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The Geothermal Resource in California

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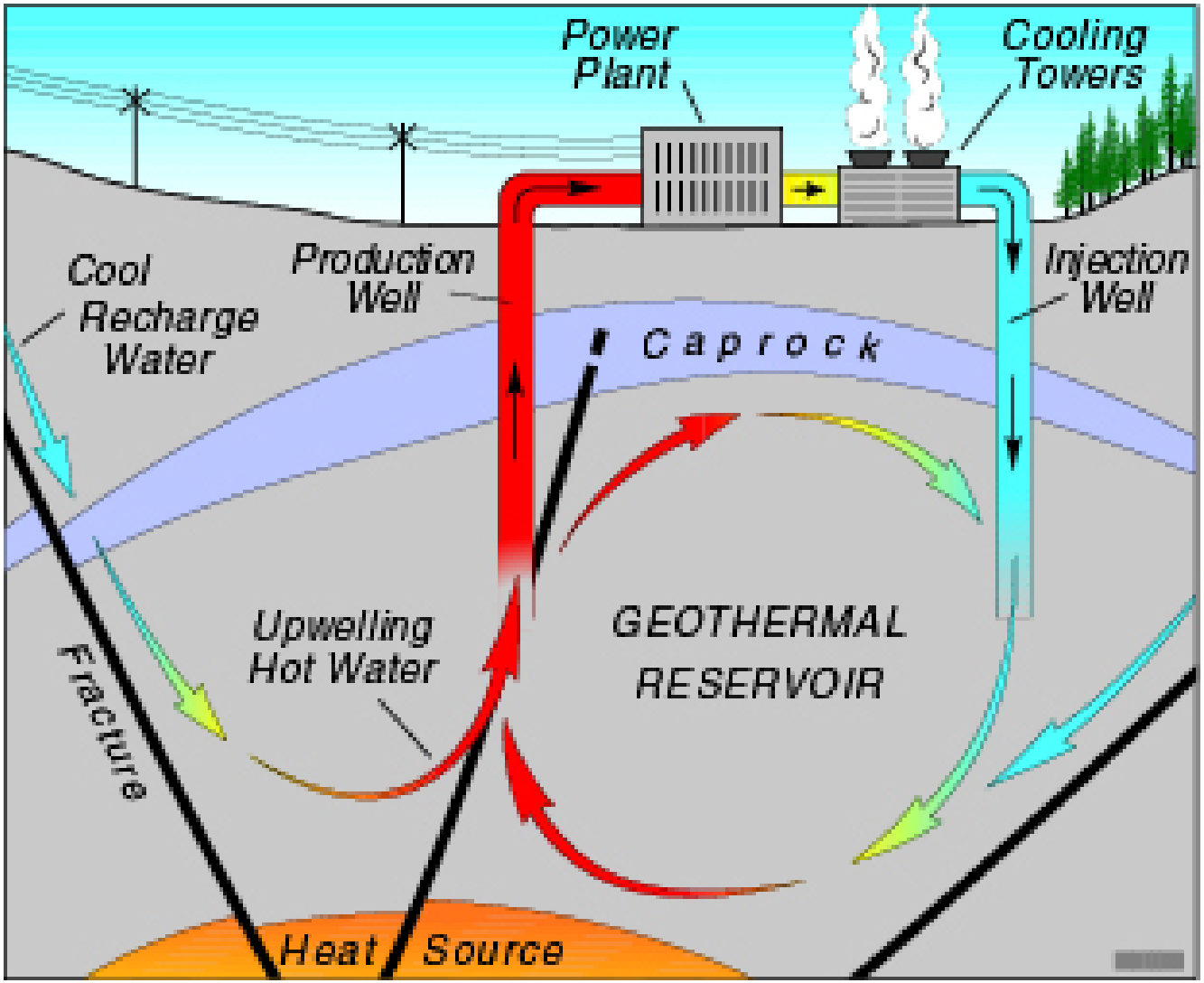
U.S. Department of the Interior
U.S. Geological Survey

The California Geothermal Resource

- What, Where and Why
- Geothermal Resource Assessments
- Geothermal Development
- New Technologies
- Undiscovered Resources
- Future Directions


Power Plant
Cooling Towers
Cool Recharge Water
Production Well
Injection Well
Caprock
Upwelling Hot Water
GEOTHERMAL RESERVOIR
Fracture
Heat Source

GEA 1999


GM
SV
LASSEN
AL
GEYSERS
GREAT
BASIN
SIERRA NEVADA
GREAT CENTRAL VALLEY
COAST RANGES
LV
DEATH
VALLEY
COSO
MOJAVE
BLOCK
TRANSVERSE RANGES
PENINSULAR
RANGES
IMP.
VALLEY

USGS

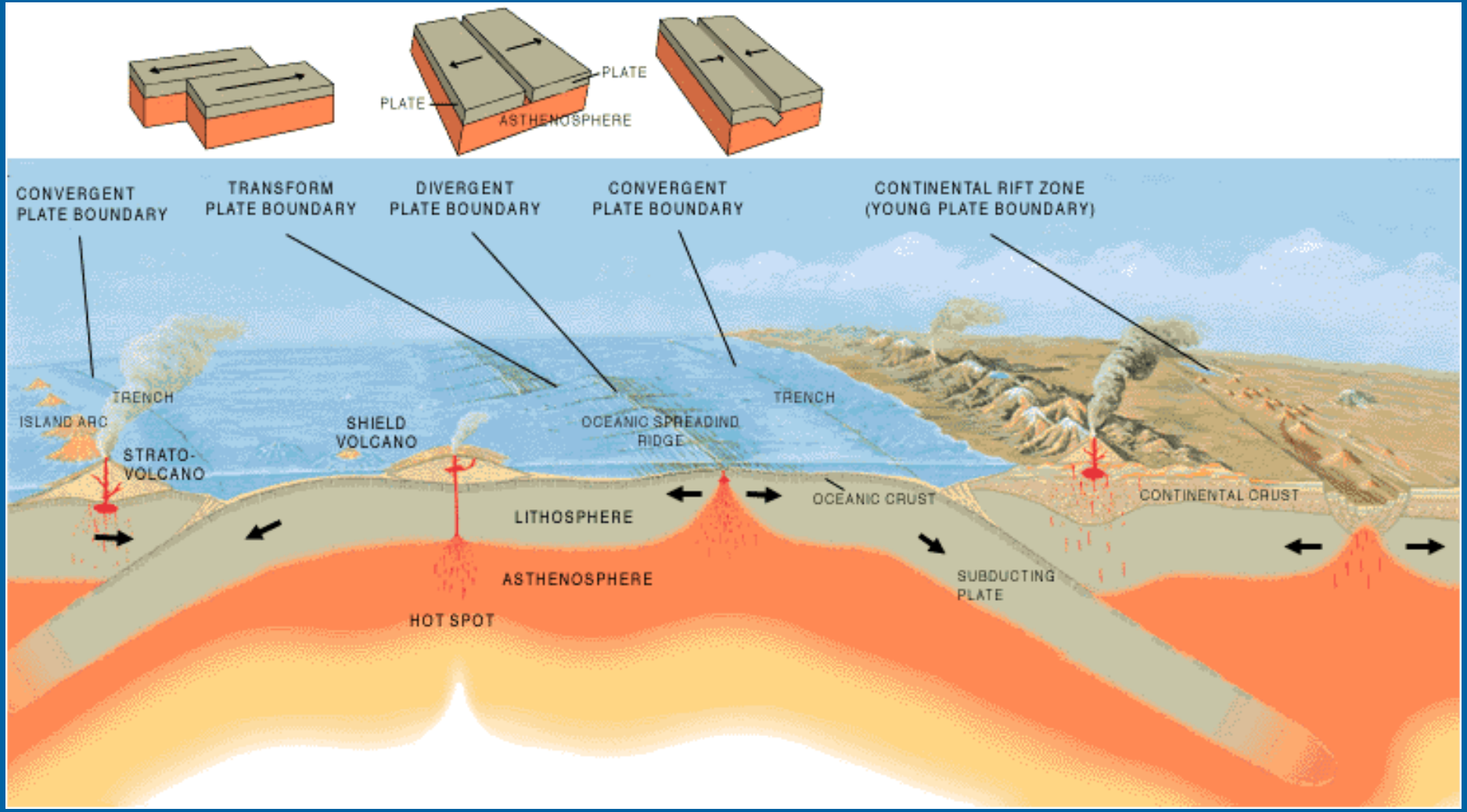


PLATE
PLATE
ASTHENOSPHERE
CONVERGENT PLATE BOUNDARY
TRANSFORM PLATE BOUNDARY
DIVERGENT PLATE BOUNDARY
CONVERGENT PLATE BOUNDARY
CONTINENTAL RIFT ZONE (YOUNG PLATE BOUNDARY)
TRENCH
ISLAND ARC
STRATO-VOLCANO
SHIELD VOLCANO
OCEANIC SPREADING RIDGE
TRENCH
OCEANIC CRUST
CONTINENTAL CRUST
LITHOSPHERE
ASTHENOSPHERE
HOT SPOT
SUBDUCTING PLATE

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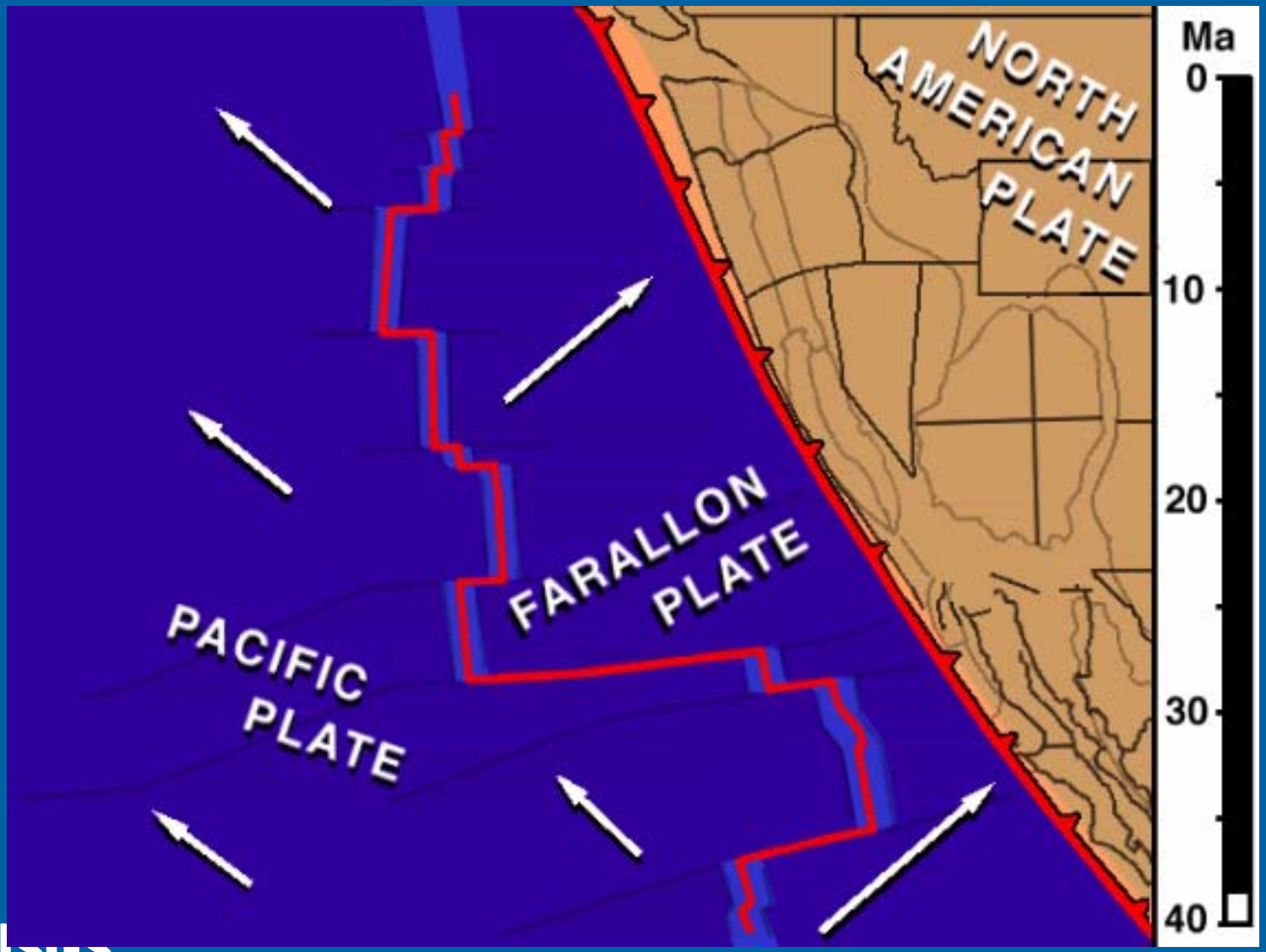
NORTH AMERICAN PLATE
FARALLON PLATE
PACIFIC PLATE
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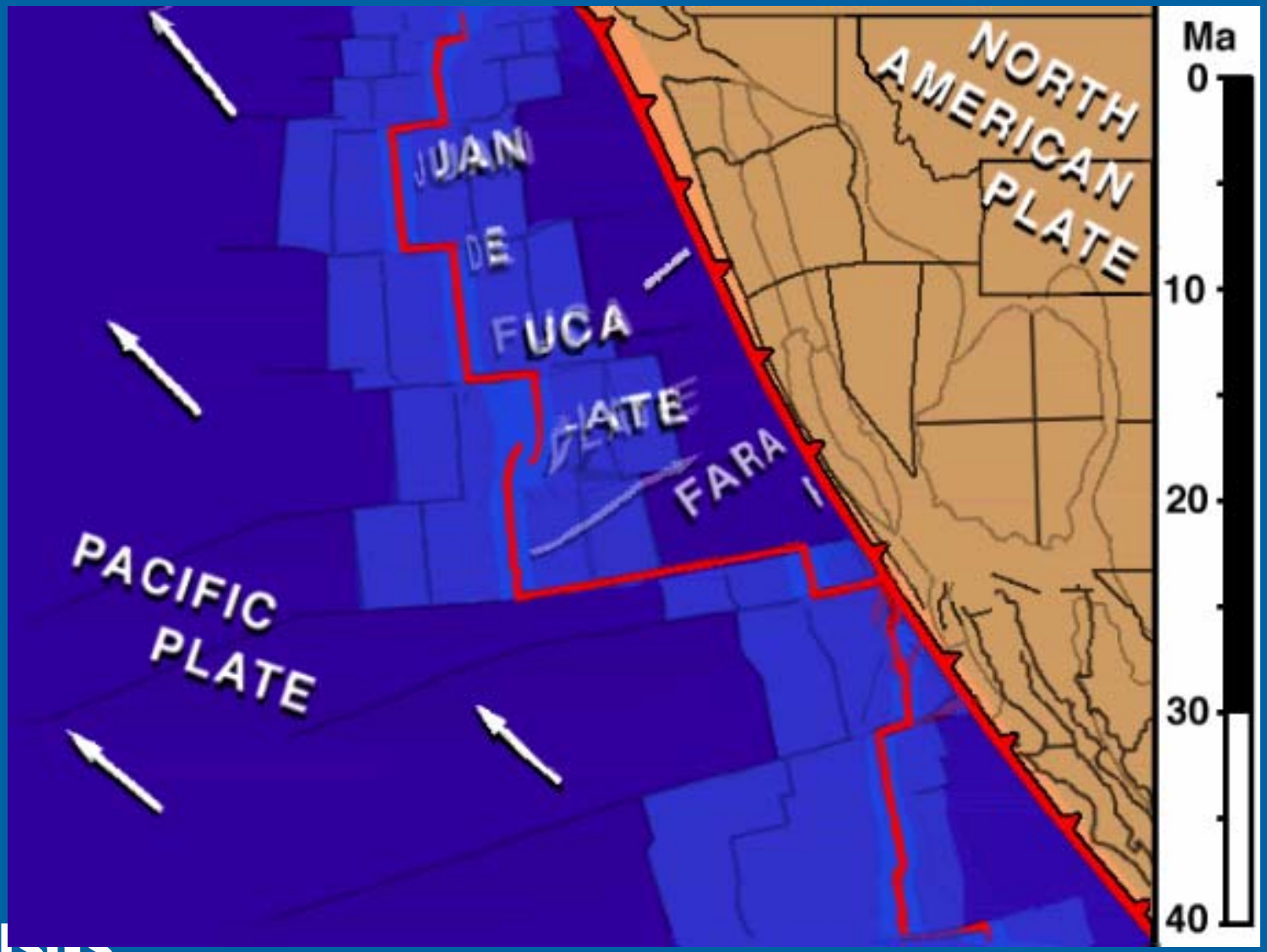
NORTH AMERICAN PLATE
JUAN DE FUCA PLATE
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PACIFIC PLATE
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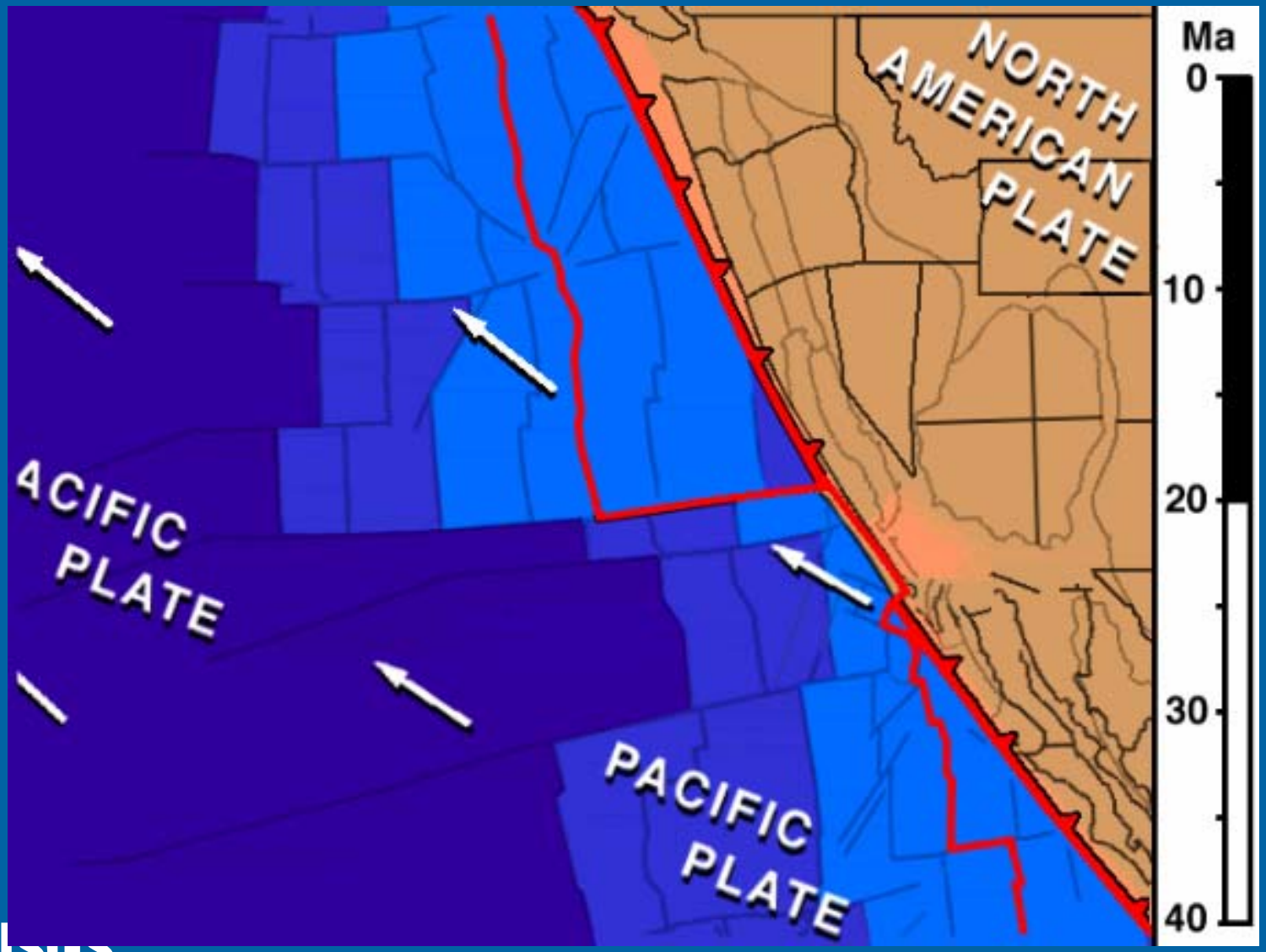
NORTH AMERICAN PLATE
ACIFIC PLATE
PACIFIC PLATE
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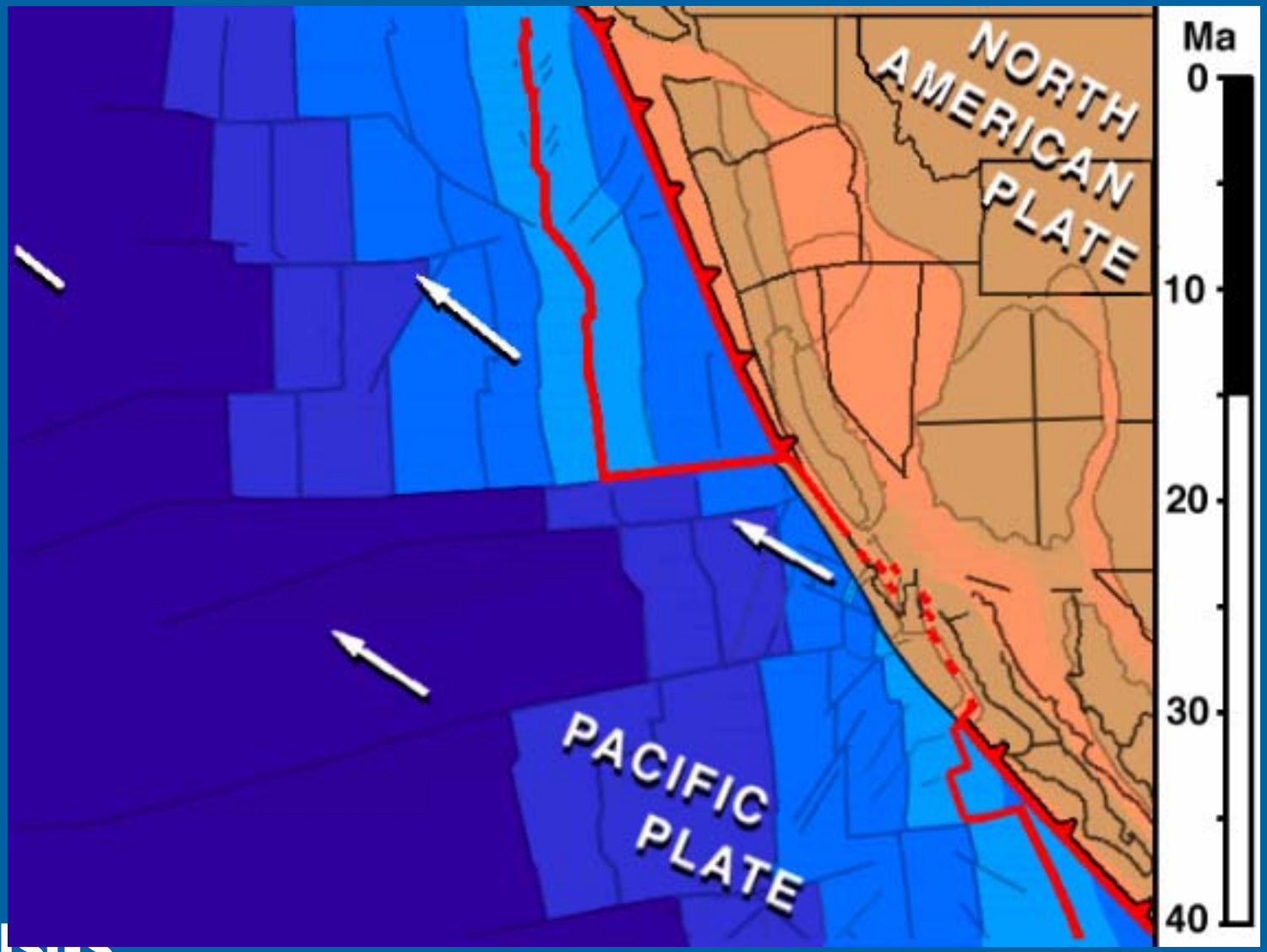
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PACIFIC PLATE
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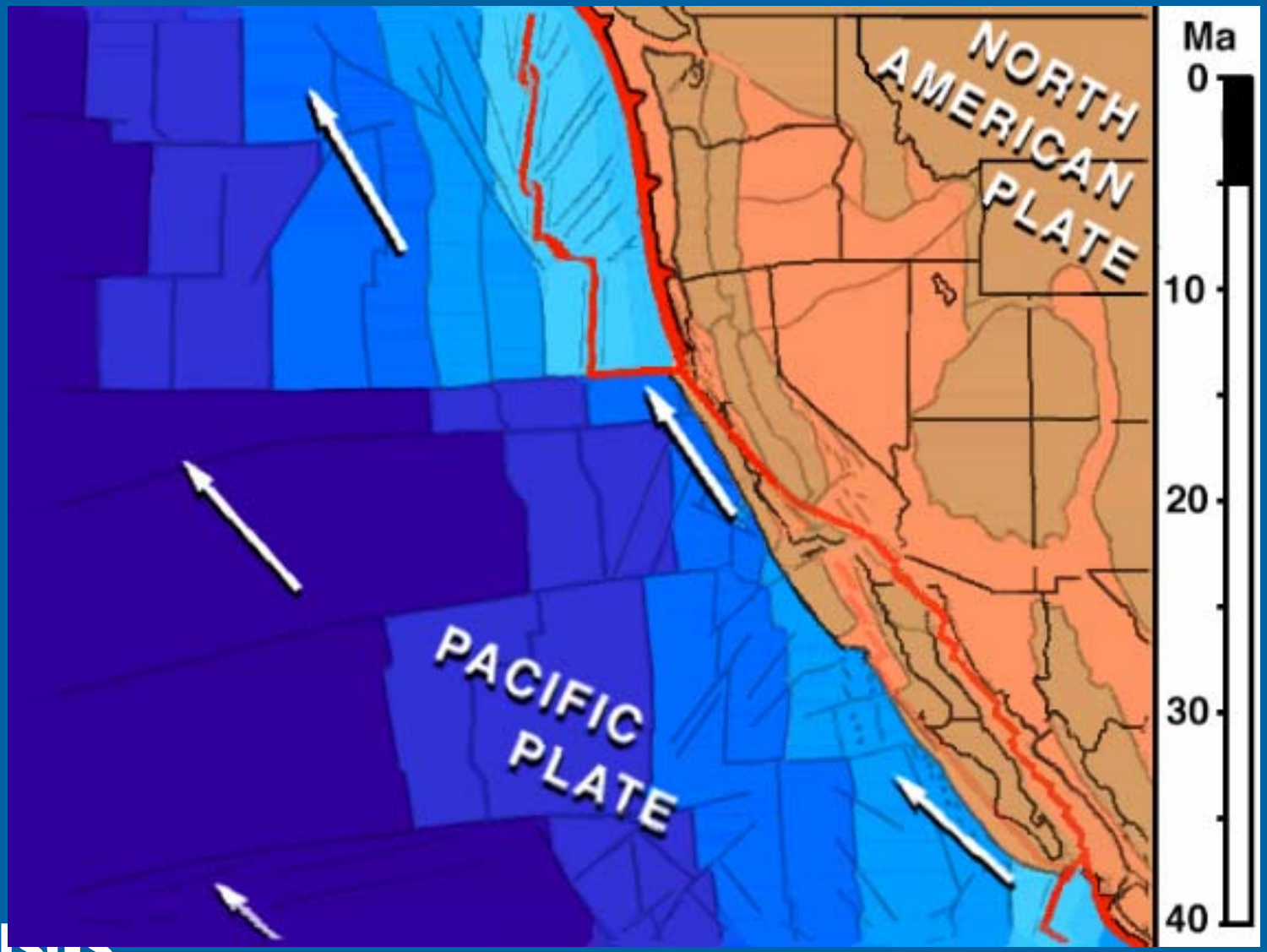
NORTH AMERICAN PLATE
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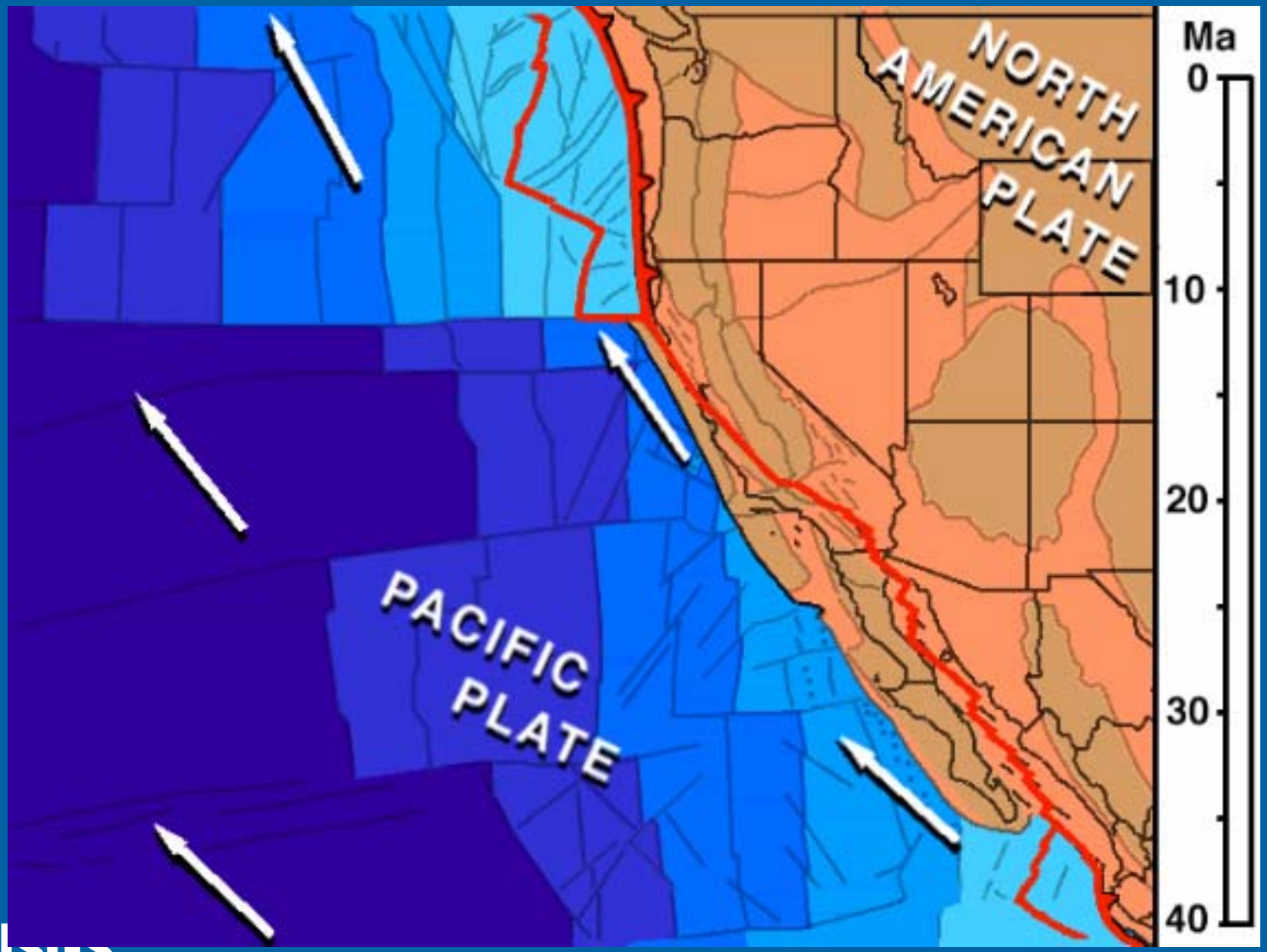
NORTH AMERICAN PLATE
PACIFIC PLATE
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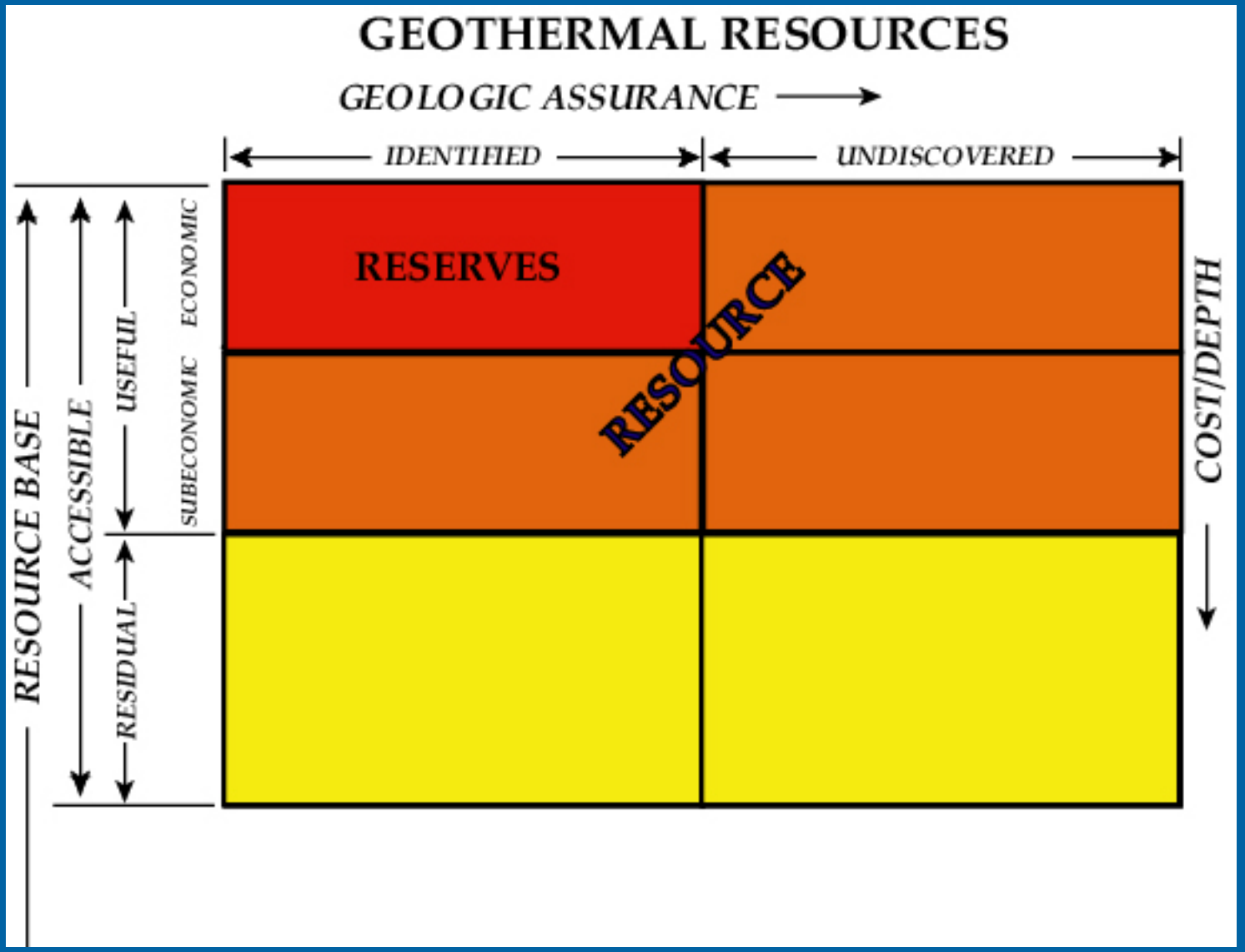
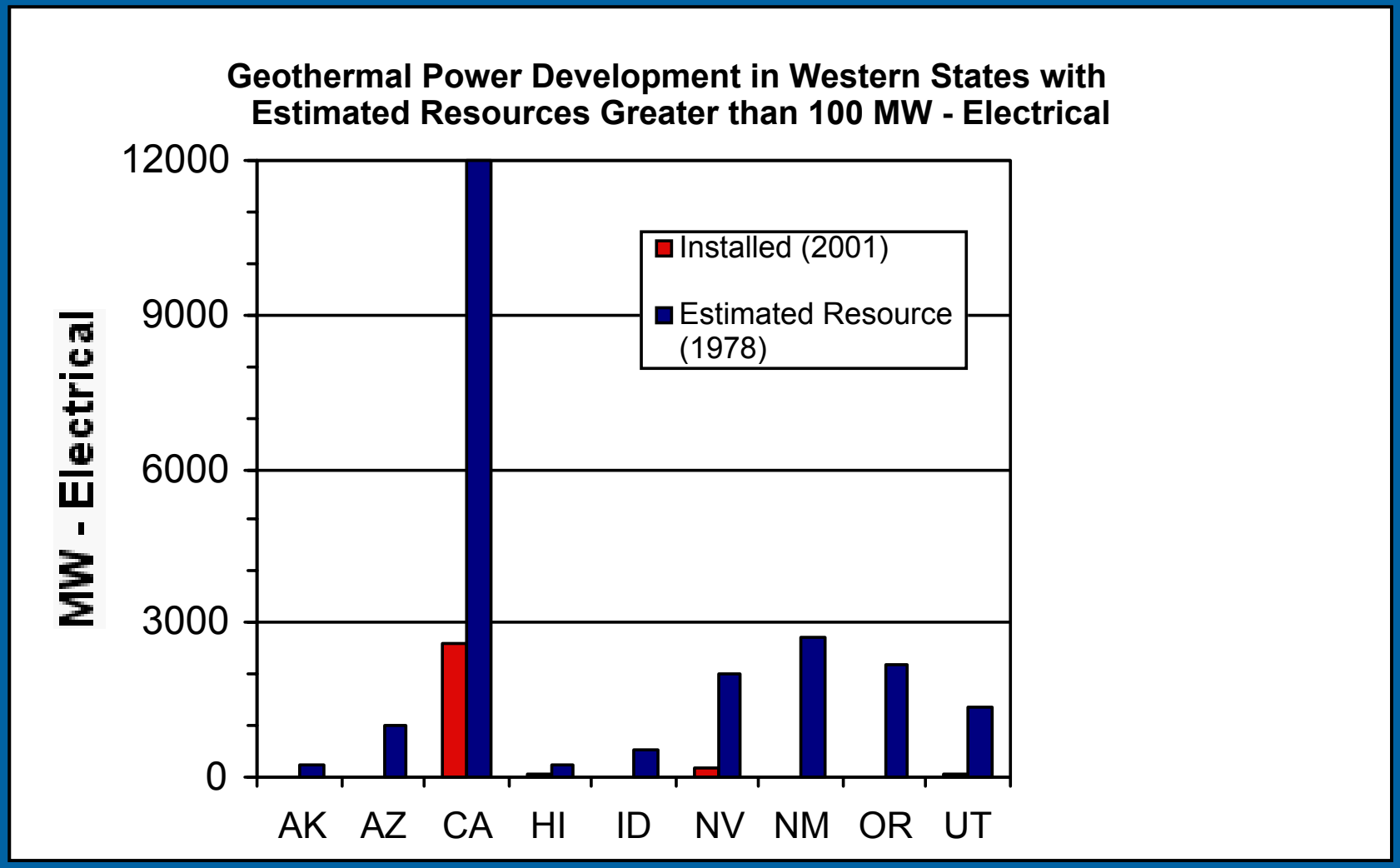

GEOTHERMAL RESOURCES
GEOLOGIC ASSURANCE
IDENTIFIED
UNDISCOVERED
RESERVES
RESOURCE
RESOURCE BASE
ACCESSIBLE
USEFUL
ECONOMIC
SUBECONOMIC
RESIDUAL
COST/DEPTH

Status of California Geothermal

- At one point approximately 2800 MWe installed
- Currently >2000 MWe
- 1978 USGS Resource Assessment
  - 12,000 MWe in identified systems
  - >10,000 MWe in undiscovered systems
- New Resource Assessments - Geothermex
  - >5000 MWe in identified, conventional resources
- Largest resource in U.S., both installed and in potential development


Geothermal Power Development in Western States with Estimated Resources Greater than 100 MW - Electrical
MW - Electrical
12000
9000
6000
3000
0
Installed (2001)
Estimated Resource (1978)
AK
AZ
CA
HI
ID
NV
NM
OR
UT

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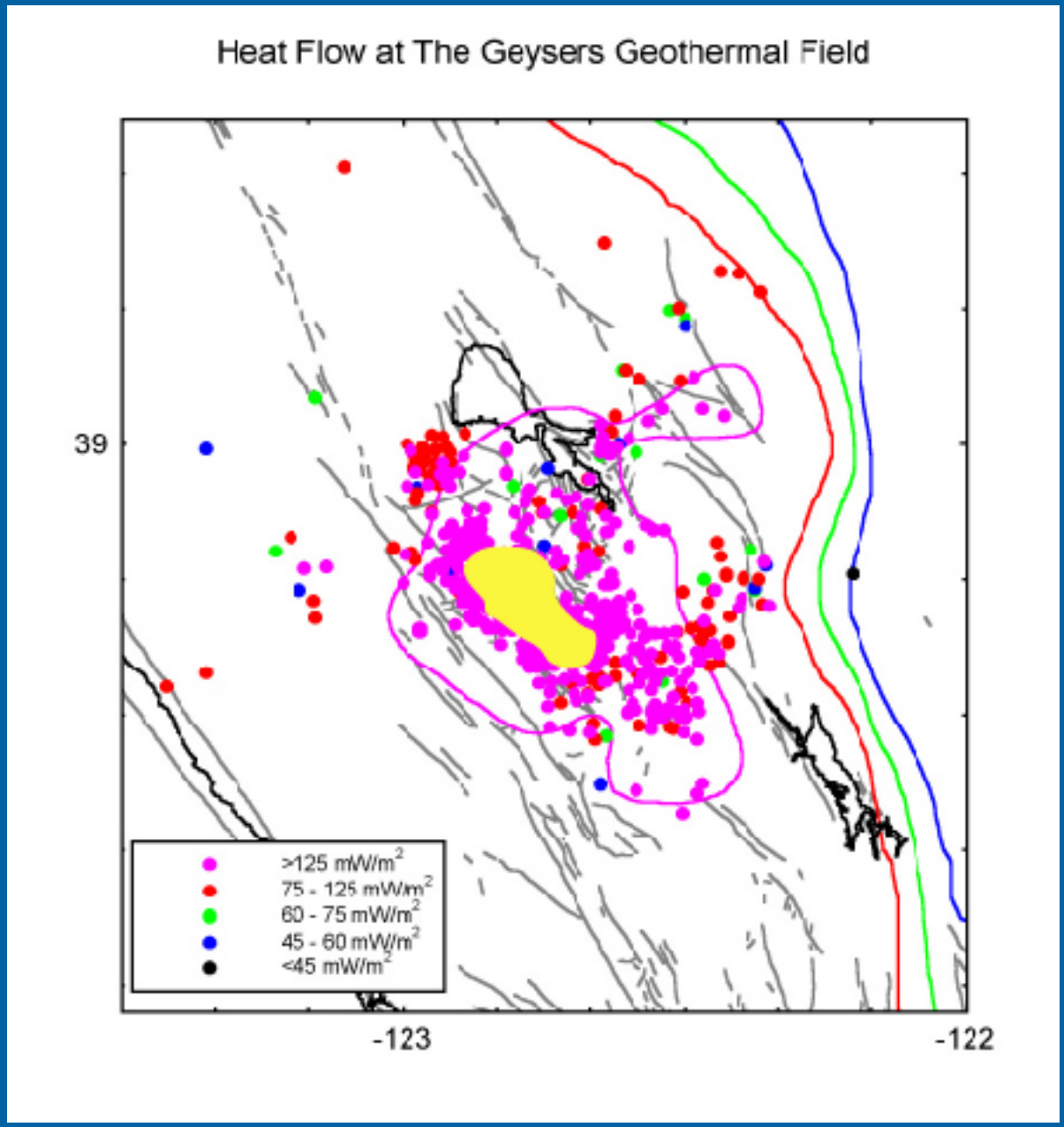
Developments and Changes

- 1970s
  1. Temperature >300°F(150 °C) and Depth <10,000ft (3 km) for power production
  2. 218 identified high temperature systems
  3. Chemical geothermometers for temperature
  4. Uncertain reservoir geometries
  5. Rough estimates of undiscovered resources
  6. Resource limited to high permeability systems

- Current
  1. Temperature ~212°F(100 °C) and Depth >10,000ft (3 km) for power production
  2. Dozens of new systems discovered
  3. Direct temperature measurements
  4. Revised reservoir geometries
  5. Quantitative estimates of undiscovered resources
  6. Enhanced Geothermal Systems (EGS)


Heat Flow at The Geysers Geothermal Field
39
-123
-122
>125 mW/m2
75 - 125 mW/m2
60 - 75 mW/m2
45 - 60 mW/m2
<45 mW/m2

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Future Directions

- Comprehensive Resource Assessments
  - Combine National, State and Local Information in a Single Coherent Product
- Confirmation of Resource
- Refined Land Use Plans
- Exploration
- Continuing Development of EGS Technology
- New and Unconventional Applications
  - Hydrogen
  - Local Use in Urban Areas


GM
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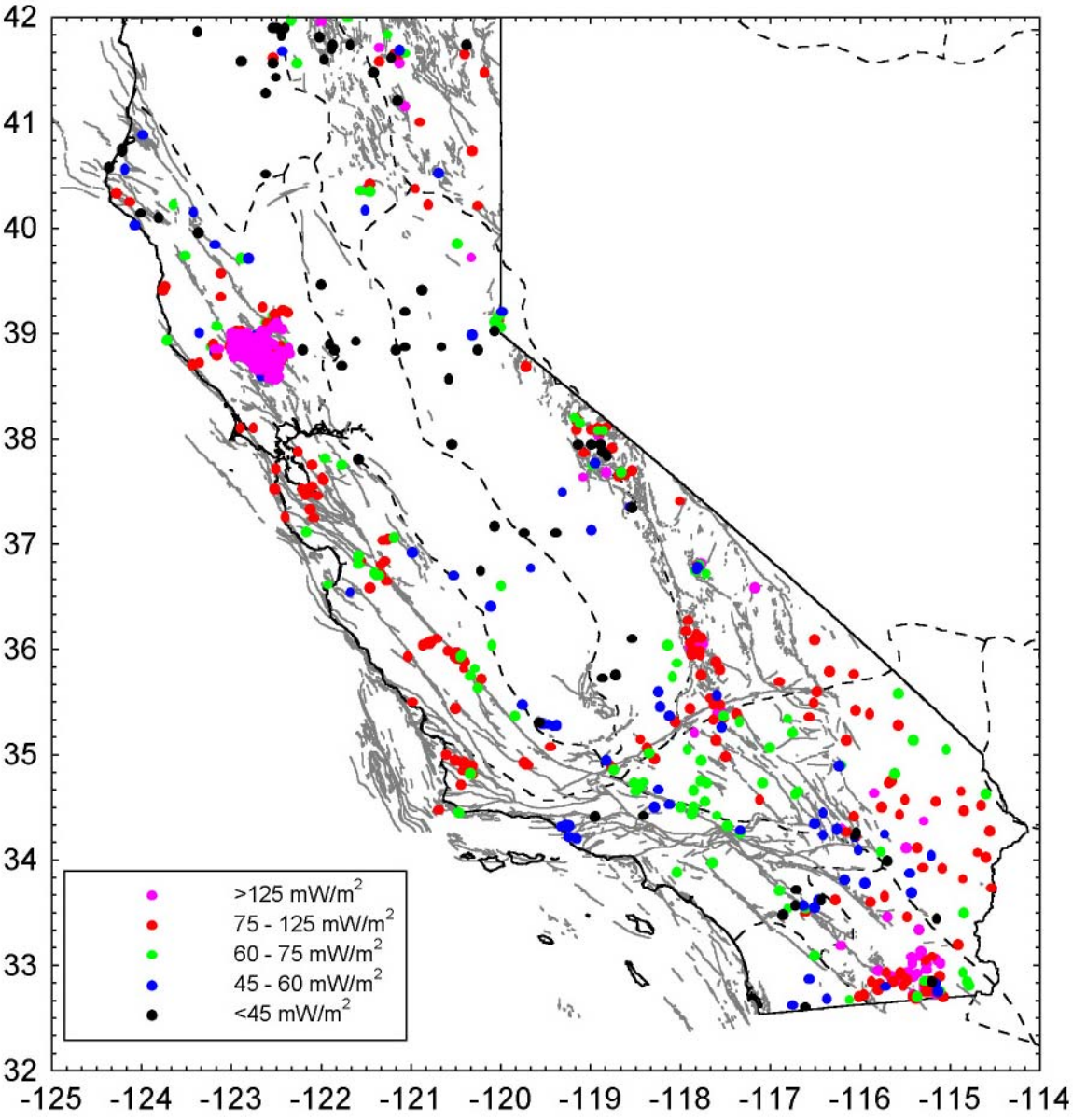
42
41
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36
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33
32
-125
-124
-123
-122
-121
-120
-119
-118
-117
-116
-115
-114
>125 mW/m2
75 - 125 mW/m2
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