Ventura Basin Oil Generation, Timing, Migration, and Entrapment*

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Abstract

In the Ventura Basin large volumes of oil and gas are now being generated in Miocene Monterey-Modelo source rocks and are actively migrating into numerous high-relief Late Quaternary shortening structures. These structures contain much of the oil and gas found so far. Today's western Ventura basin kitchen is big and generation rates there are high. In contrast, the eastern kitchen is divided into areally small generating synclines and presently growing anticlines whose uplift is shutting off previously generative source rock.

During Pliocene-Miocene time the basin was wide and simply structured. Hydrocarbons generated at that time followed migration paths different from those of today. In the east, low-relief growing anticlines directed and trapped this early-generated oil. In the west, much oil was generated, but few anticlines were available to fill, so mainly early-formed stratigraphic or fault-related pools were present.

Fetch areas and migration shadows have controlled oil field size and distribution through time. For example, the present-day fetch area for the Ventura-San Miguelito-Rincon Anticlinorium is large; this structure contains the largest oil accumulation in the basin. In contrast, the huge Quaternary Pico Anticline in the eastern Ventura Basin is almost dry because it is now partly migration shadowed behind the Newhall-Potrero Anticline and also because in much of the basinal area downdip of the anticline the source rock was spent prior to anticlinal growth. Much of the southern flank of the basin is presently migration shadowed because of the Quaternary development of the Oak Ridge Anticlinorium. The oil fields in this migration shadow were probably charged before the anticlinorium formed.

The western basin contains the largest oil fields not only because of its large kitchen areas and large structures but also because Monterey-Modelo source rock facies are rich there. Furthermore, faults have facilitated upward migration into thick numerous Pliocene deepwater sand reservoirs. One reason why eastern fields are smaller is because source facies there are leaner, having been diluted by clastics shed from nearby San Gabriel basement complex highlands. Additionally, many faults in the east die out upward within Miocene strata so are unavailable to aid cross-stratal migration into younger sands.

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Oil Generation, Timing, Migration, and Entrapment in Ventura Basin, California

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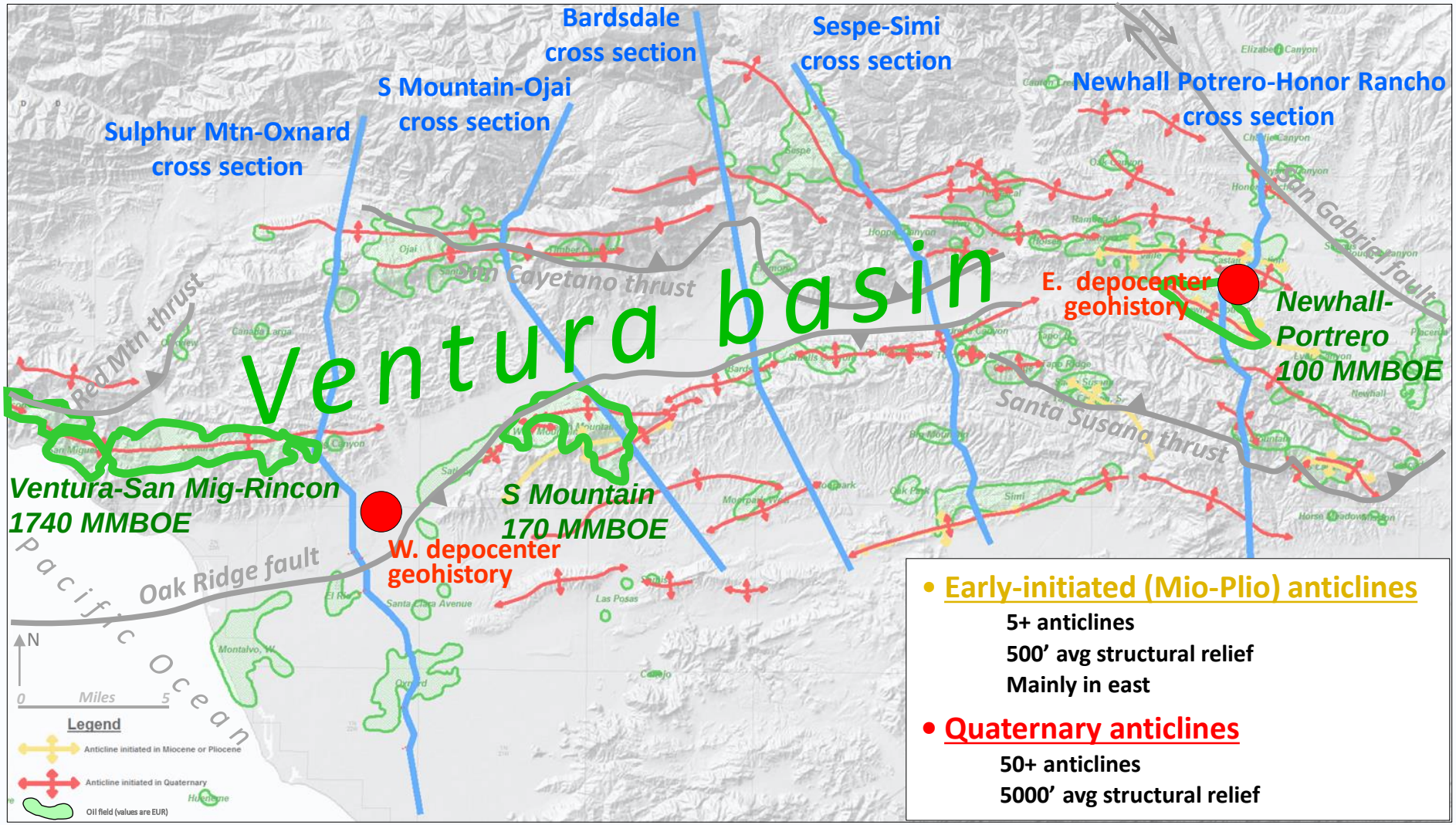
Recent Ventura basin drilling

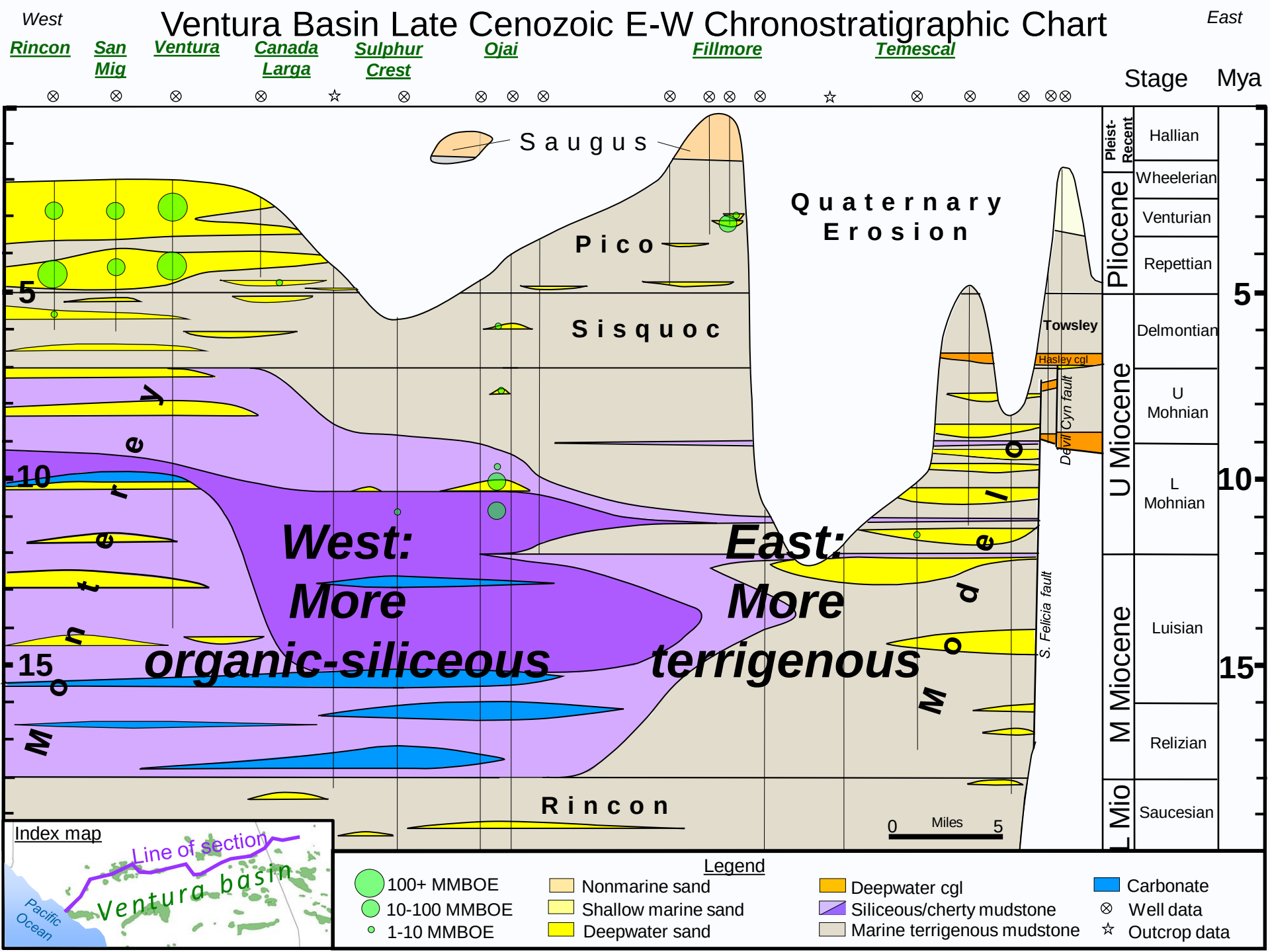
CONCLUSIONS

- Neogene basin evolution has been dramatic
  - Wide, simple, and extensional through most of Miocene
  - Mild folding in latest Miocene-Pliocene, concentrated in east
  - Narrow and strongly shortened now
- Monterey (called Modelo in eastern basin) is the source rock
- Western basin
  - Bigger fields
  - Richer source rocks
  - Pliocene sands are main producers
  - Mostly late-charged structures
  - Migration up and across faults is crucial
- Eastern basin
  - Smaller fields
  - Leaner source rocks
  - Coarse clastics predominate
  - Miocene sands are main producers
  - Early-charged structures common
  - Late uplift of source rocks is slowing generation over much of the area
- Migration shadowing makes large parts of the basin dry

Ventura Basin Faults, Anticlines, and Oil Fields

Dramatic Quaternary shortening of widespread Miocene basin




West
East
Ventura Basin Late Cenozoic E-W Chronostratigraphic Chart
Rincon
San Mig
Ventura
Canada Larga
Sulphur Crest
Ojai
Fillmore
Temescal
Stage
Mya
Saugus
Pico
Sisquoc
Monterey
Quaternary Erosion
Towsley
Hasley cgl
Devil Cyn fault
S. Felicia fault
Modelo
Rincon
West: More organic-siliceous
East: More terrigenous
5
10
15
Pleist-Recent
Hallian
Pliocene
Wheelerian
Venturian
Repettian
U Miocene
Delmontian
U Mohnian
L Mohnian
M Miocene
Luisian
Relizian
L Mio
Saucesian
0 Miles 5
Index map
Line of section
Ventura basin
Pacific Ocean
Legend
100+ MMBOE
10-100 MMBOE
1-10 MMBOE
Nonmarine sand
Shallow marine sand
Deepwater sand
Deepwater cgl
Siliceous/cherty mudstone
Marine terrigenous mudstone
Carbonate
Well data
Outcrop data

Monterey Formation Is the Dominant Source Rock

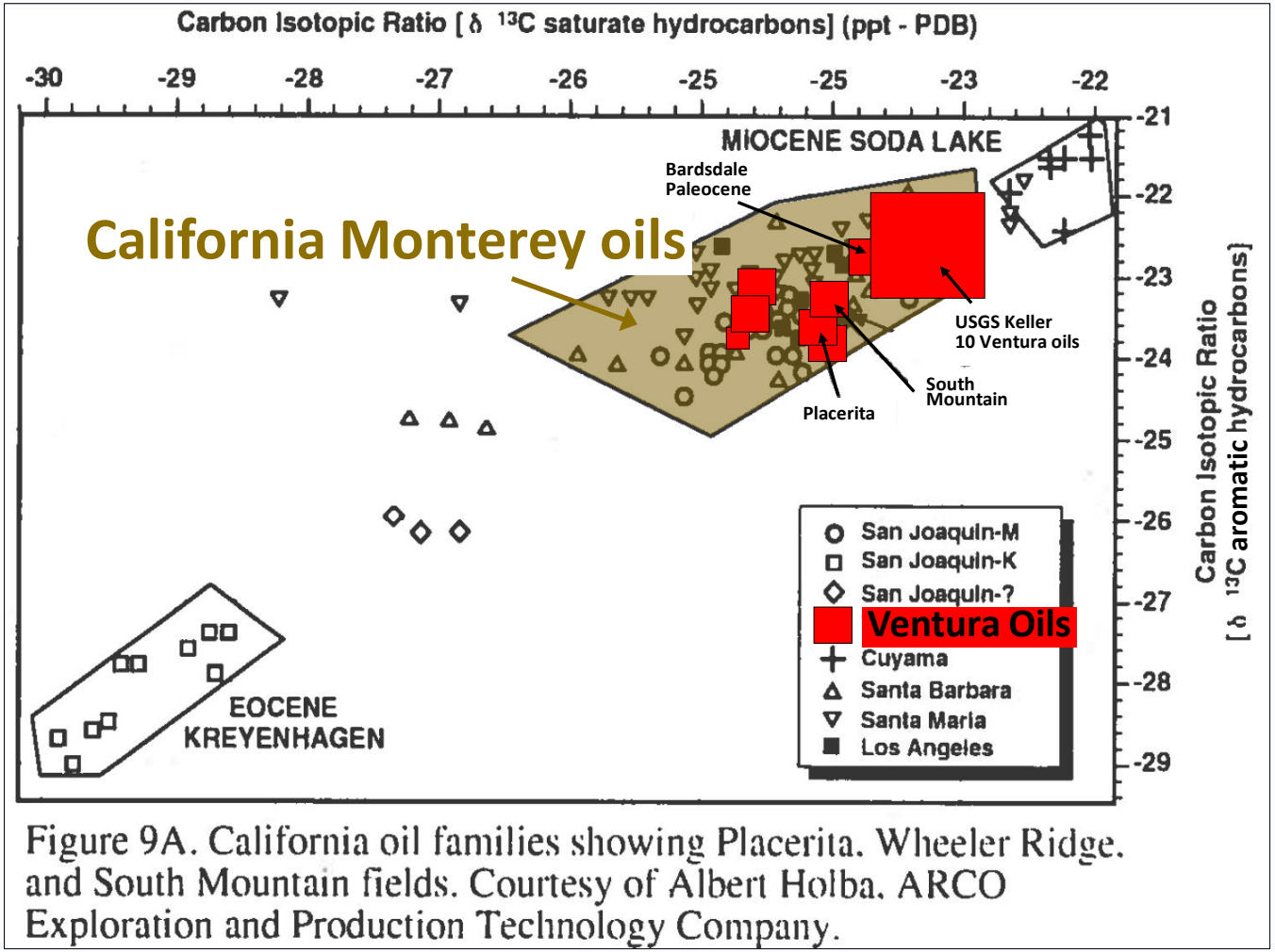
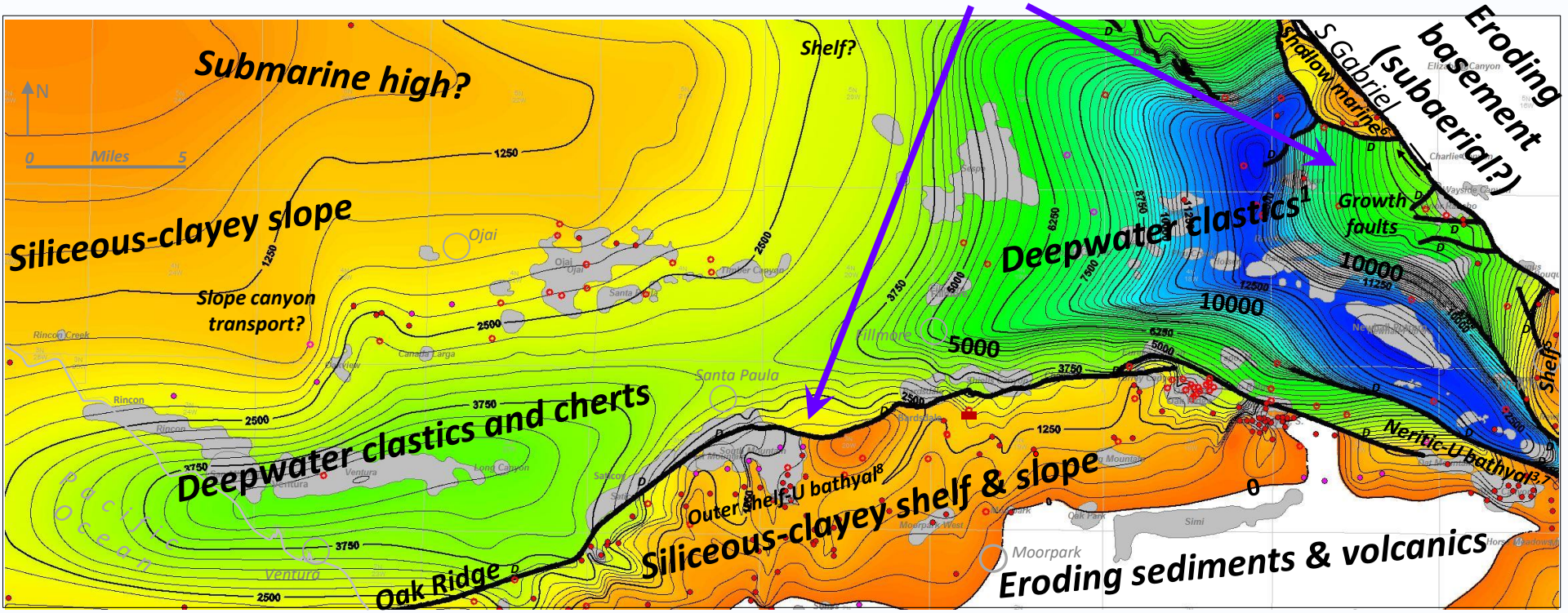


Figure 9A. California oil families showing Placerita, Wheeler Ridge, and South Mountain fields. Courtesy of Albert Holba, ARCO Exploration and Production Technology Company.

Modified rom Davis et al. (1996).

Ventura Basin Monterey Gross Isopach

Normal faults active during Monterey deposition

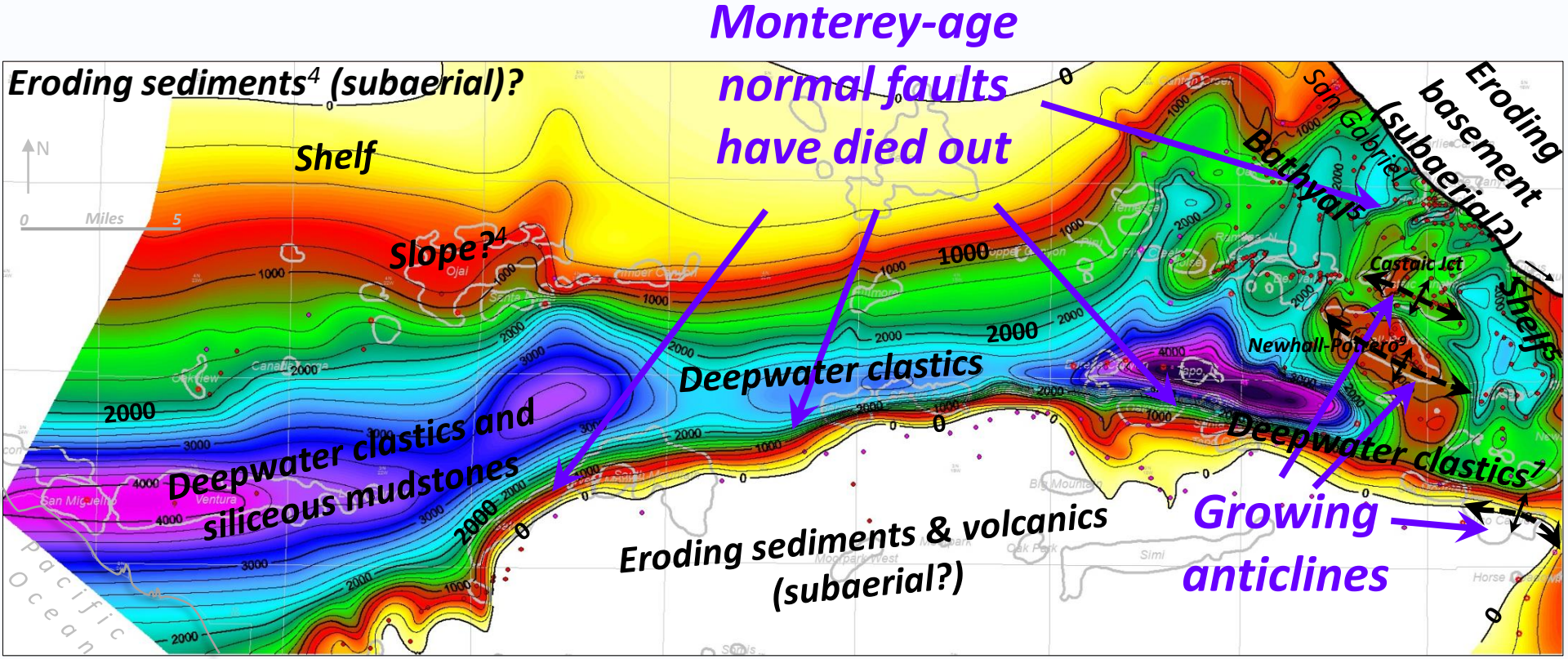


Legend

- Well data: highly constraining points are solid (mostly full penetrations), less constraining points (mostly partial penetrations) are open
- Outcrop data: highly constraining points are solid, less constraining points are open
- D — Growth fault showing downthrown side
- Oil field

TST feet; Monterey includes Relizian, Luisian, and Mohnian strata; restored for early Pliocene and Quaternary erosion; Quaternary shortening not restored. Superscript denotes reference cited.

Delmontian Gross Isopach

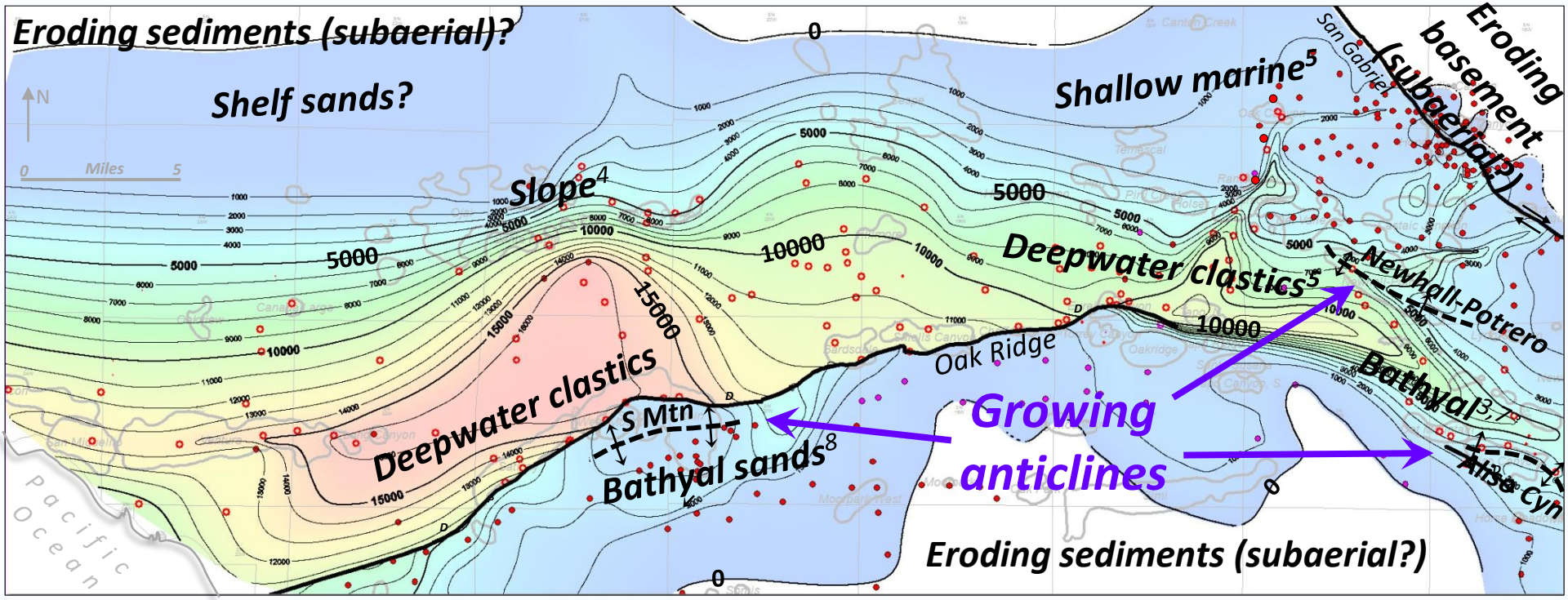


Legend

- Well data: highly constraining points are solid (mostly full penetrations), less constraining points (mostly partial penetrations) are open
- Outcrop data: highly constraining points are solid, less constraining points are open
- Sand transport
- Delmontian growth anticline
- Oil field

TST feet; Includes Sisquoc, Santa Margarita, and Towsley Formations; restored for early Pliocene and Quaternary erosion; Quaternary shortening not restored. Superscript denotes reference cited.

Pico Gross Isopach



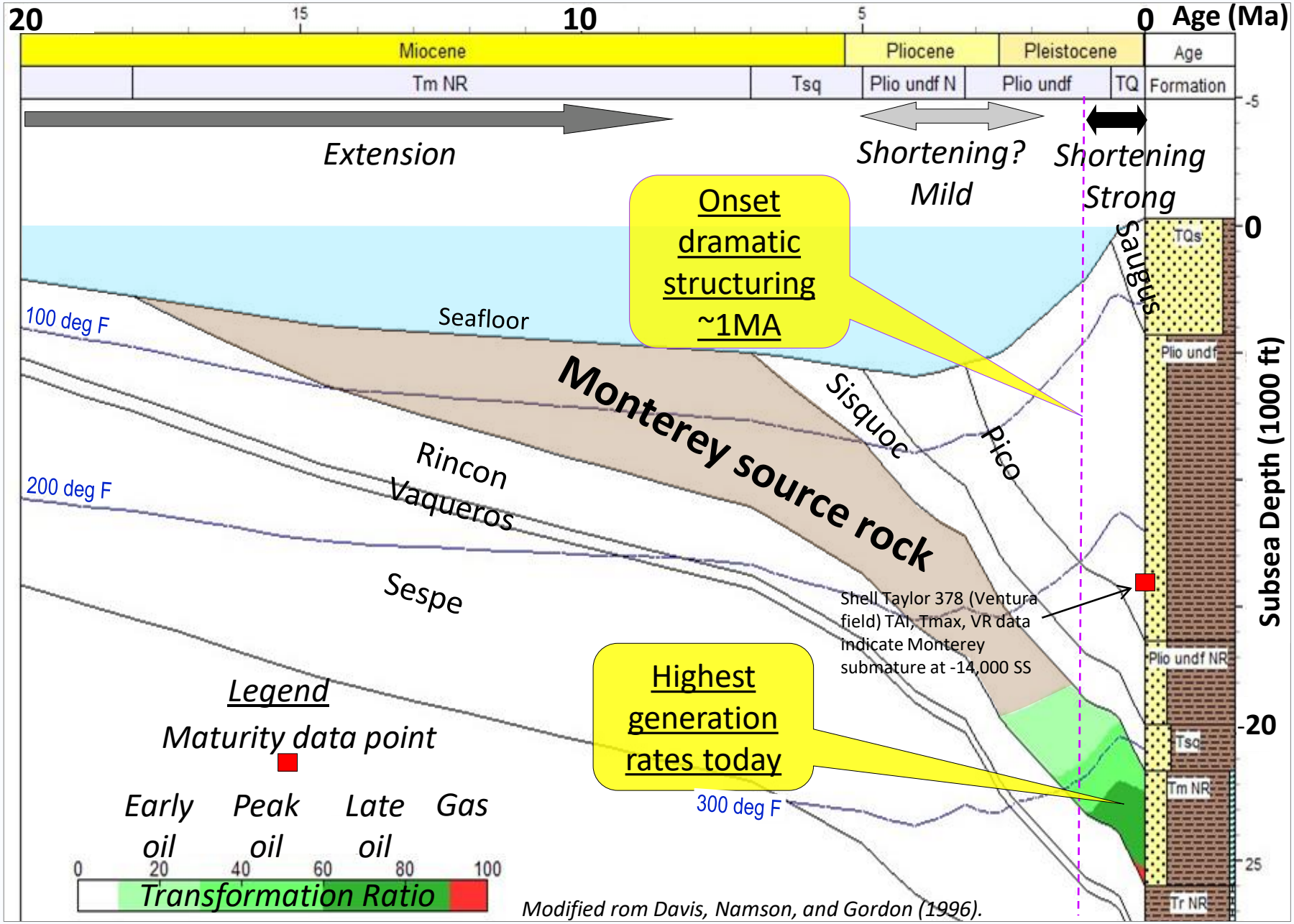
Legend

- Well data: highly constraining points are solid (mostly full penetrations), less constraining points (mostly partial penetrations) are open
- Outcrop data: highly constraining points are solid, less constraining points are open
- Sand transport
- Pico growth anticline
- Oil field
- Downthrown side of normal growth faults

TST feet; restored for early Pliocene and Quaternary erosion; Quaternary shortening not restored. Superscript denotes reference cited.

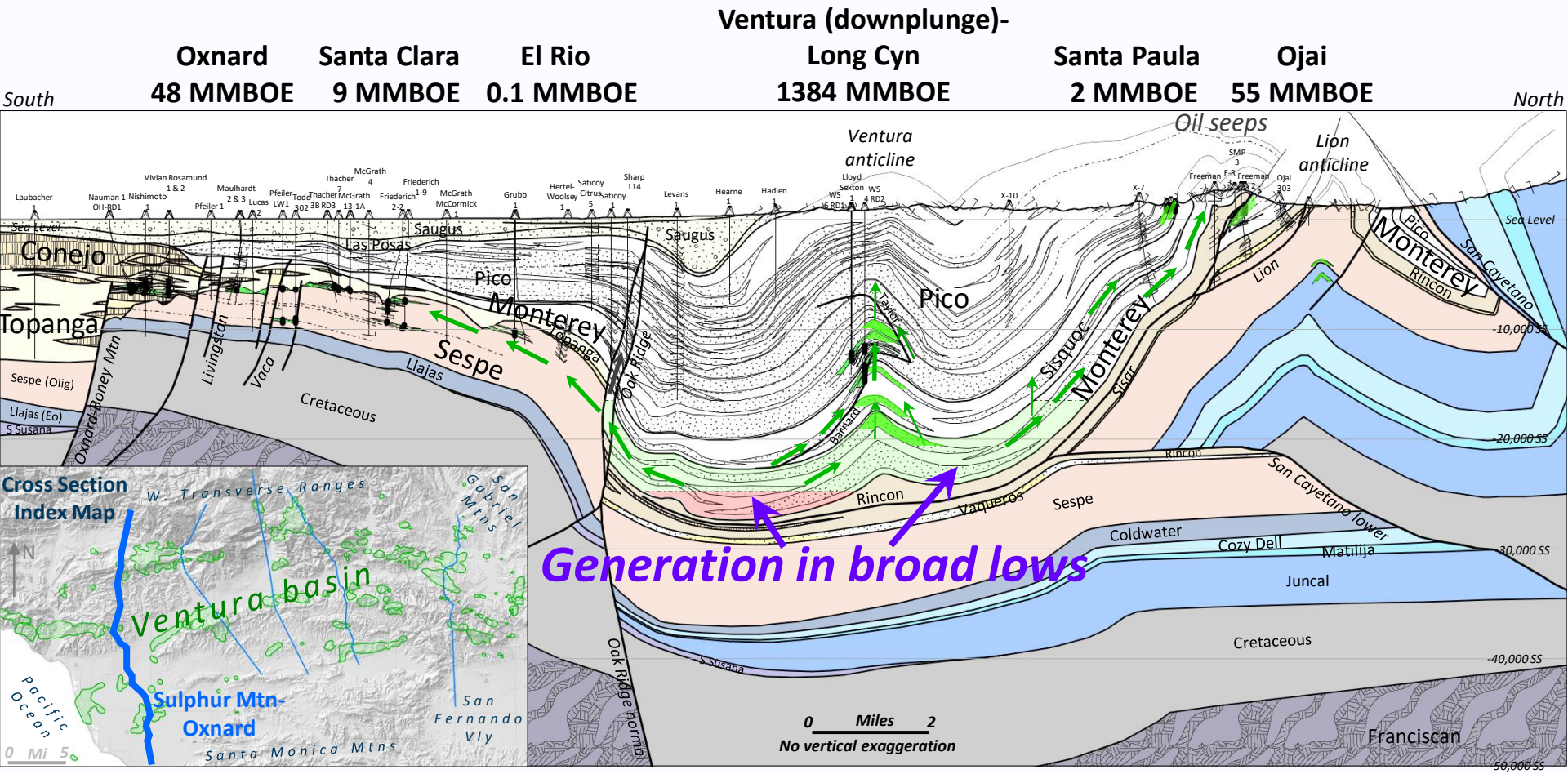
Near West Ventura Basin Depocenter Geohistory

Showing Transformation Ratio (%) and Temp (deg F); 1.10 HFU transient; Humble Leavens 1 well



Modified rom Davis, Namson, and Gordon (1996).

Sulphur Mtn-Oxnard Cross Section (Western Depocenter)

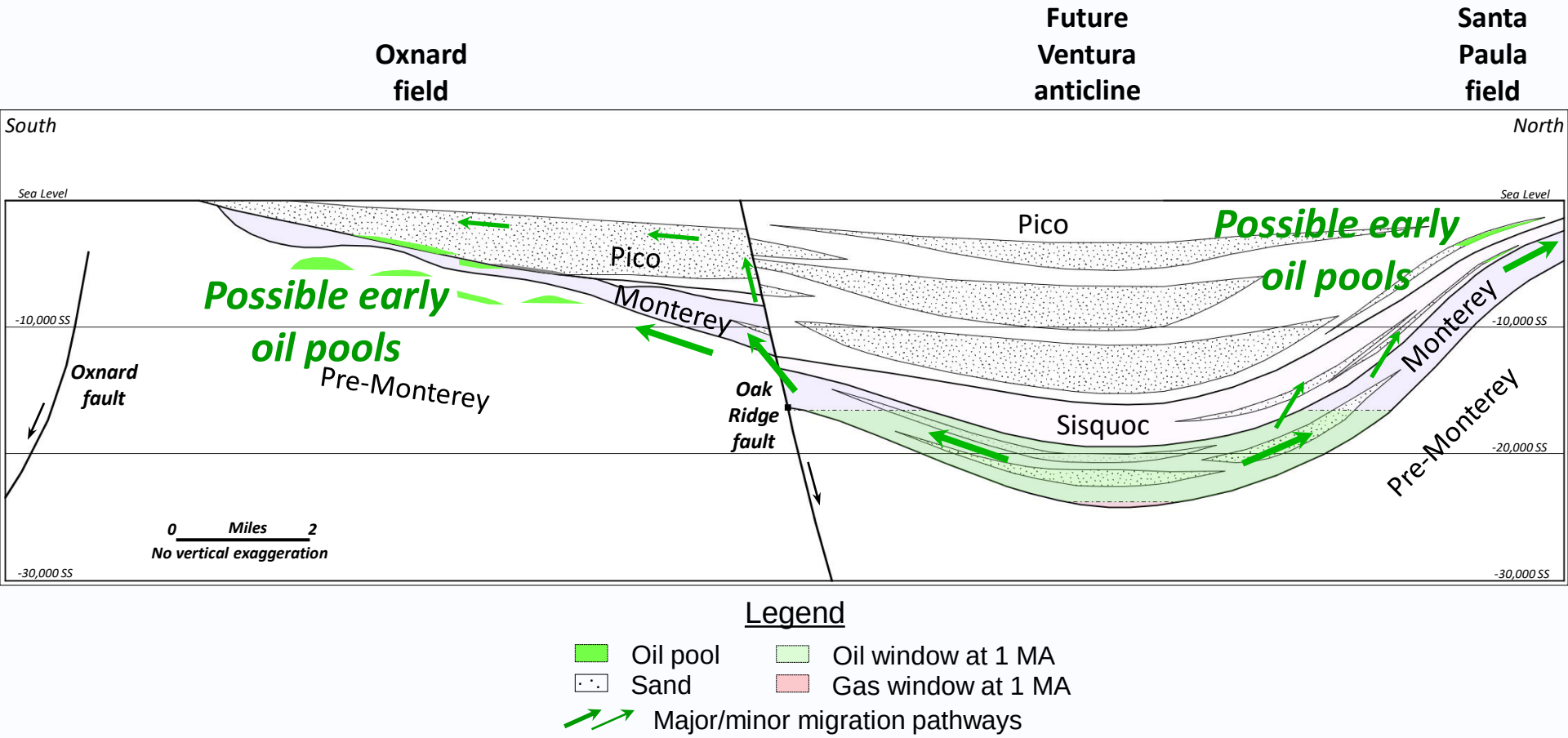


Legend

- Oil pool
- Sand
- Oil window
- Gas window
- Major/minor migration pathways

Restored Sulphur Mtn-Oxnard (Western Depocenter) Cross Section

End Pico time (~1 MA)

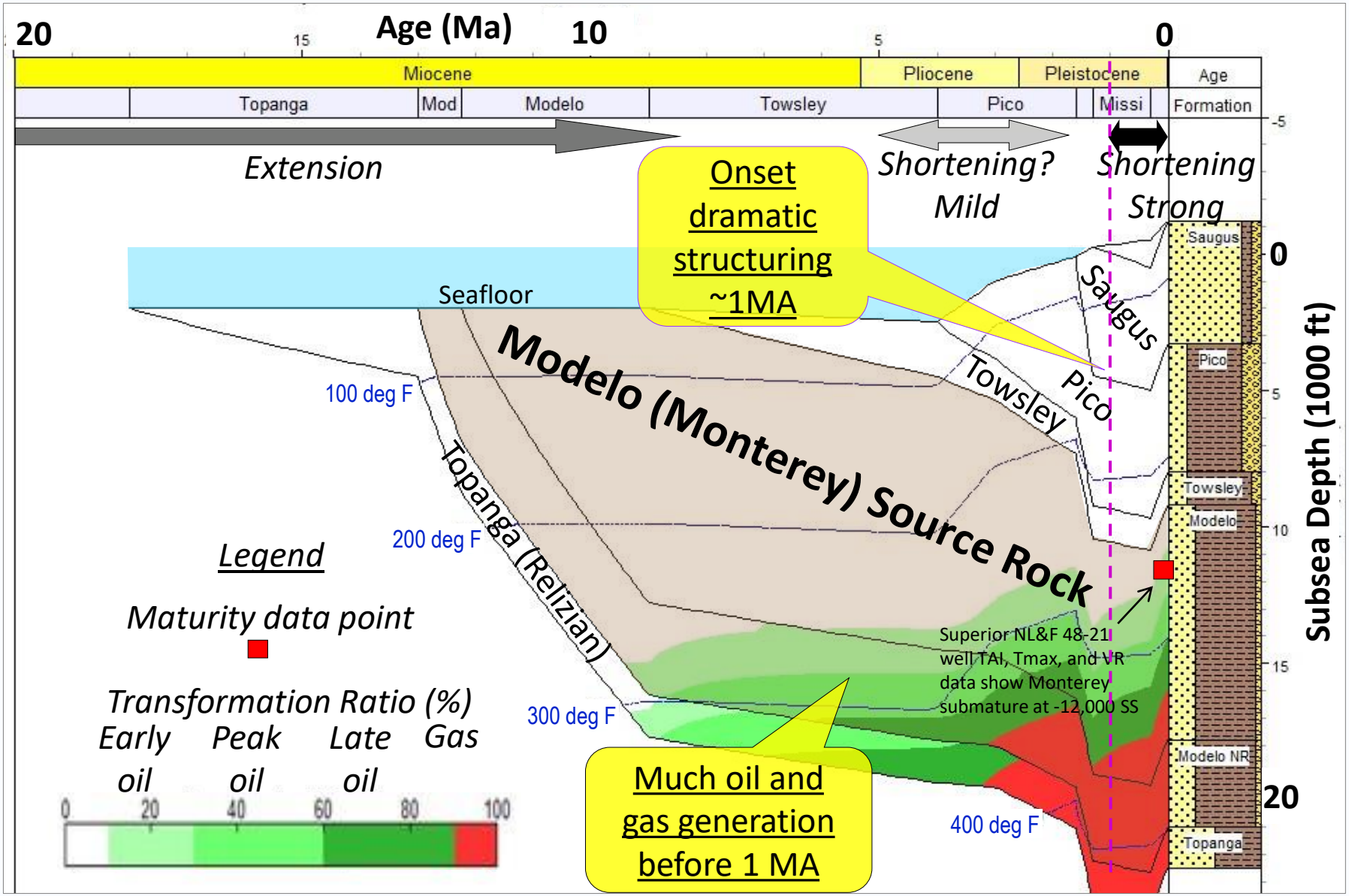


Legend

- Oil pool
- Sand
- Oil window at 1 MA
- Gas window at 1 MA
- Major/minor migration pathways

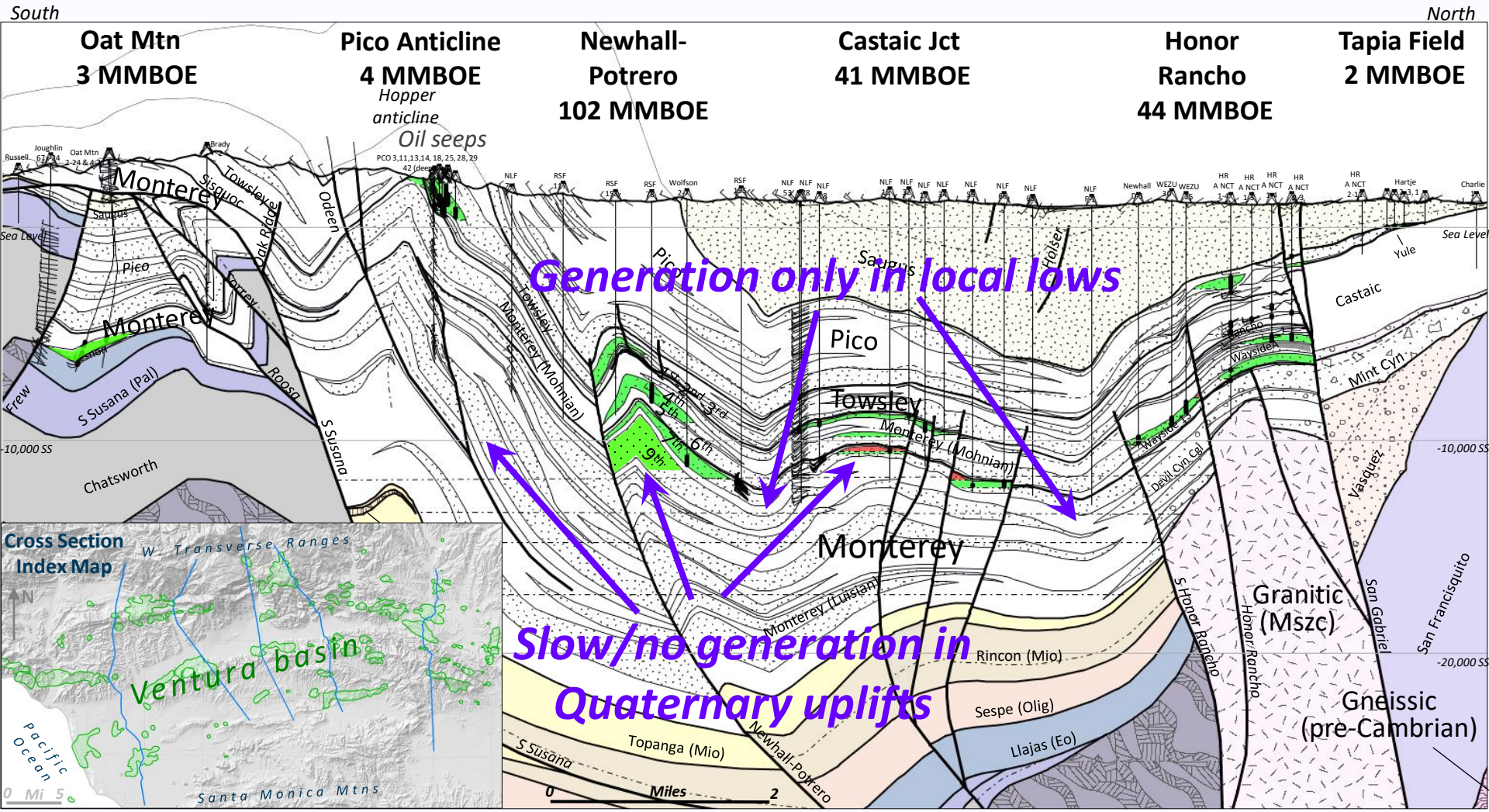
East Ventura Basin Depocenter Geohistory

Showing Transformation Ratio (%) and Temp (deg F); 1.35 HFU Steady State; Composite of NLF 18,53, 78 wells



Modified from Davis, Namson, and Gordon (1996).

Newhall-Potrero Honor Rancho (Eastern Depocenter) Cross Section

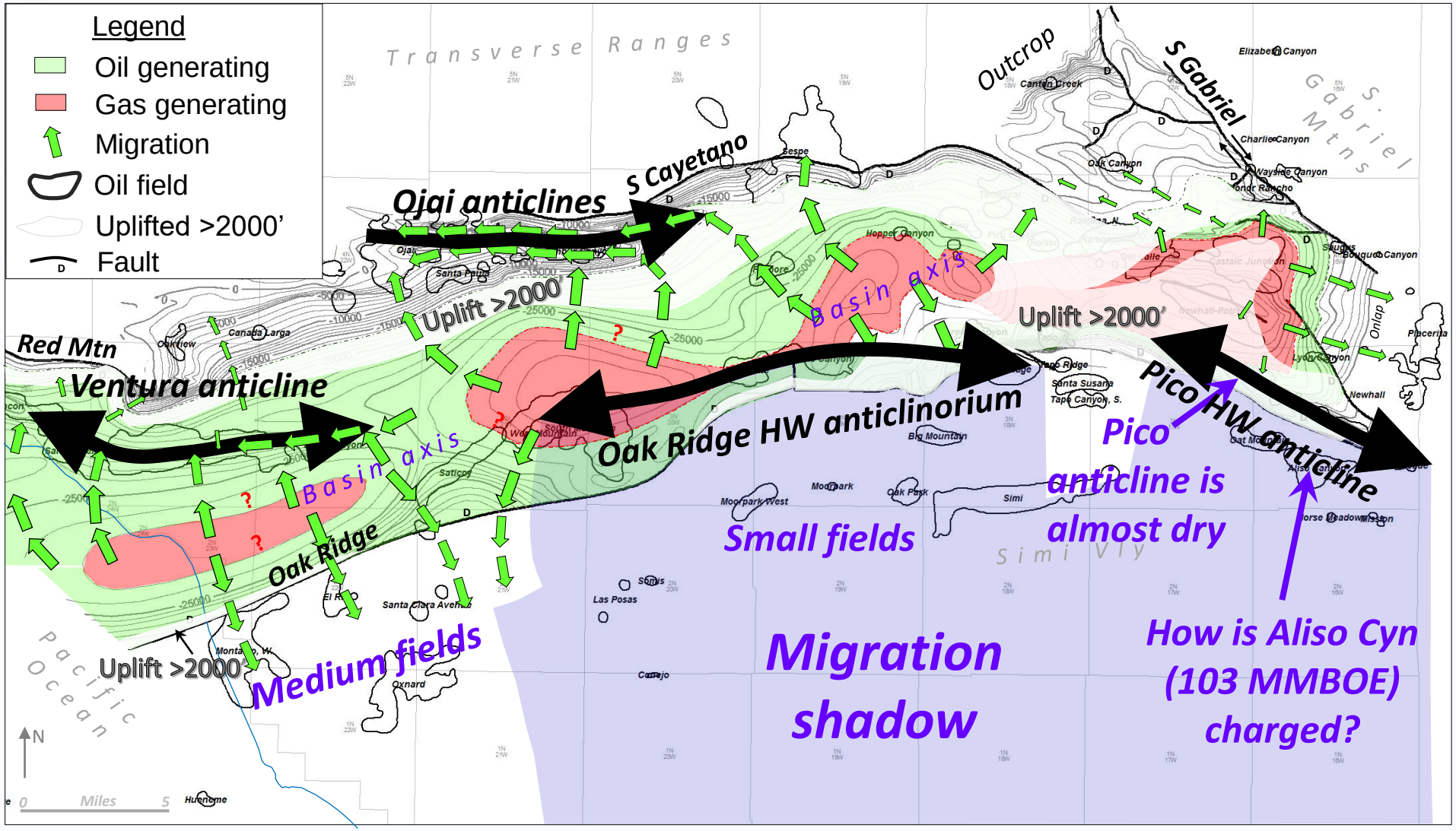


Legend

- Oil pool
- Sand
- Oil window
- Gas window
- Oil completion interval
- Major/minor migration pathways

Base Monterey Basinal Structure and Generation Today

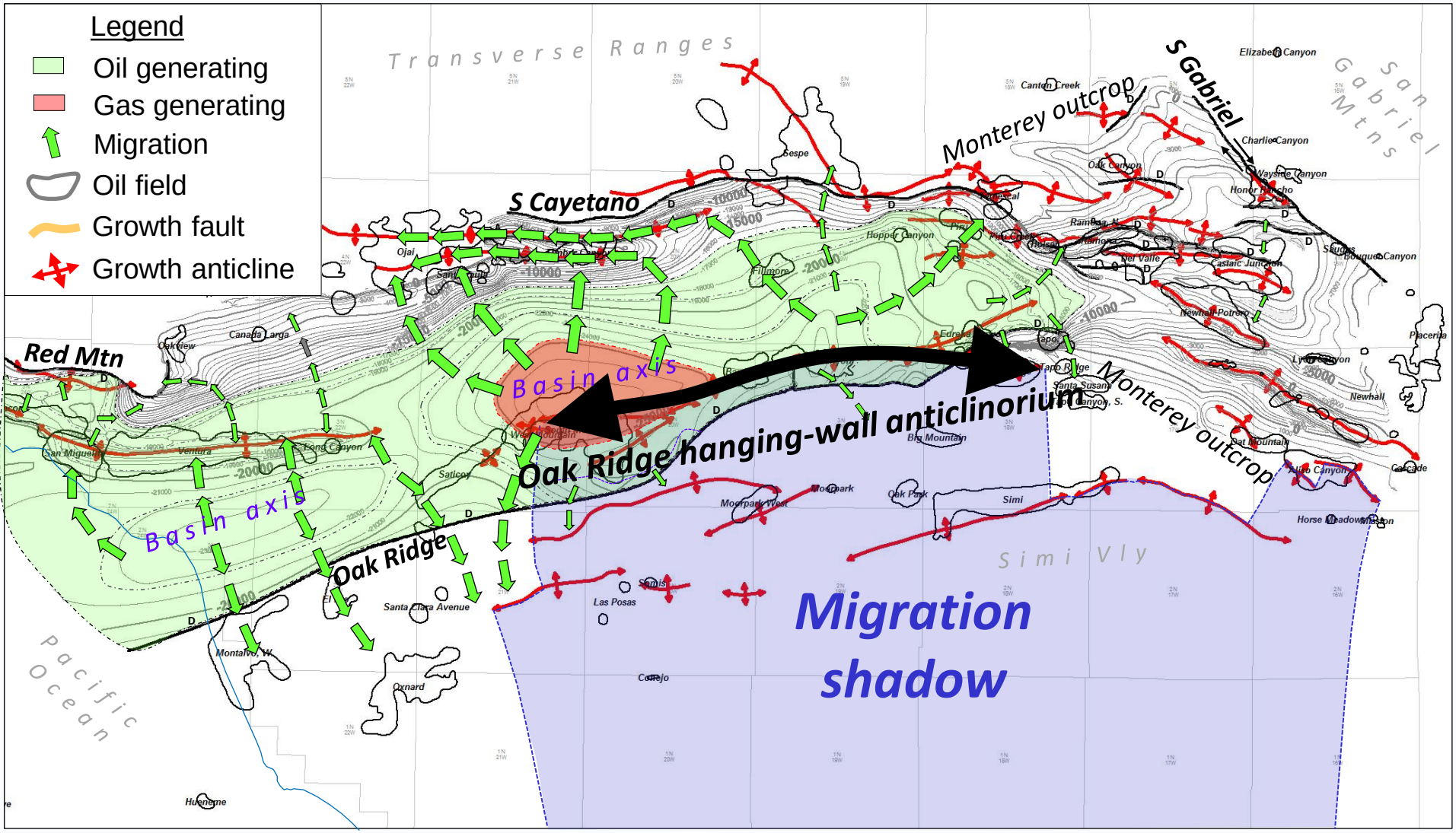
Contours in subsea feet, oil fields, maturity, HC kitchens, and migration pathways



HW is hanging wall; S Cayetano, Red Mtn, and Oak Ridge footwall cutoffs shown; Sisar thrust hanging wall shown but not footwall.

Top Monterey Structure and Petroleum System Today

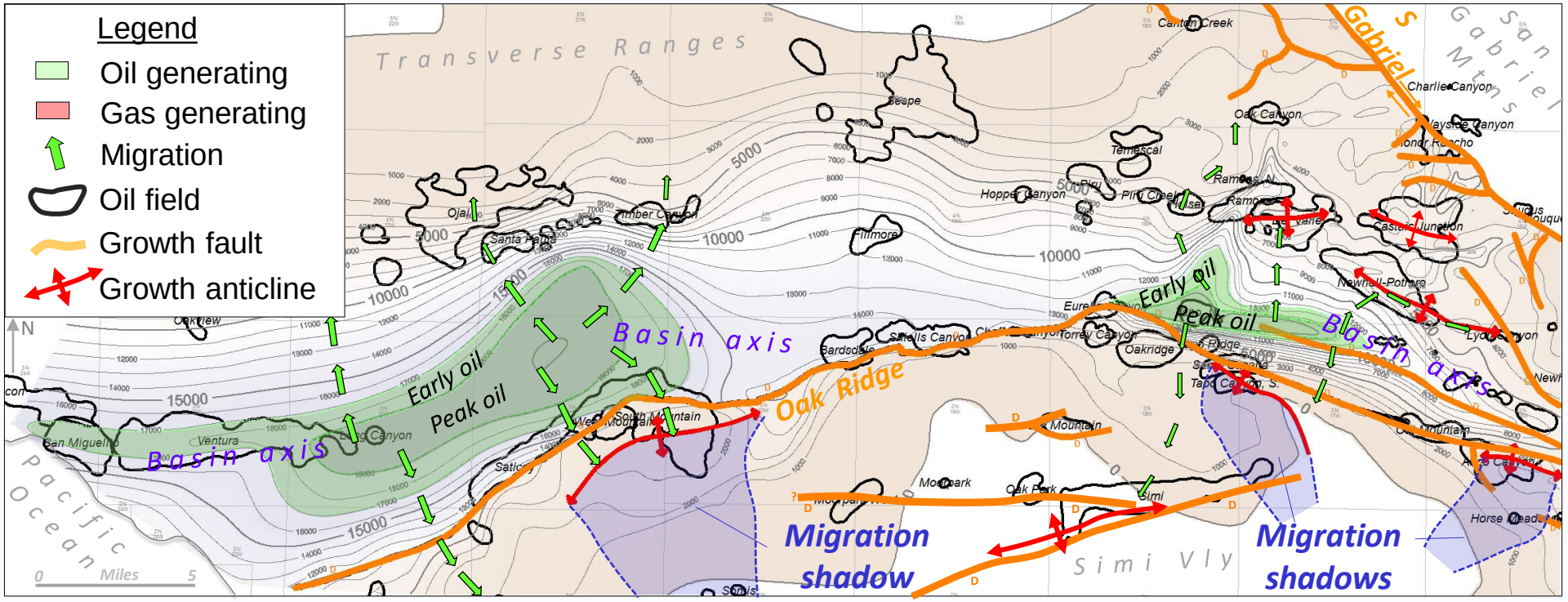
Contours in subsea feet, oil fields, maturity, HC kitchens, and migration pathways



Top Monterey is top Mohnian; S Susana thrust hanging wall shown but not footwall; S Cayetano thrust footwall shown but not hanging wall; Sisar thrust hanging wall shown but not footwall.

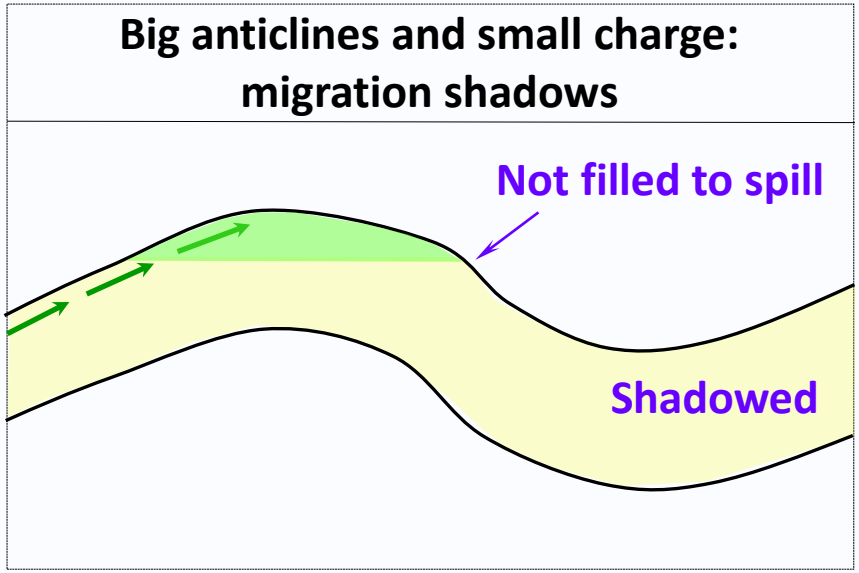
Top Monterey Paleostructure and Petroleum System at End Pico Deposition (~1 MA)

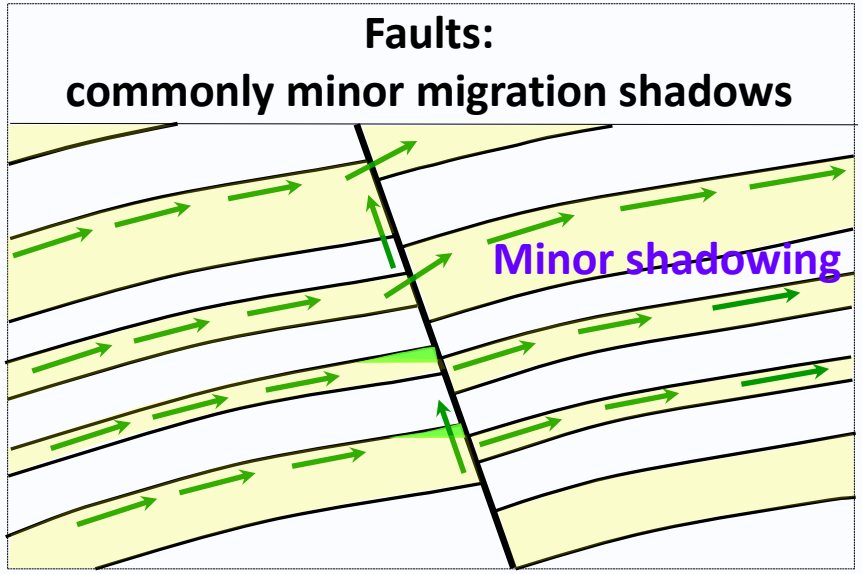
Contours in subsea feet, oil fields, maturity, HC kitchens, and migration pathways



Quaternary shortening not restored.

Migration Shadows





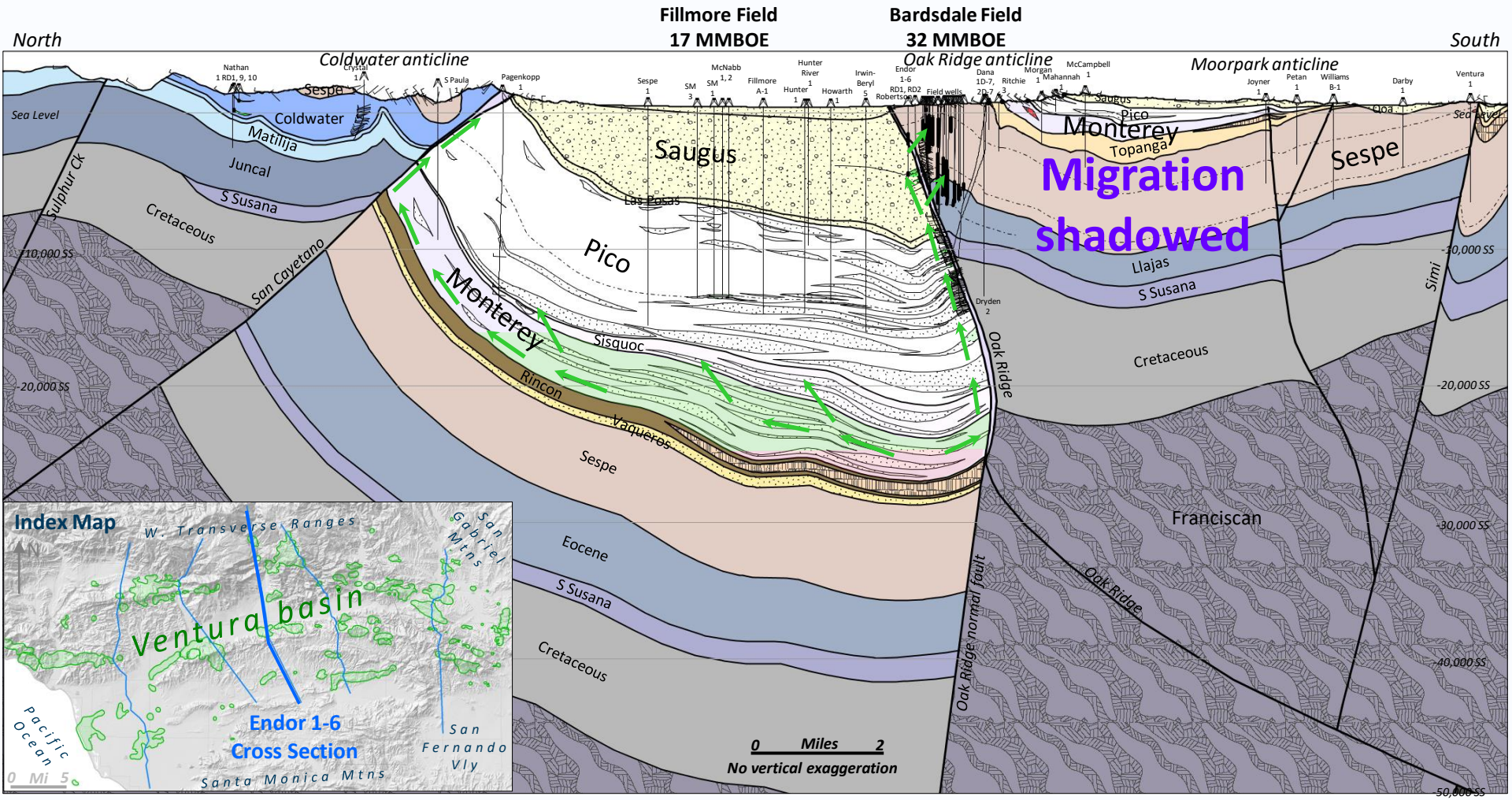
Legend

Oil pool

Sand

Migration

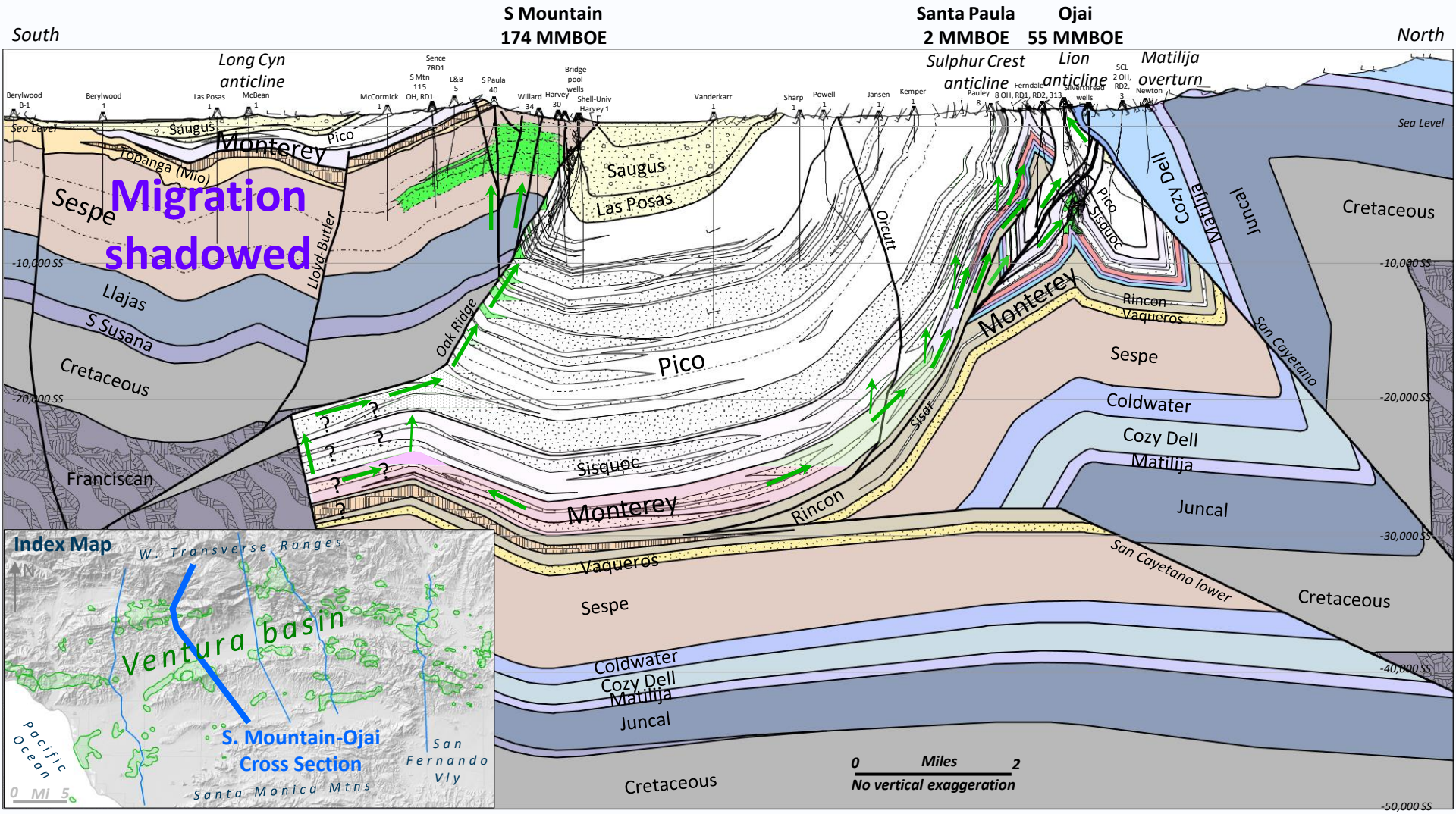
Bardsdale Cross Section



Legend

- Oil pool
- Sand
- Oil window
- Gas window
- Major/minor migration pathways
- Oil completion interval

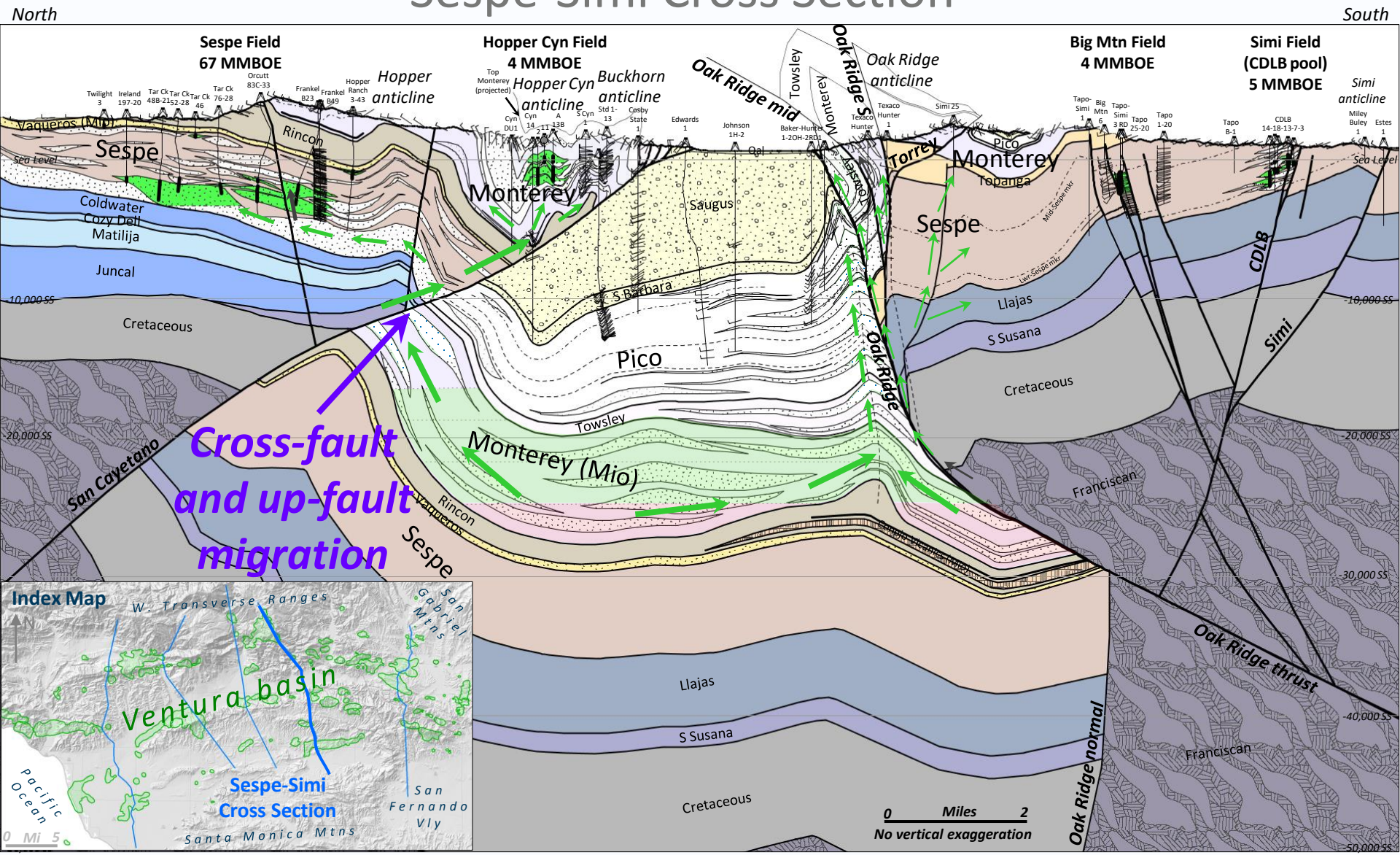
S Mountain-Ojai Cross Section



Legend

- Oil pool
- Sand
- Oil window
- Gas window
- Major/minor migration pathways

Sespe-Simi Cross Section

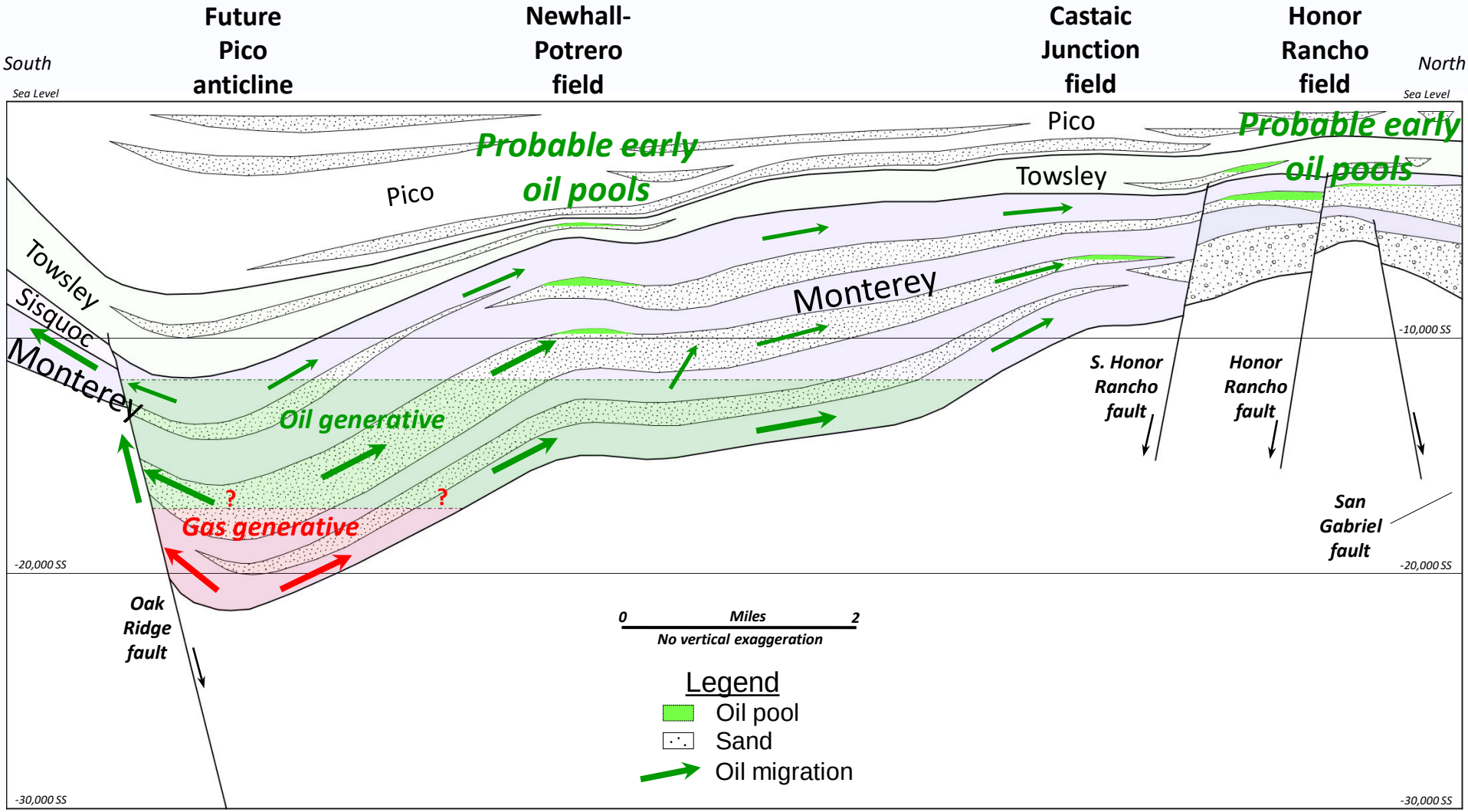


Legend

- Oil pool
- Oil window
- Sand
- Gas window
- Major/minor migration pathways

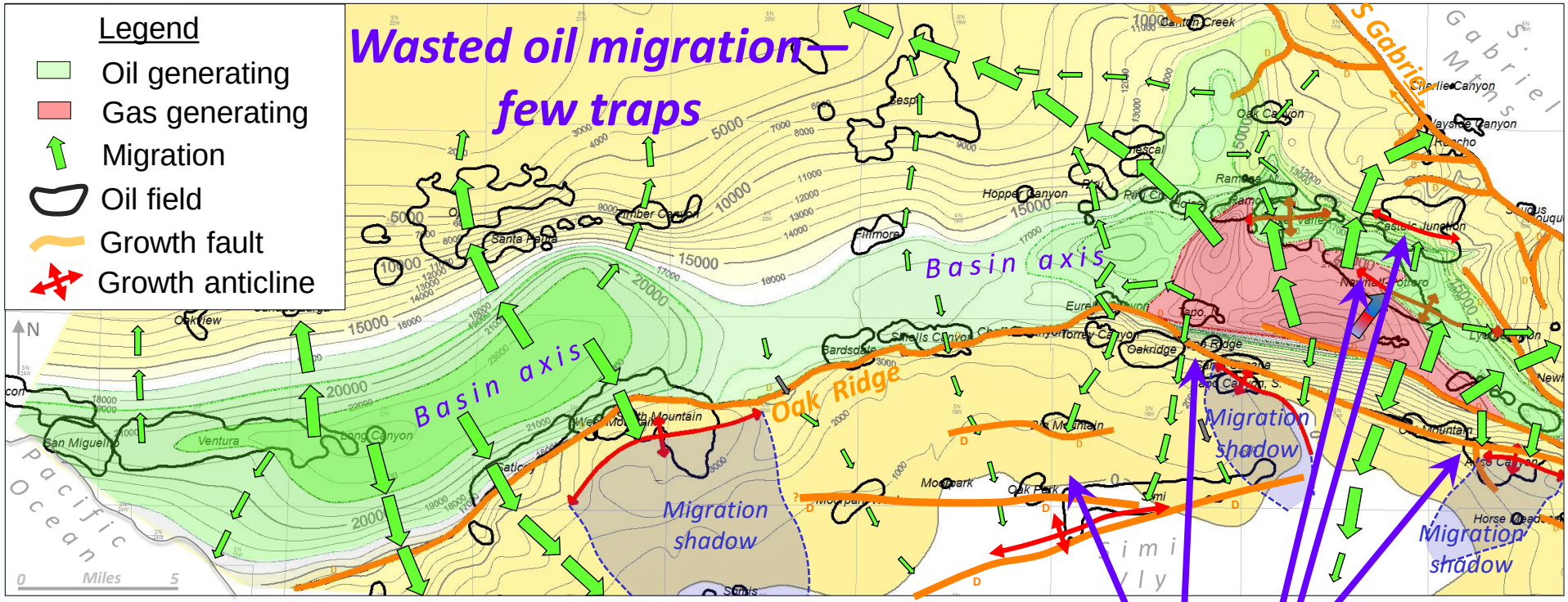
Restored Eastern Ventura Basin Cross Section (Generalized)

End Pico time (~1 MA)



Base Monterey Paleostructure and Petroleum System at End Pico Deposition (~1 MA)

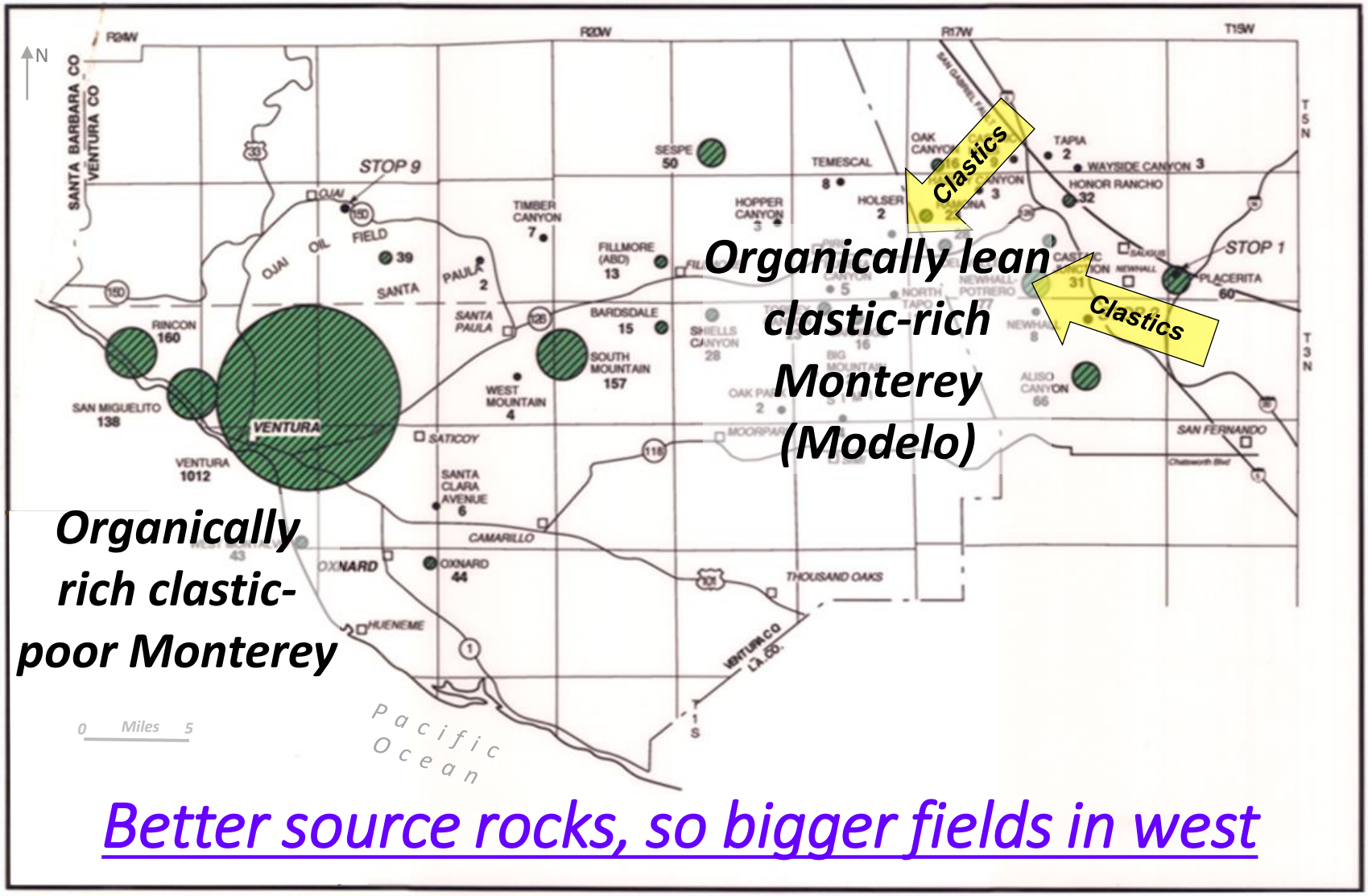
Contours in subsea feet, oil fields, maturity, HC kitchens, and migration pathways



Quaternary shortening not restored.

Aliso Cyn and other early traps received early charge

Ventura Basin Oil Field Sizes (MMBO) and Organic Facies

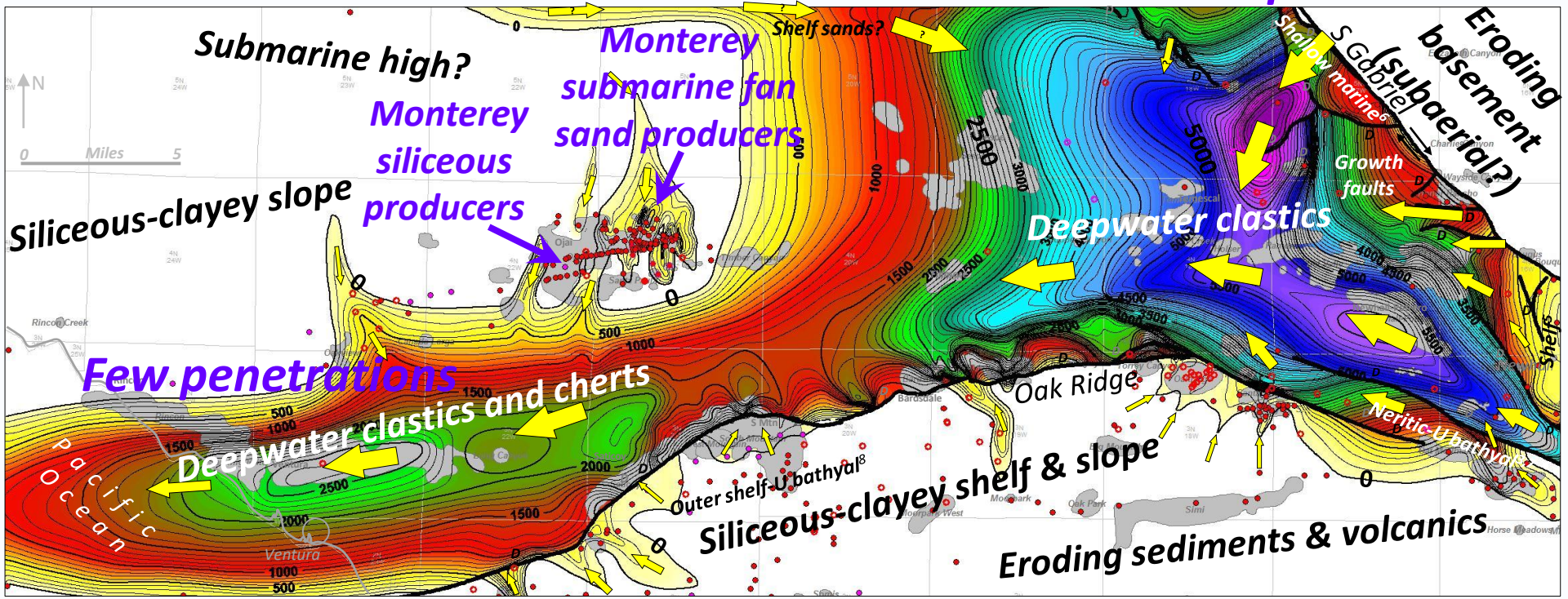


Modified from Davis et al. (1996).

Ventura Basin Monterey Sand Plus Conglomerate Distribution and Facies

E basin:

Monterey (Modelo) sands are main producers

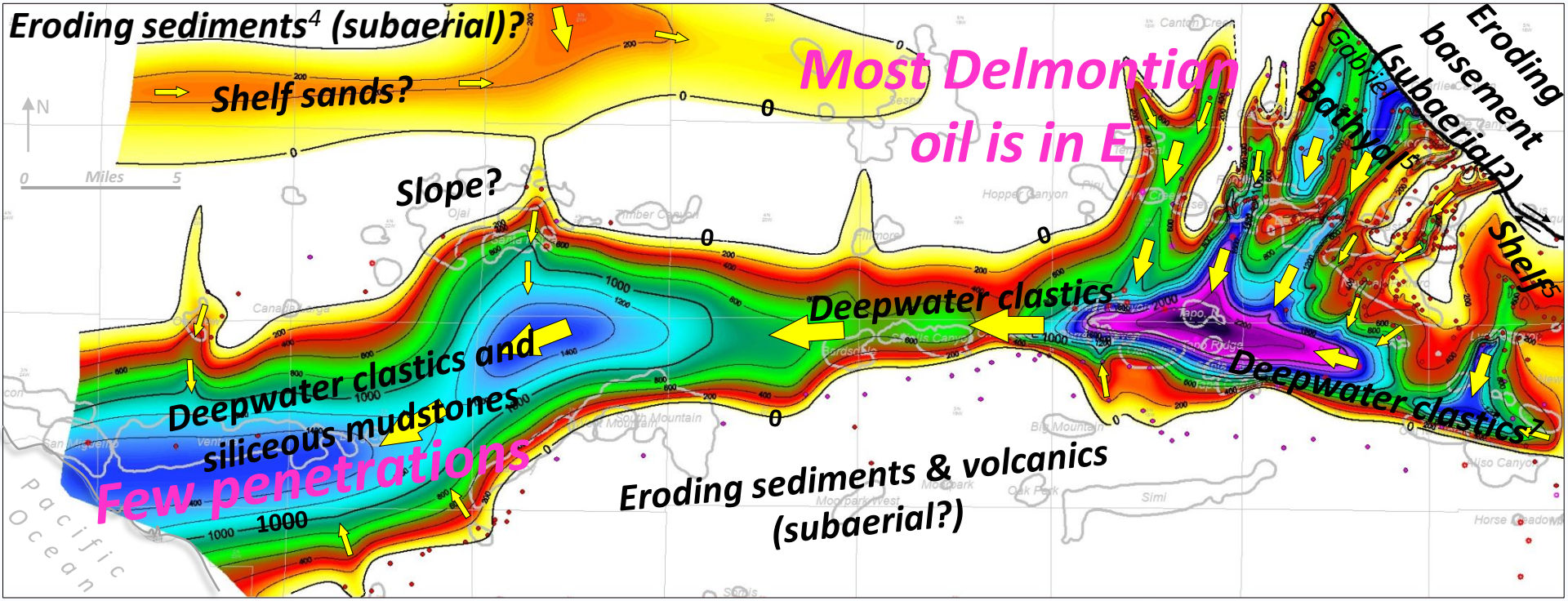


Legend

- Well data: highly constraining points are solid (mostly full penetrations), less constraining points (mostly partial penetrations) are open
- Outcrop data: highly constraining points are solid, less constraining points are open
- Sand transport
- Growth fault showing downthrown side
- Oil field

TST feet; Monterey includes Relizian, Luisian, and Mohnian strata; restored for early Pliocene and Quaternary erosion; Quaternary shortening not restored. Superscript denotes reference cited.

Delmontian Sand Plus Conglomerate Isopach and Facies



Legend

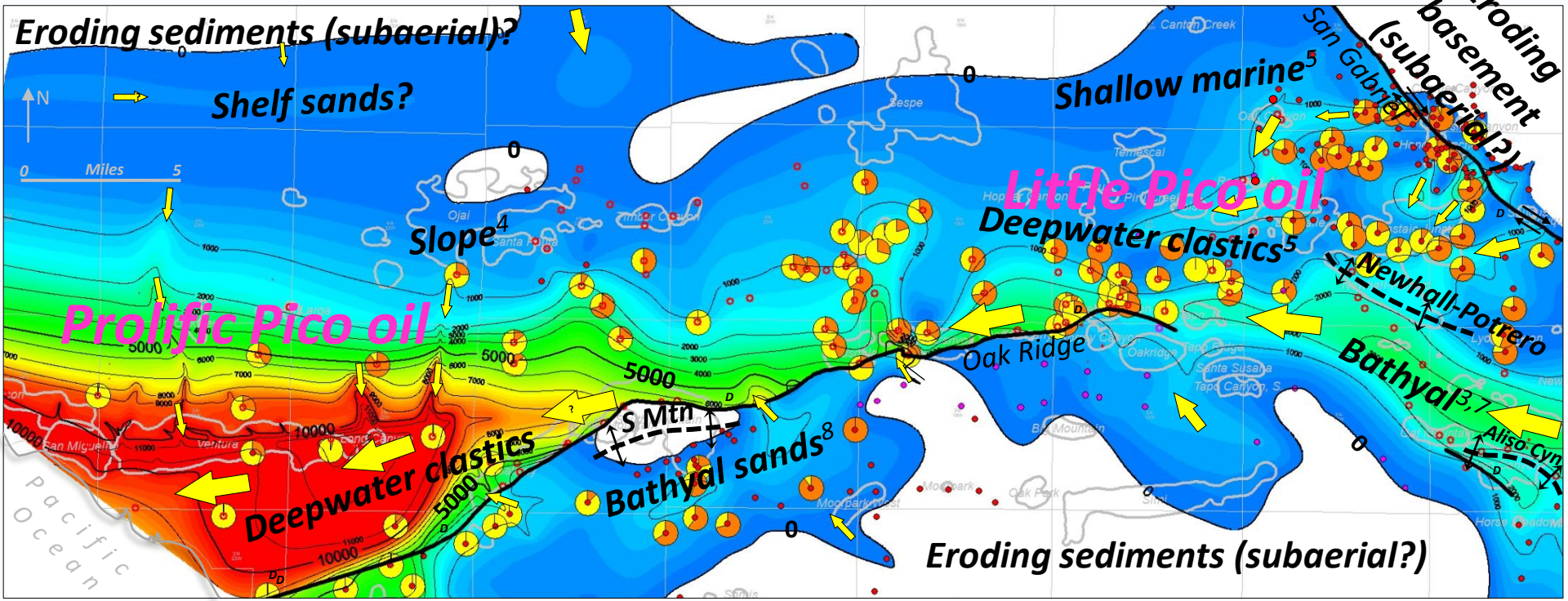
- Well data: highly constraining points are solid (mostly full penetrations), less constraining points (mostly partial penetrations) are open
- Outcrop data: highly constraining points are solid, less constraining points are open
- Sand transport
- Delmontian growth anticline
- Oil field

TST feet; Includes Sisquoc, Santa Margarita, and Towsley Formation sand and conglomerate; Quaternary shortening not restored. Superscript denotes reference cited.

Pico Coarse Clastic Isopach and Sand-Conglomerate Fraction

Western Pico prolific: charging up faults common, tight conglomerates uncommon

Eastern Pico little charge: faults uncommon



Legend

- Well data: highly constraining points are solid (mostly full penetrations), less constraining points (mostly partial penetrations) are open
- Outcrop data: highly constraining points are solid, less constraining points are open
- Clastic transport
- Pico growth anticline
- Oil field
- Growth fault showing downthrown side
- Cgl / Sand

Pico sand plus conglomerate isopach and sand/conglomerate pie diagrams; TST feet; restored for early Pliocene and Quaternary erosion; Quaternary shortening not restored. Superscript denotes reference cited.

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Professor Bob Yeats and his numerous Ohio State and Oregon State University students

Ventura Basin Study Group (Hopps, Stark, and Hindle), 1992, Subsurface Geology of the Ventura Basin, https://projects.eri.ucsb.edu/hopps/

NEOS Geosolutions gravity-magnetic survey data

Nagle and Parker, 1971, Future Oil and Gas Potential of Onshore Ventura Basin

Davis and Namson, balanced cross sections throughout the Transverse Ranges, www.davisnamson.com