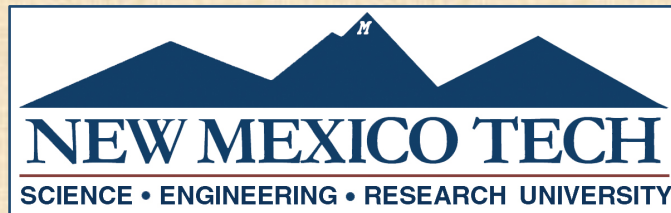


“CONTINENTAL SMOKERS”

MODELING MANTLE-TO-SURFACE HYDROLOGIC CONNECTIONS IN THE RIO GRANDE RIFT

EMILY WOOLSEY

**M. PERSON, L. CROSSEY, F. PHILLIPS,
& K. KARLSTROM**

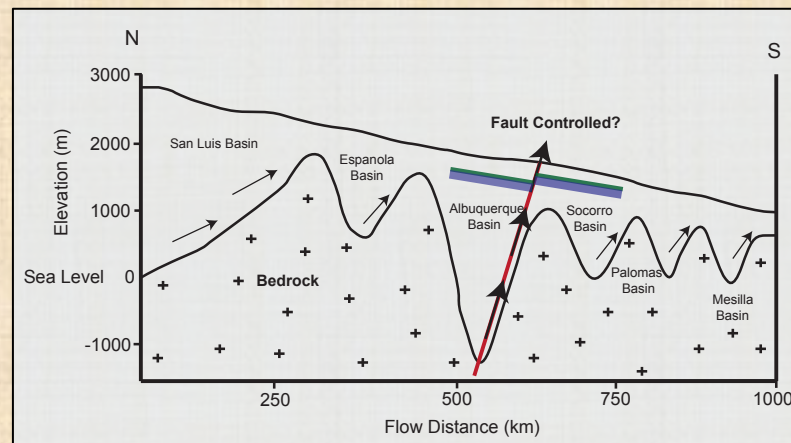


OBJECTIVE

EVALUATE THE SOURCES OF ELEVATED SALINITY
& ^3He ANOMALIES AT THE SOUTHERN
ALBUQUERQUE BASIN TERMINUS USING
MATHEMATICAL MODELING

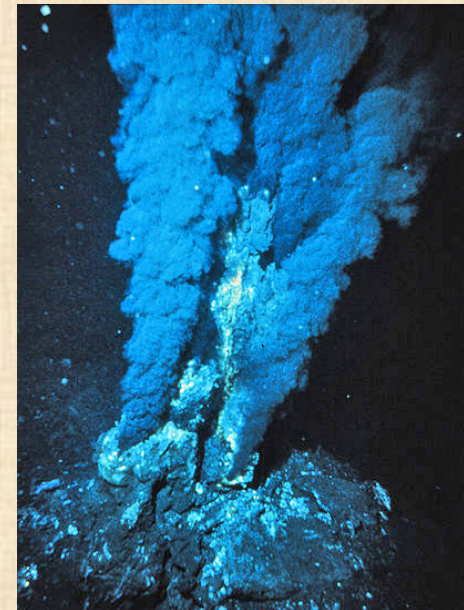
HIGH SALINITY → LESS POTABLE WATER & SMALLER
CROP YIELDS

→ UPWELLING BASIN BRINES AT
CONSTRICTION OR FAULT CONTROLLED?



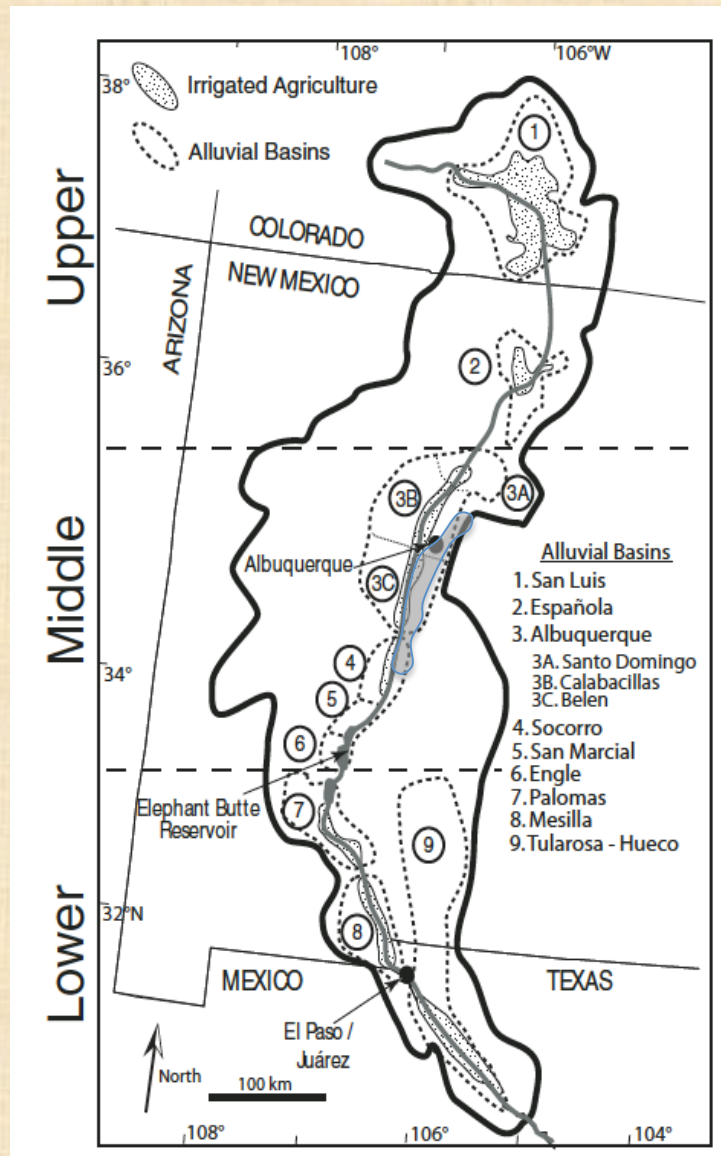
“CONTINENTAL SMOKERS”

- **FLUID VENTS**
 - TRANSPORT DEEPLY DERIVED FLUIDS TO SURFACE
 - OCCUR IN ACTIVE EXTENSIONAL ZONES
- **MANTLE VOLATILES IN RGR**
 - ^3He (PRIMORDIAL ORIGIN)
 - TRACER FOR MANTLE GAS
 - HIGHLY SALINE MANTLE FLUIDS
- **HYDROLOGIC MODEL**
 - DEEP, BASIN-SCALE
 - GEOCHEMICAL & THERMAL TRACERS
 - FLUX THROUGH CONDUIT

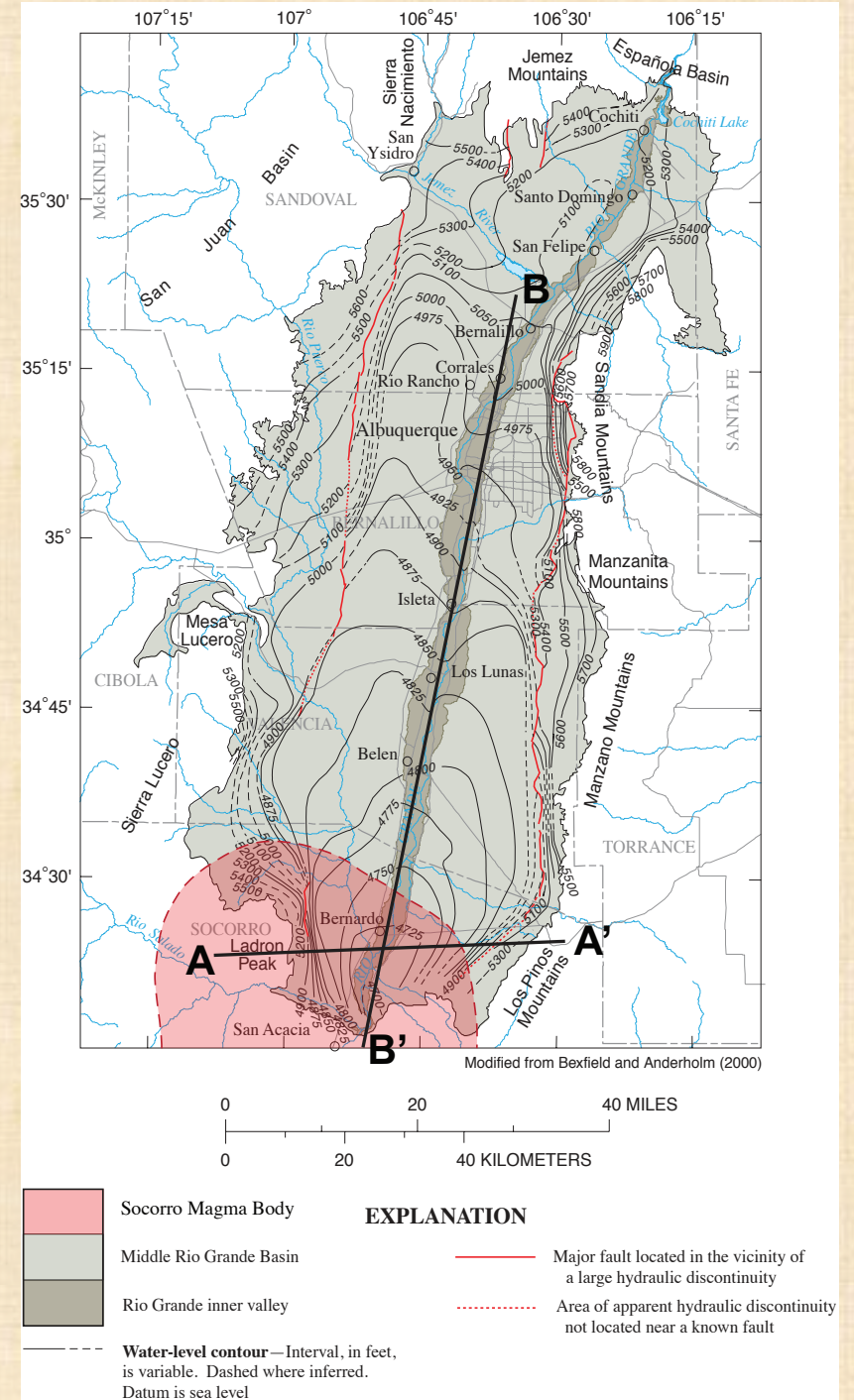


BLACK SMOKER ON MOR

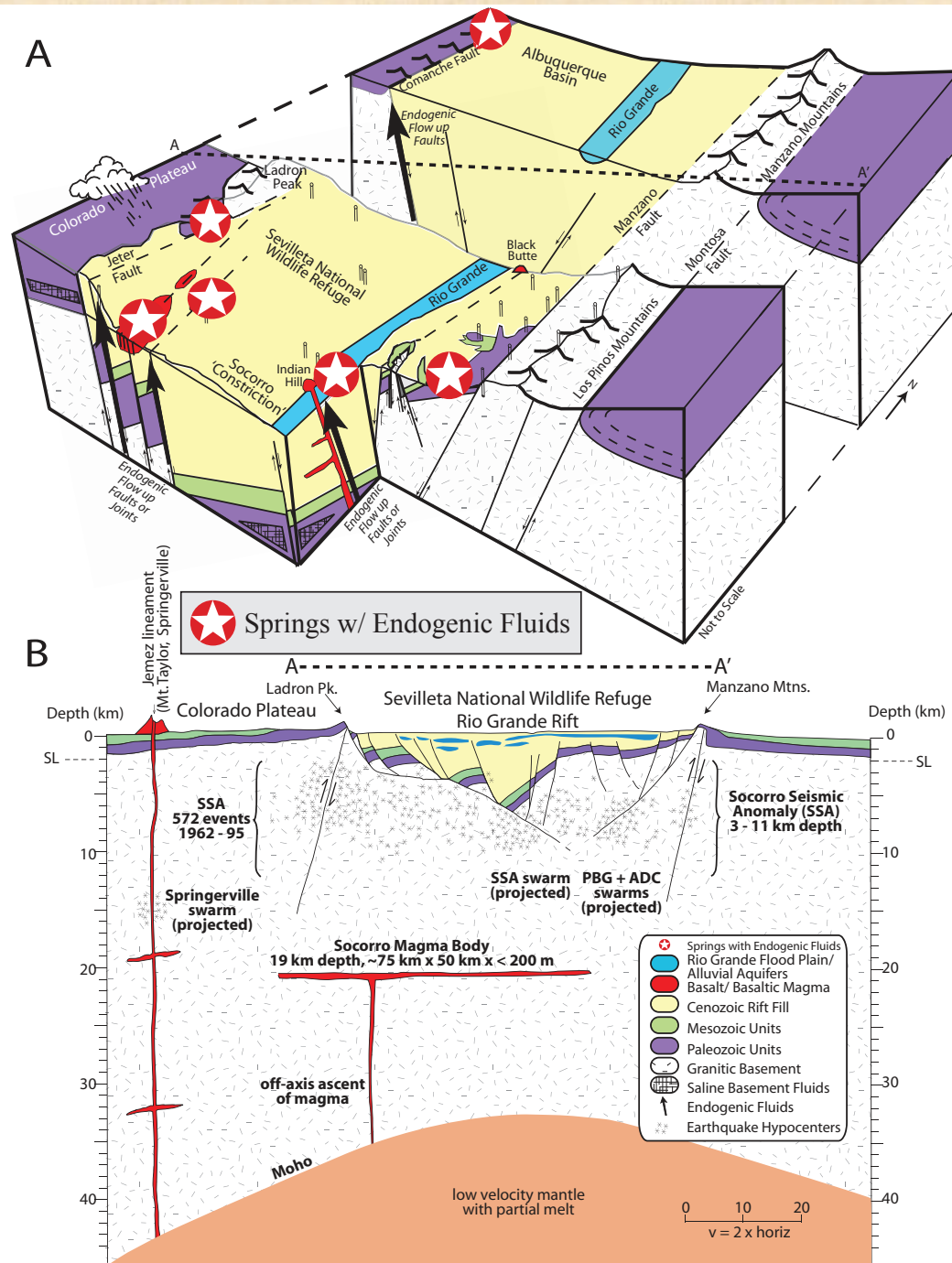
RGR BASINS



(Hogan, 2007)



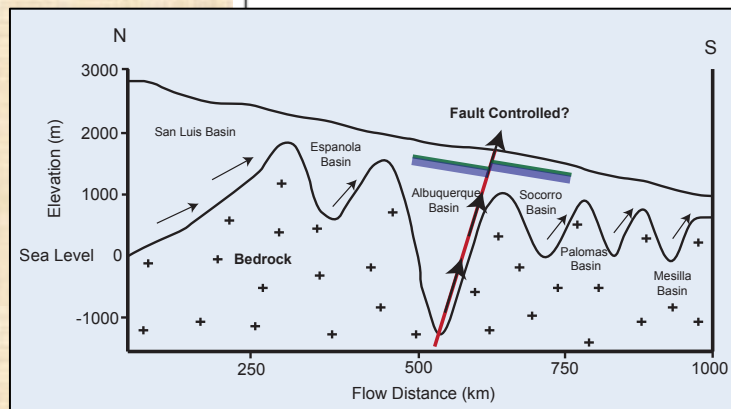
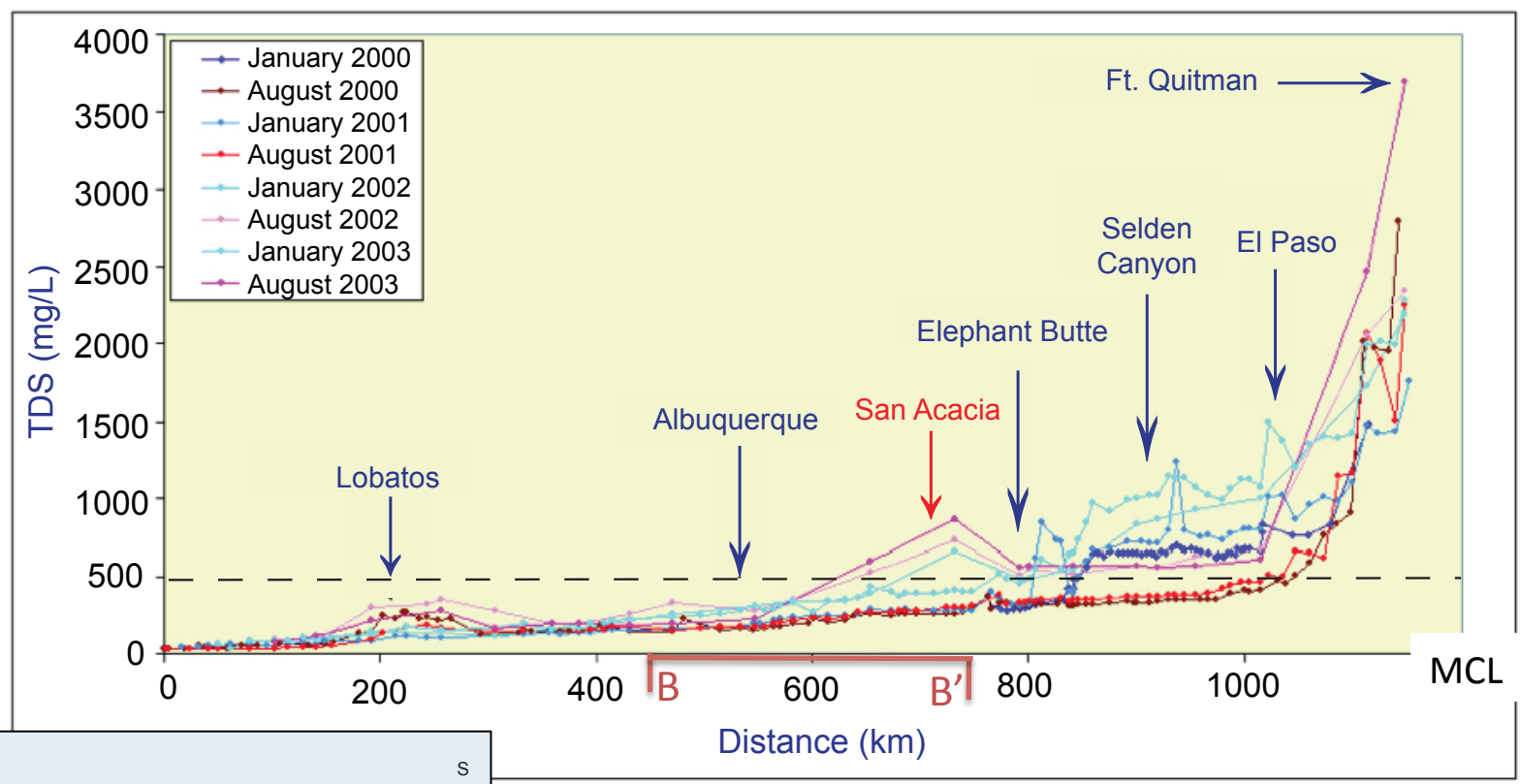
GEOLOGIC SETTING



Quaternary	Alluvium, pediment, terrace gravels, & colluvium	Cenozoic
	Riley travertine	
	Basalt Flows	
Tertiary	Sierra Ladrones Formation (sandstone & conglomerates)	Tertiary
	Popotosa Formation (sandstone & conglomerates)	
	Datil Group (volcaniclastics)	
	Baca Formation (arkosic sandstone)	
	Crevasse Canyon Formation (sandstone w/ coal members)	
Cretaceous	Gallup Sandstone	Mesozoic
	Dakota Sandstone	
	Chinle Formation (red mudstones w sandstone)	
Triassic	San Andres Limestone	Paleozoic
Permian	Glorietta Sandstone	
	YESO FM	
Pennsylvanian	Abo Formation (red sandstone w/ mudstones)	Sedimentary
	Bursum Formation (shale, limestone)	
	Madera Group (limestone, lower shale)	
Precambrian	Sandia Formation (clastic Sandia granite)	Precambrian
	Igneous & Metamorphic rocks	

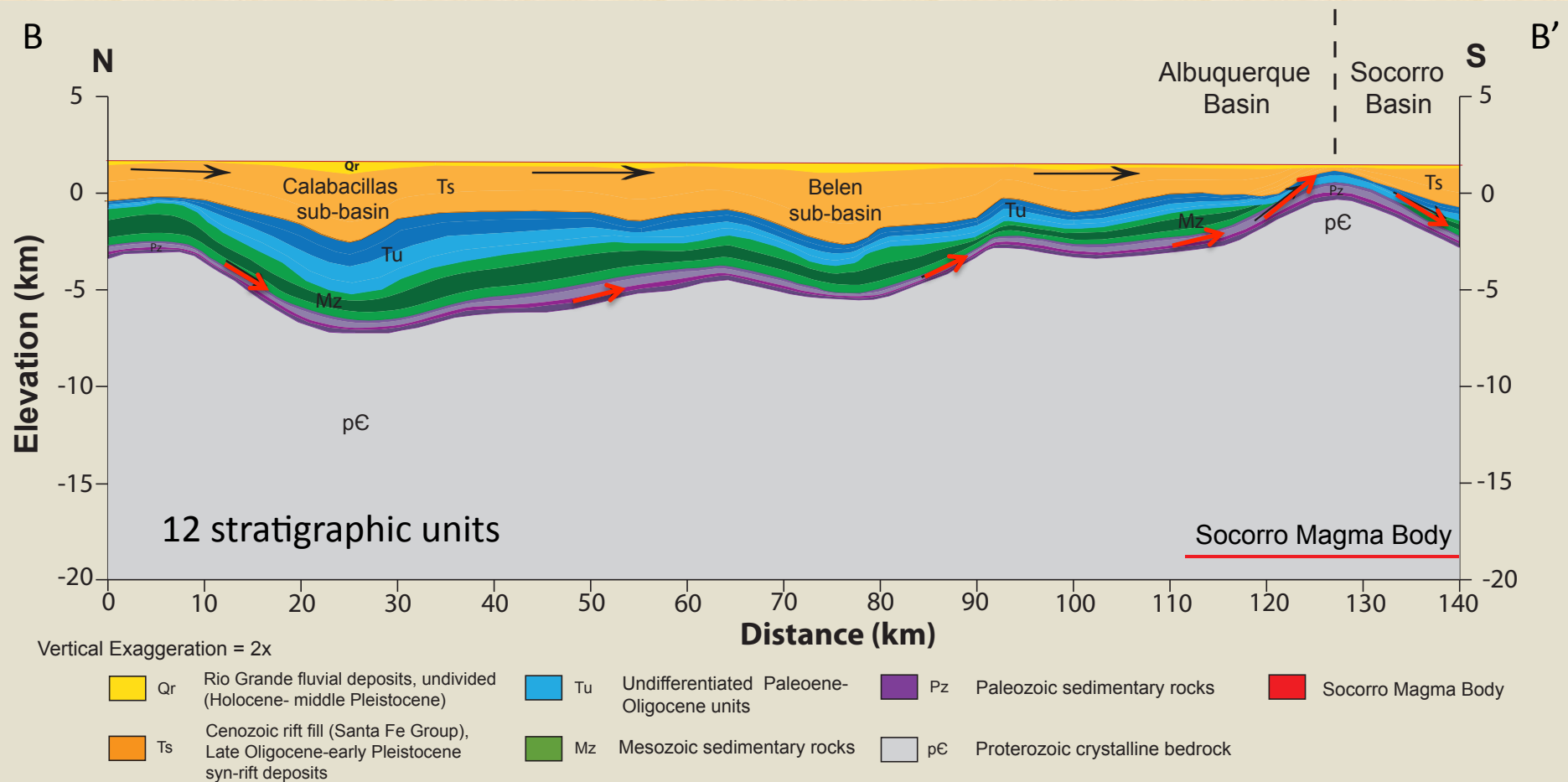
Williams et al., [in prep]

RIO GRANDE SALINITY INCREASE



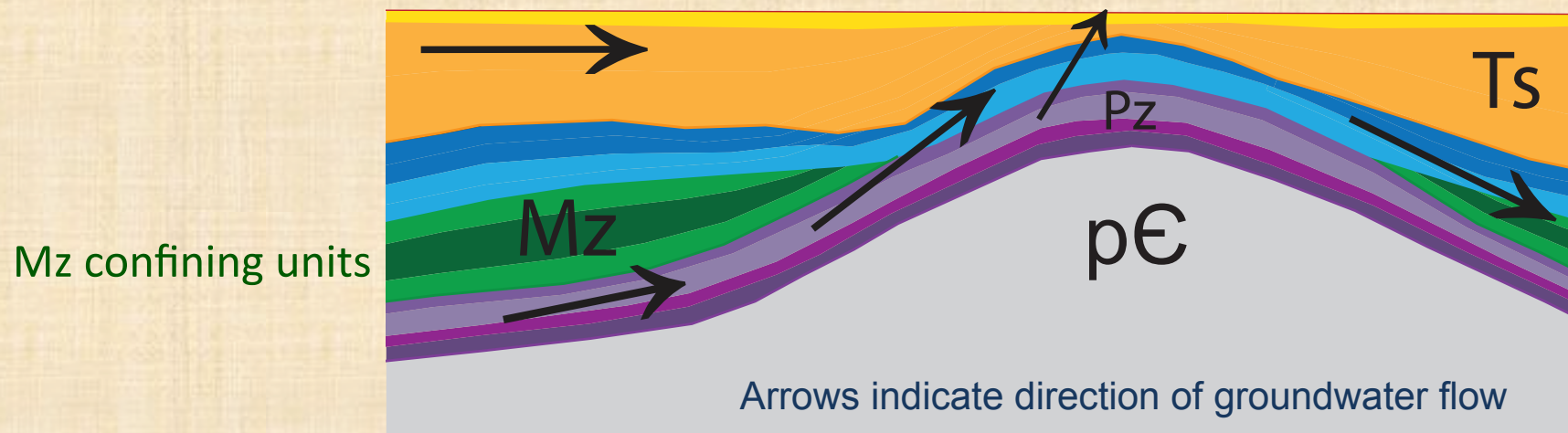
Modified from (Newton, 2004)

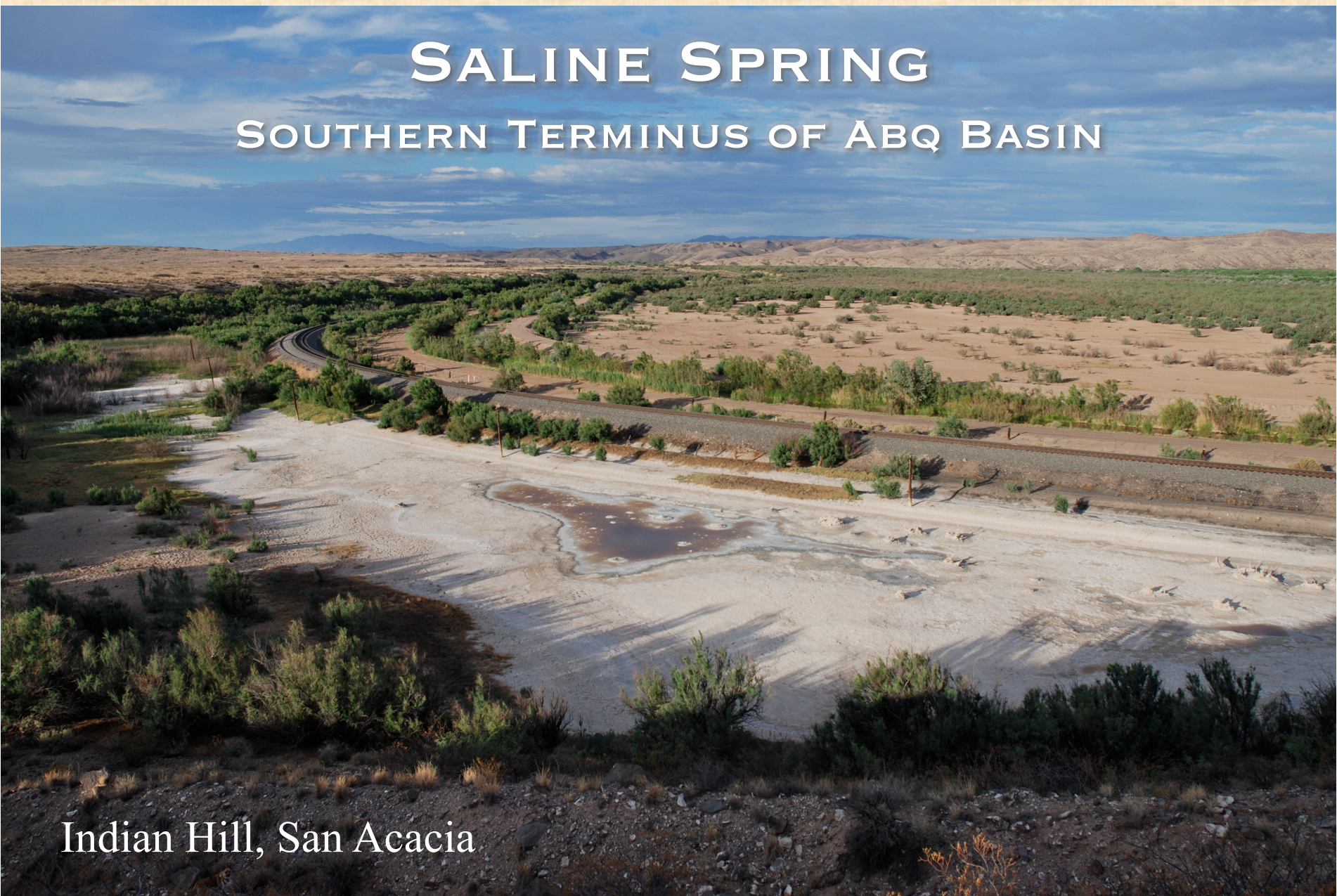
GROUNDWATER CIRCULATION



Arrows indicate direction of groundwater flow

HYDROLOGIC WINDOW





SALINE SPRING

SOUTHERN TERMINUS OF ABQ BASIN

Indian Hill, San Acacia

WATER CHEMISTRY ANALYSIS

Supersaturated w/ respect to
gypsum (Ca-SO_4)

Ca: 500 mg/L
 SO_4 : 7,000 mg/L

Elevated levels:

(Concentration through
evaporation)

CO_2 , trace metals

Cl: 32,000 mg/L

Na: 27,000 mg/L

~ 20 TDS (ppt)

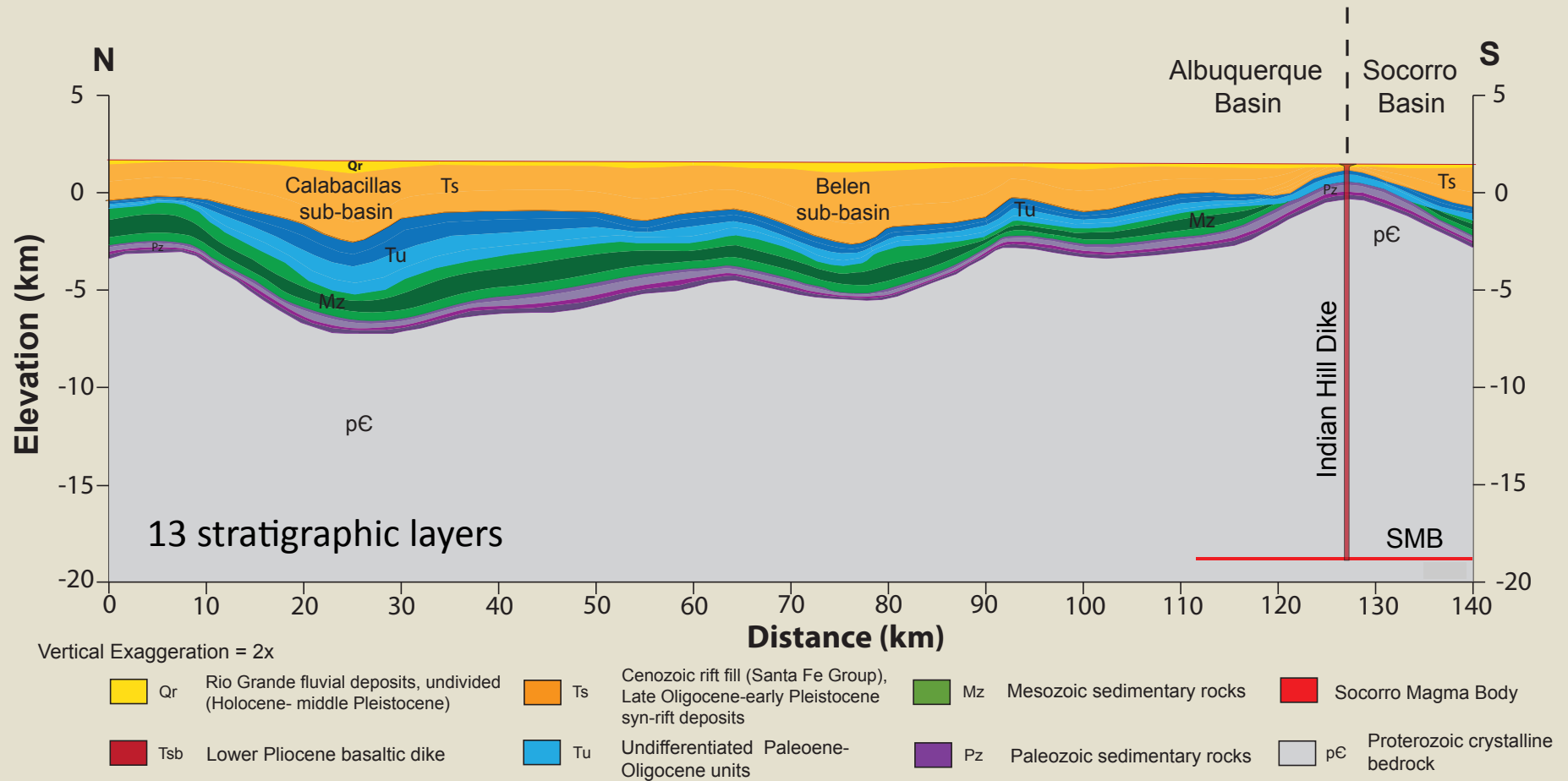
→ $^3\text{He}/^4\text{He}$ ratio: 0.26 R/R_A

Crustal (radiogenic) $\text{R/R}_A \sim 0.02 \pm 0.01$

Mantle component $\text{R/R}_A > 0.1$

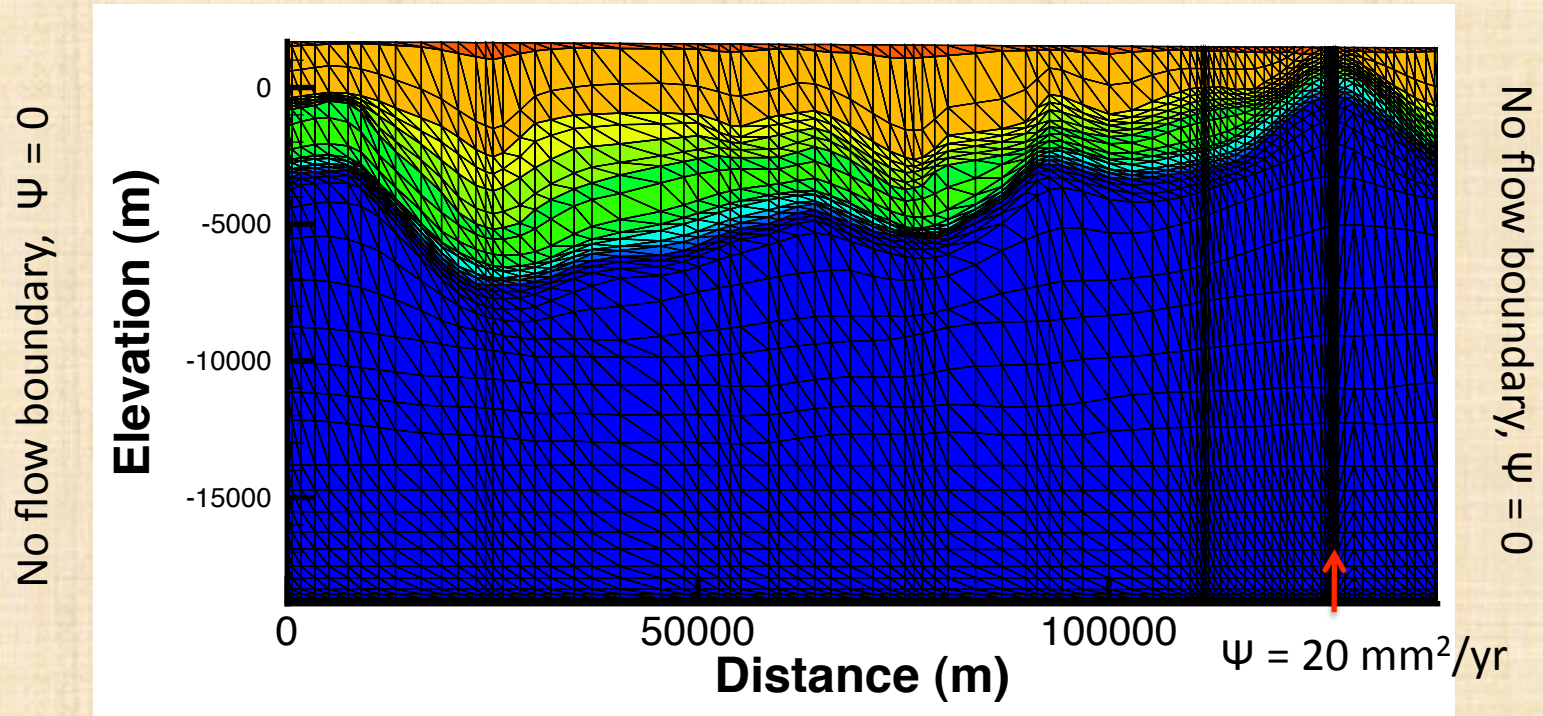
Williams et al., [in prep]

ALTERNATE HYPOTHESIS: DIKE CONDUIT



BOUNDARY CONDITIONS

Topography driven flow system: surface head based on water table elevation



Basal heat flux 80 mW/m^2

$^3\text{He}/^4\text{He} = 8 R_A$ applied at base

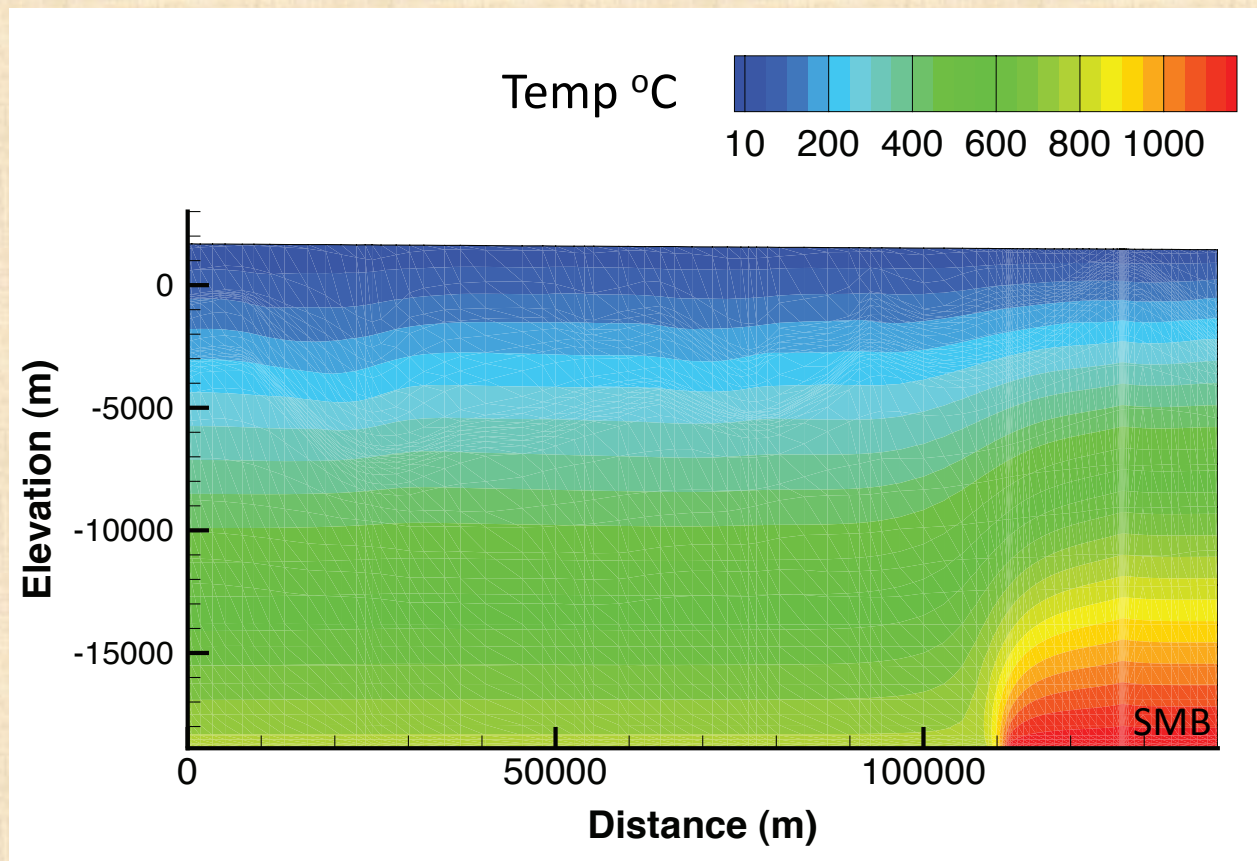
Initial TDS gradient = 1.15 ppt/km

Initial Geothermal Gradient = 40°C/km

TEMPERATURE

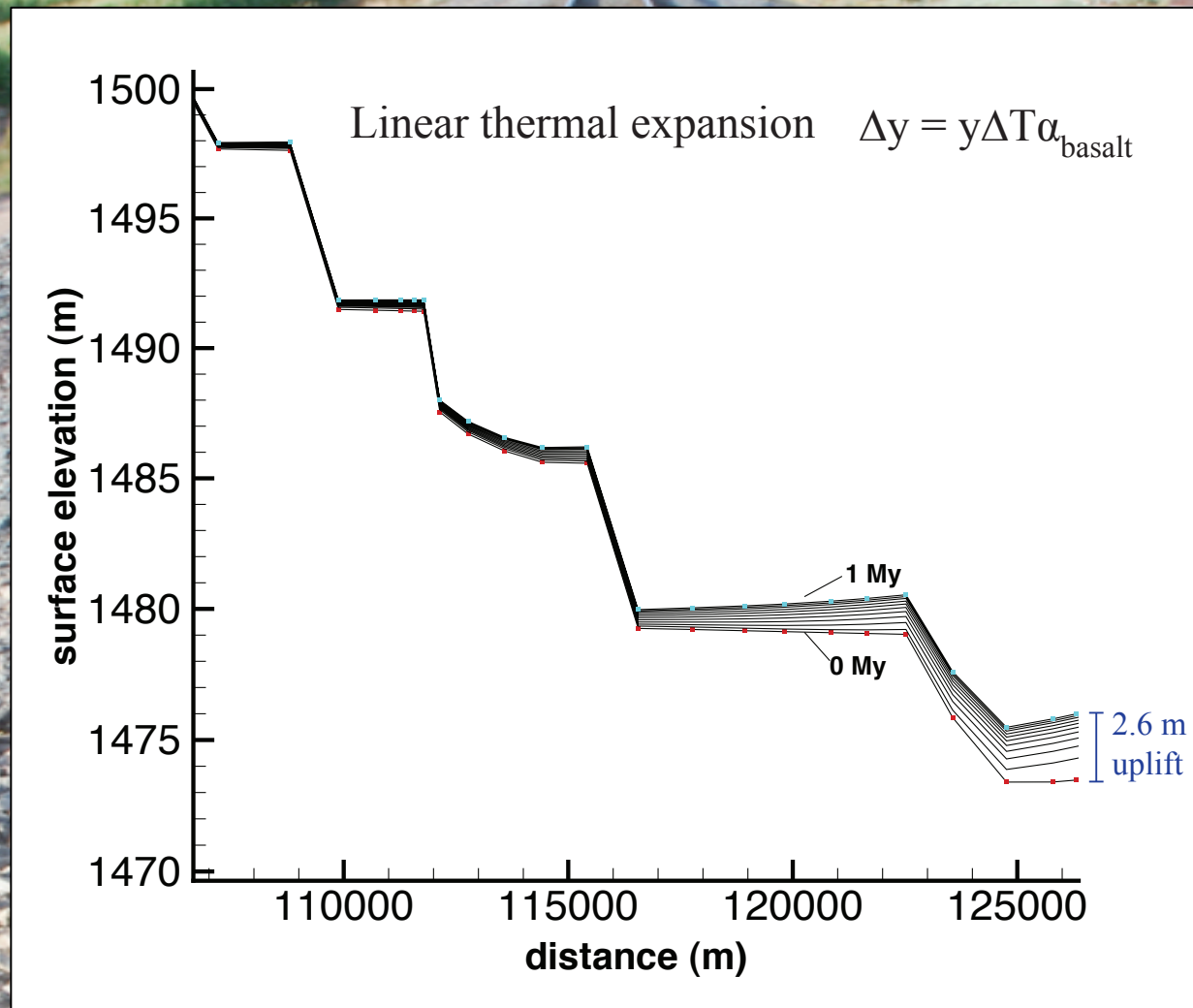
1 MILLION YEAR SIMULATION

Initial Geothermal Gradient = $40^{\circ}\text{C}/\text{km}$



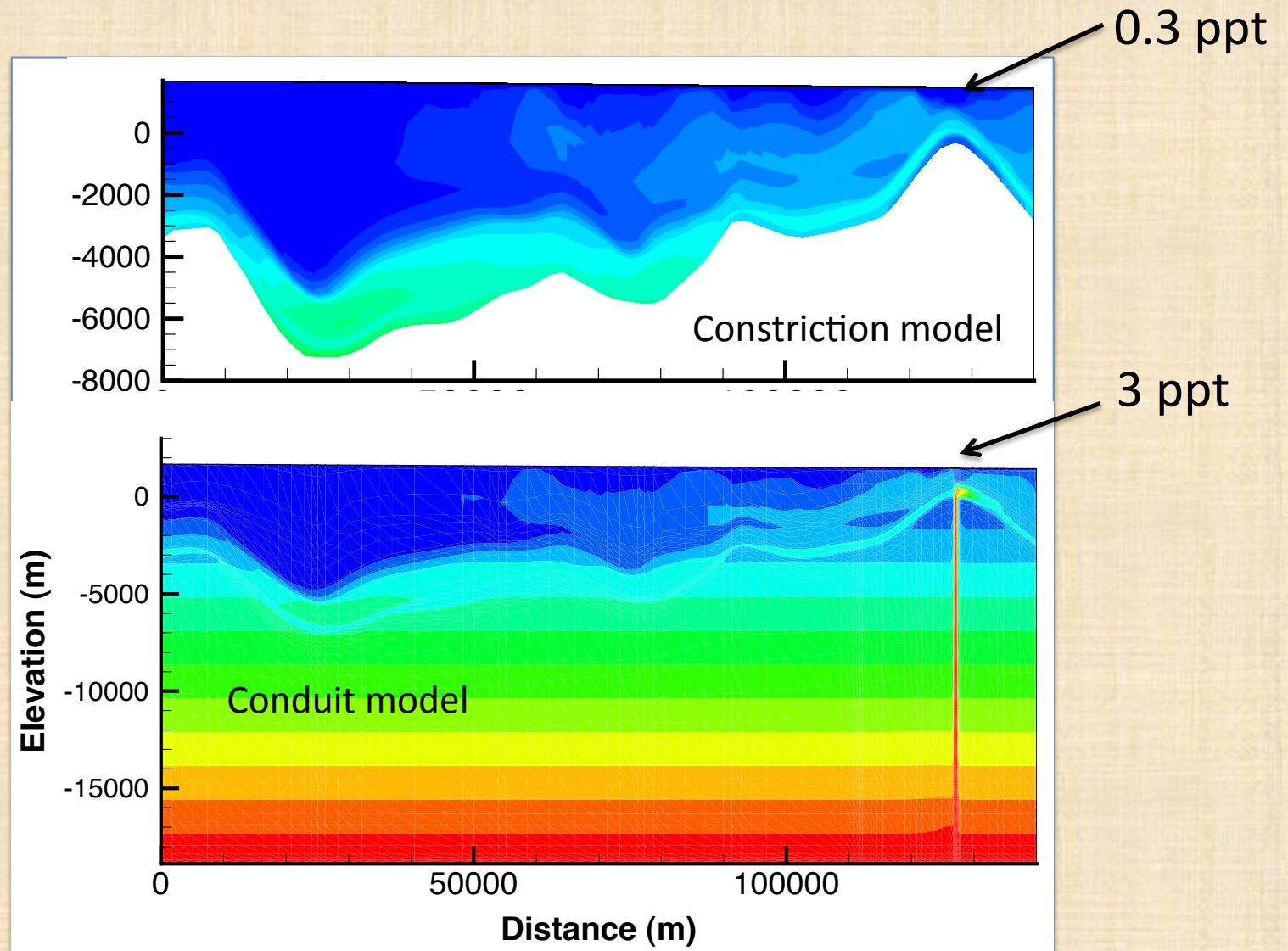
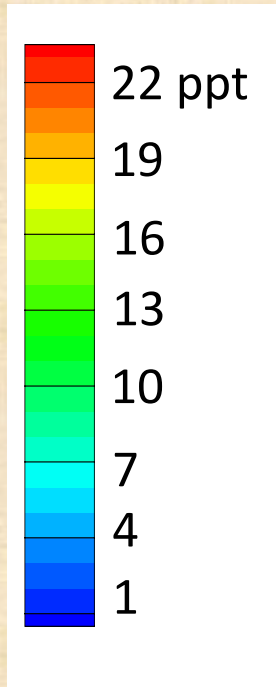
* $T = 1200^{\circ}\text{C}$ at SMB (continuously injecting)

UPLIFT 1 MILLION YEAR SIMULATION



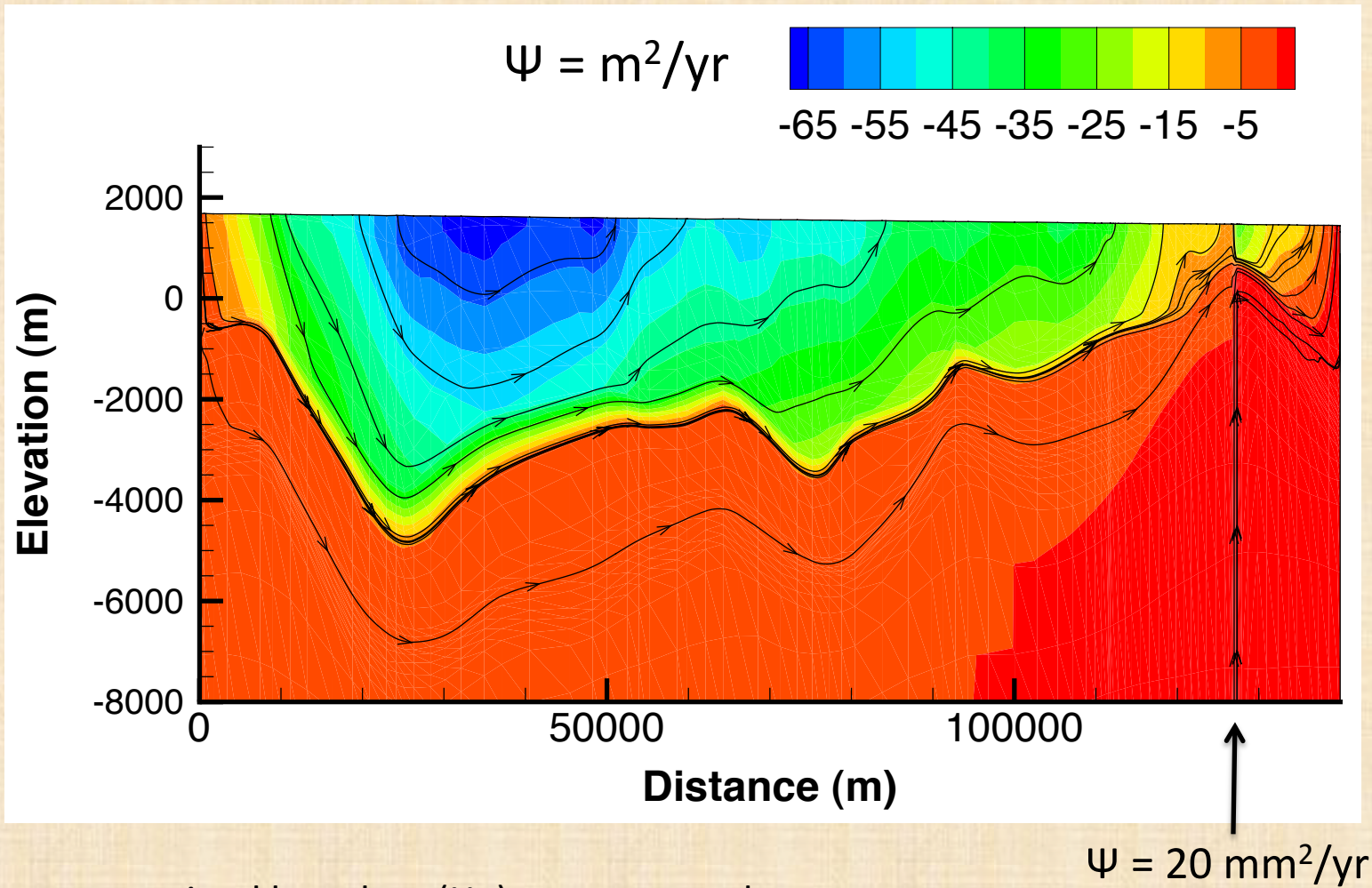
BRINE CONCENTRATION

1 MILLION YEAR SIMULATION



STREAMLINES

1 MILLION YEAR SIMULATION



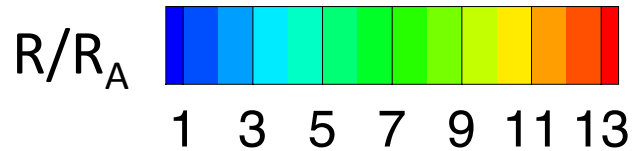
Flux rate constrained by solute (He) transport and temp.

HELIUM ISOTOPES

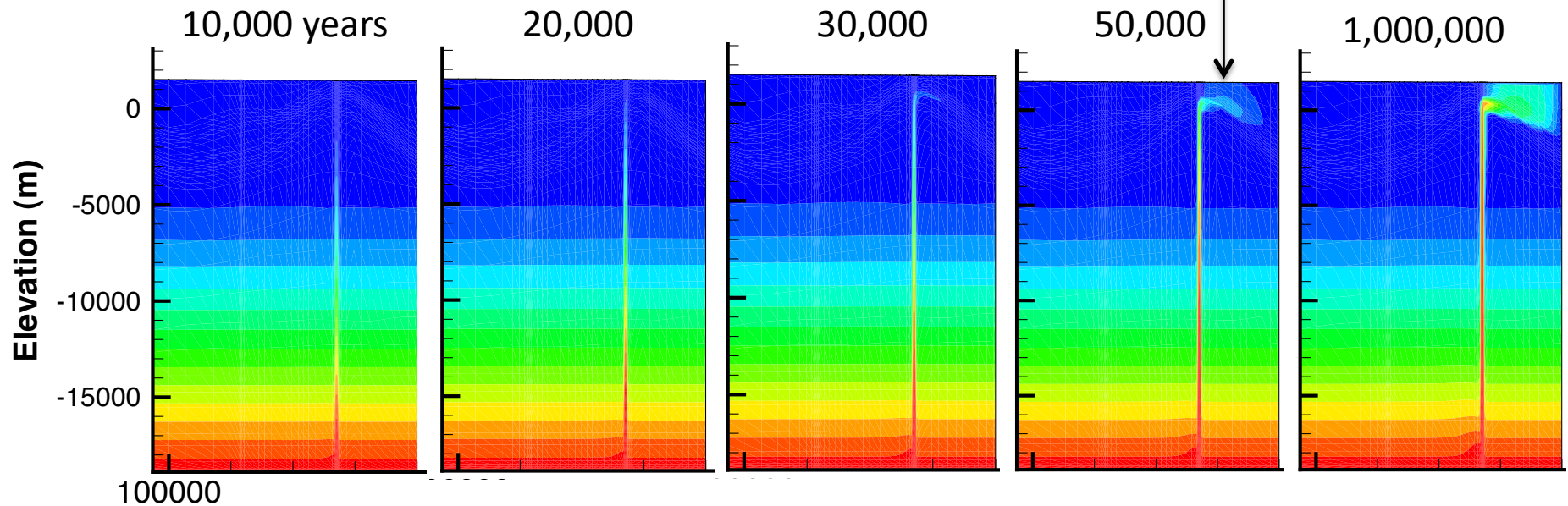
1 MILLION YEAR SIMULATION

Crustal (radiogenic) $R/R_A \sim 0.02 \pm 0.01$
Mantle component $R/R_A > 0.1$

$$\frac{R}{R_A} = \frac{\frac{{}^3\text{He}}{{}^4\text{He}}_{\text{sample}}}{\frac{{}^3\text{He}}{{}^4\text{He}}_{\text{atmosphere}}} = \frac{{}^3\text{He}}{{}^4\text{He}}_{\text{sample}} \frac{1}{1.4 \times 10^{-6}}$$



$0.87 R/R_A$



CONCLUSIONS

- Salinity and ^3He anomalies at basin boundary are related
- Deep and permeable conduit system/fault zone necessary in advective transport of ^3He to the surface
- Highly saline mantle fluids mixing with deep sedimentary basin brines to account for salinity increase in Rio Grande

FUTURE WORK

- **CONSTRAIN AGE OF SMB EMPLACEMENT**
- **FIELDWORK IN SAN ACACIA**
 - Distributed temperature sensing (DTS) experiment
 - Collect T data and water samples along transect of Rio Grande at basin boundary
 - Looking for spike/drop in T that correlates with high salinity to identify seepage locations

