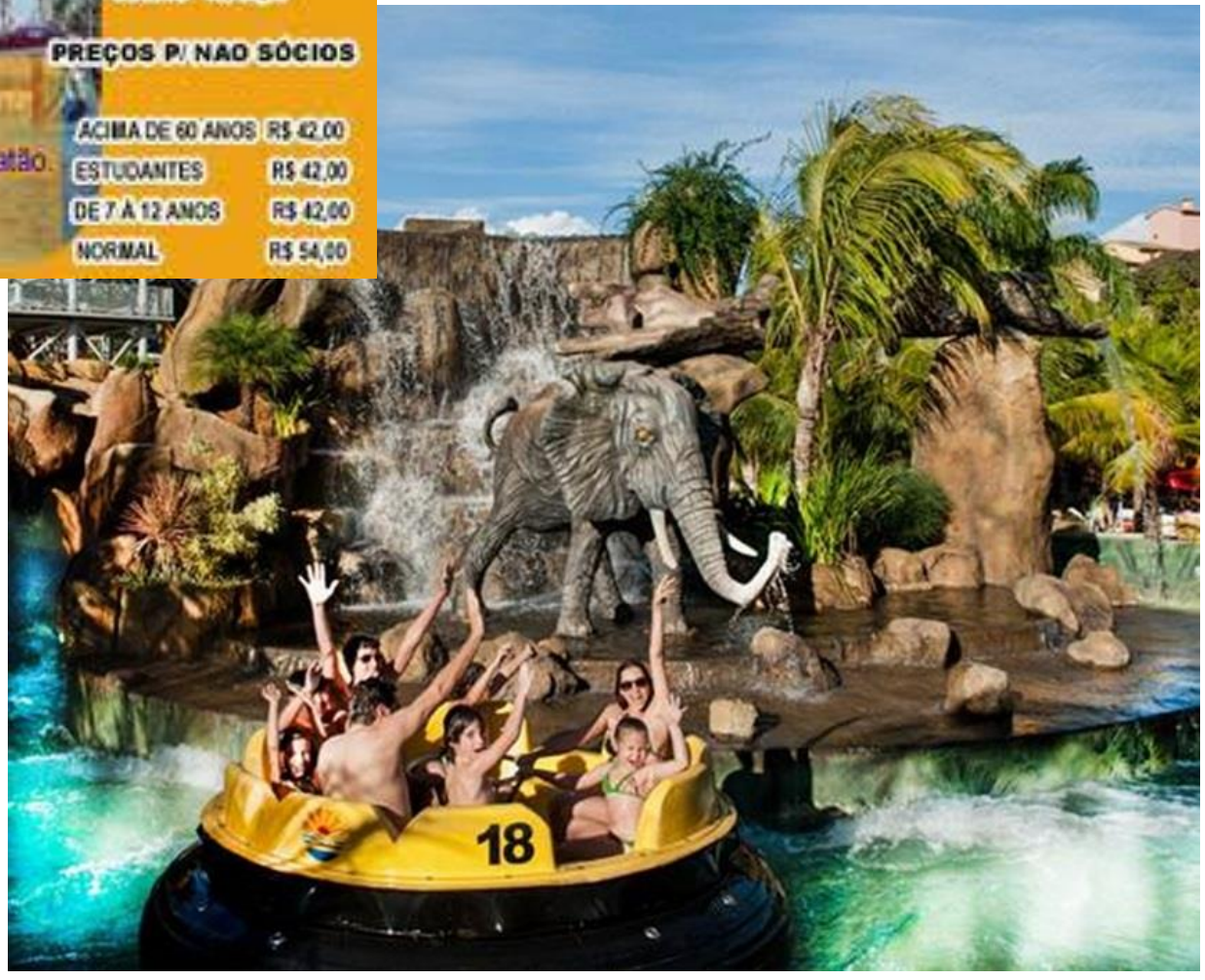


Hamza et al. (2020)



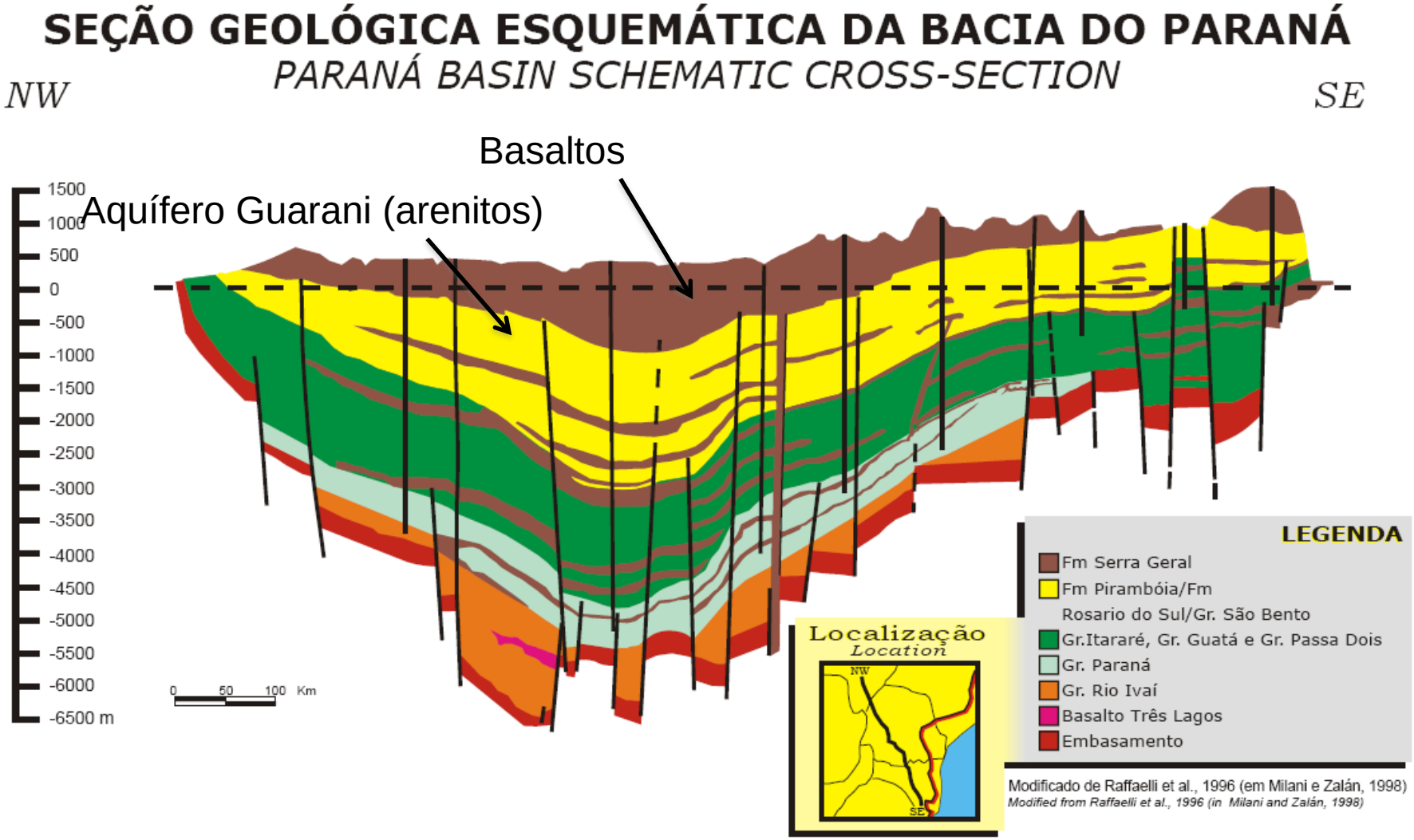
Hamza et al. (2018)

Energia geotérmica no Brasil?




Aquífero Guarani

Aquífero Guarani



10-40^{o}C/km (Chang, 2001)

Consulta!

- International Geothermal Association
- http://www.geothermal-energy.org
- iddp.is (website – Iceland Deep Drilling Project)
- Massachusetts Institute of Technology. 2006. The Future of Geothermal Energy.