Pacific Petroleum Geology
NEWSLETTER
Pacific Section • American Association of Petroleum Geologists
January & February 2020

2020 PSAAPG / SEPM / SEG Convention Update

2019-2020 Officers

Staff

Cover Photo is of fractured Monterey Formation at Gaviota State Park, taken by Dr. Richard Behl, and will be a stop on the Petroleum Migration in an Active Petroleum System Field Trip, part of the 2020 Pacific Section Annual Meeting. See Page 5 for more information.

PSAAPG Newsletter has now gone DIGITAL!

In an effort to reduce overhead and provide meaningful programs to our membership and the community, PSAAPG has decided to go DIGITAL!

For those members still wanting hard copies of the newsletter, please email editor@psaapg.org or write to us at:

Pacific Section AAPG
P.O. Box 1072
Bakersfield, CA, 93302

- CONTACT THE EDITOR at editor@PSAAPG.org
- Images (graphics, photos, and scans) must be at least 300 dpi resolution. Text should be at least 600 dpi.
- Scanned photos, illustrations (line art) or logos should preferably be submitted as a .tif, .gif, or .bmp; .jpeg

Hello and Happy New Year!

I hope you all had a happy and healthy holiday! Each year the time between Thanksgiving and New Year seems to go by more and more quickly. This year was no exception- barely three weeks between Thanksgiving and Christmas!

I've been a development geologist for the last six years. Last Fall, I was traded to the regulatory group. I've worked on quite a few Aquifer Exemptions and Underground Injection Control programs (UIC), but I am not a Professional Geologist (PG) yet. I also have not taken the FG (GIT certificate). It behooves me to take these tests now. In California, there are three tests we need to pass in order to become a PG - Fundamental/GIT (FG), Practice (PG), and California Specific Exams. You can take the first part, FG as soon as you graduate with your degree, but you need 5 years of qualifying experience before you can take the PG exam. I'm taking the exams in March.
If you haven't taken them, or wondered what its all about, let me tell you.

Full disclosure, I really like studying. I love making flash cards, organizing my notes, and recalling information. In college, one of my best friends, Nicky Oliver and I used to go for long walks testing each other (and would bake while studying too)! However, while I like studying I do not like taking tests as much.

I am fortunate to have a group of friends to study with, which helps hold us all accountable.

There is a lot to study, much of it I have not referenced in more than a few years. Styolites. When was the last time you thought of styolites? When I took Sedimentology in college, I really liked styolites, because they were very distinguishable. They were all over our office in downtown Long Beach, in the tile near the elevators, and in the bathrooms. However, I didn't consider them as being a barrier to fluids in a reservoir or an aquifer until last week!

While I am finding studying for the PG exams very challenging, I am also rediscovering my passion and joy in geology and all its cumulative sciences. When I took Introduction to Geology, I was smitten. When describing my classes, I would often describe geology as "everything dangerous we have no control over – earthquakes, volcanoes, landslides, tsunamis." Natural disasters are covered early in the semester to get us hooked on Earth Science! I'm realizing now that while we may not have control over the actual events themselves, we do have some control over the structures and events that overlie our Earth's surface. It's critical that we use our understanding of the Earth and its processes to ensure that our homes, schools, public facilities, roads, bridges, and dams are built to the best quality that they can to keep the public safe. We also have an obligation to ensure that any and all mineral, water, oil, and gas extraction is done in a safe and efficient manner that keeps our environment, communities and hard-working men and women safe.

So, to all our PG friends and those studying, thank you for all that you do and best luck in your studies. We need solid, smart, technical geologists with strong moral compasses guiding and qualifying our science!

You may have noticed that we have a new Editor-in-Chief. Tony Reid has taken over the role, as Brandi Johnson will be moving to Houston next month. I'd like to thank Brandi for all her time and effort as editor over the last 2 years. She also put together our beautiful program for our 2018 convention. She will be sorely missed. I wish she and family all the best in their new adventure. Tony, thank you for taking on this new role.

Cheers to a happy and healthy 2020! Until next time,

Becca Schempp

2020 Pacific Section AAPG Convention

2020 Vision: Producing the Future

April 4-8 at the Embassy Suites Beach Resort in Oxnard, CA

Call for Papers

Extended to January 31, 2020

Technical Program:

- Two-day technical program with oral and poster sessions on a variety of technical themes
- Lecture series will feature extended technical presentations to dive deeper into the following topics:
  - Seismic Interpretation for Geologists
  - Environmental Sequence Stratigraphy
  - Montecito Debris Flows
  - Source to Sink Studies
  - Holocene History of the Santa Barbara Channel
  - Age Control, Source Rocks, and Paleoceanography

Field Trips:

- Southwest Santa Cruz Island: Intraplate Motion and Deformation led by Jim Boles, UC Santa Barbara
- Montecito and Santa Barbara Debris Flows led by Ed Keller, UC Santa Barbara
- Petroleum Migration in an Active Petroleum System, Santa Barbara Basin, California USA led by Rick Behl, CSU Long Beach, and Marc Kamerling, Consultant
- Sedimentation, Tectonics, and Petroleum Systems of the Eastern Ventura Basin led by Greg Gordon, Aera Energy, and Stuart Gordon, CRC
- The Ridge Basin: Transition from Marine to Non-marine Sedimentation in a Basin-Filling Cycle, led by Dan Schwartz, Dan Schwartz LLC

Short Courses:

- Mitigating Uncertainty, Risk, and Bias in Geotechnical Decision Making instructed by Creties Jenkins, Rose and Associates
- Sequence Stratigraphy for Graduate Students and Early Career Professionals instructed by Morgan Sullivan, Chevron and Kenn Ehman, Chevron

Special Events:

- Icebreaker
- All-Convention Luncheon
- Awards Luncheon
- Dinner on the Beach
- Wine/Beer/Spirits Tasting

Visit the website for more information!

www.psaapgconvention.org/2020

Grand Canyon in Winter

Becca Schempp

Grand Canyon is one of my favorite places in the world. In my first President's Letter I discussed how hiking Grand Canyon inspired me to be a geologist. I was barely 18 the first time I hiked Grand Canyon.

The first time I hiked Grand Canyon I was only two months into my first geology class, so I didn't recognize many of the sedimentary structures, like the amazing cross-bedding in the Coconino Sandstone, or understand just what the Great Unconformity meant. I still joke that "we should all be glad for the missing rocks- it would make the hike a lot longer!" I remember my professor Janice and her other geologist friends discussing the formations and faults. Every once in a while, one of us would ask a question, to which they'd reply, "I don't know, or what do you think?" This was surprising to me, I thought they had all the answers! 2010 was the last time I hiked the canyon with Janice and her class. By this point I had taken all my undergrad classes, so my geological knowledge had increased significantly since that first hike in the Fall of 2004. I am proud to say it took me ~2 hours longer to hike in and out. Janice told me, "I was hiking too fast all other times, I missed so much in the rocks!"

My professor and her husband had reservations at Grand Canyon, but an injury sidelined them and the fine folks at Xanterra let her transfer her reservations into our name. This past Thanksgiving a very large storm slammed the West Coast. It brought snow to both the Tejon and Cajon Passes in Southern California and closed huge stretches of I-40, the route to Grand Canyon. Our reservations were for two nights at the Bright Angel Lodge (overlooking the canyon), two nights at the bottom, at Phantom Ranch, and one last night at the Bright Angel Lodge. When we left Long Beach, the day after Thanksgiving the 40 was closed from Kingman to Winslow. Luckily, by the time we got to Kingman it was opened, although it snowed the whole way to Williams. During this time Grand Canyon was without power. We decided to stop in Williams to get a hot meal before heading to the Park. While we were there, they closed the road into Grand Canyon. Not knowing when they would open the road, we decided to take the train into the park the next morning. The ride was magical, the fresh, undisturbed snow was breathtaking. We arrived in Grand Canyon Village around lunchtime. Power had been restored about 1:30 AM, so the park staff and visitors were still literally shoveling themselves out from the 2-day storm.

Then we saw it. I'd argue that the first glimpse of the canyon will take your breath, no matter how many times you have seen it. But this time, seeing the raw, wildness of the canyon covered in snow was unlike any other time before. Upon checking in we found out that the shuttles were not running, that people were hiking down, but most were taking Bright Angel down rather than South Kaibab. They strongly recommended hiking poles and traction (crampons). Before bed we took a walk along the Rim Trail, we had the whole place to ourselves. The picture below shows the snow in the canyon looking towards Indian Gardens (you can see a few lights on as well).

The next morning, we headed out, we hadn't had a chance to check out the trailhead prior. It was crazy. There was sooo much snow. Previous hikers had "cleared" a foot-wide trough in the snow, with snow up to our knees on either side. Much of the Kaibab Limestone and Torroweap Formation were covered in snow. The cross-bedding in the Coconino Sandstone was easily seen in the cliff face. We had snow/ice almost down to Indian Gardens (4.6 miles from the top)! I grossly overpacked our food and drinks. Unsure of water in the canyon, we each carried a gallon of water. We were anxious to eat and drink some of our load! After conquering the Devil's Corkscrew, we finally

saw the Colorado River! However, the Silver suspension bridge was much further than I remembered! We arrived at Phantom Ranch a little after 3pm.

During dinner we discussed our plans for our full day at the bottom of the canyon. 24-year-old Becca remembered the hike to Ribbon Falls being long, ~7 miles. 33-year-old Becca realized that the hike is actually 6.5 miles ONE WAY! My husband was a good sport. Most of the hike is relatively flat, paralleling the creek through basement rocks. The pictures below are both at the same location, in each I'm admiring the Zoroastor Granite and Vishnu Schist. Along our hike we came across several recent rock falls, we carefully scrambled over them and continued. The bridge was out, so the only way to Ribbon Falls was to cross the stream, which was very healthily flowing thanks to the recent storm. After precariously crossing the stream we made it, and it was worth it, we were the only people there. Much different than most other times of the year.

We decided to hike out the South Kaibab trail. I hadn't ever hiked out that way. It is ~three miles shorter than Bright Angel trail, but much steeper. There also isn't any water along the trail, so it is not advisable to hike out in the warmer months. It seemed like the perfect opportunity to try it. You quickly gain elevation after crossing the Black Suspension bridge. The views are spectacular and fun that you keep getting different views of Phantom Ranch/Bright Angel Campground as you ascend. Along the way we hiked with a group from the East Coast, one of them was a Principal at a Middle School in North Carolina. Her father (an engineer) and I got to talking about the canyon, and she asked to interview me. It was very fun to get to share my knowledge of the canyon with students all the way on the other side of the country. She also interviewed my husband, a Union carpenter and several other people along the trail. I forgot how quickly you can make friends hiking! South Kaibab trail offers very different views of the canyon. In the end, we were very happy that we took South Kaibab out. It was wonderful to see the canyon through such different vantage points. As we got closer to the top the snow turned to slush, which did make it very tiring to hike through! When we saw the last switchback, we were very excited, we climbed out of the canyon ecstatic, but with no one else to share it with. So, we waited shortly at top and loudly applauded the next couple that came up the trail!

2010

2019

Grand Canyon is an amazing place. I was very happy to be able to share it with my favorite person. We were able to see the canyon blanketed in snow, something that not many people get to see. We were so fortunate to experience the canyon with so few people there too! My tip to you is to brave the canyon in the winter, it's worth it!

ROBERT D. "BOB" HOFFMAN

March 8, 1930 - November 23, 2019

Robert D. Hoffman, also known as “Old Bob” Hoffman, died in Burlingame, California on November 23, 2019. He was born in Oklahoma City in 1930, moving to California when he was five years old. He grew up in the cities of Fontana, Altadena and Sausalito, graduating from Tamalpais High in Mill Valley, California. In high school he was always good at math and thought he would become a civil engineer like his father. However, an uncle who had a gold claim in the Mojave Desert brought back some interesting rocks and that piqued Bob’s interest in geology. He took classes in geology at Stanford University and graduated with a bachelor’s degree in Mineral Science in 1952. His college education was interrupted by military service in the U.S. Air Force between 1948 and 1949.

Following graduation, Bob moved to Bakersfield in the summer of 1952 to take a job with Tidewater Associated Oil Co. On his first night in Bakersfield he was greeted by the Tehachapi earthquake which he rode out on the fifth floor of the Padre Hotel. Undeterred by the seismic event, he stayed in Bakersfield for 2 ½ years doing the work of a new geologist: well sitting and core parties with some subsurface and surface mapping thrown in.

In 1954 Bob married his wife Dolores whom he met at Stanford when they were both students. A few months later, in 1955 they were transferred to Ventura, where Bob continued his subsurface and surface mapping in the Ventura Basin. They had five children, three girls and two boys and Bob immensely enjoyed coaching boys’ soccer for many years. He served as the first commissioner for the American Youth Soccer Organization (AYSO). Four of their children live in the Bay Area as do their three grandchildren.

In 1958, he was transferred back to Bakersfield but around 1960 Bob decided to try his luck at consulting. He left Tidewater and worked on his own, sharing an office with John Thomson for a number of years. Consulting turned out to be quite an adventure that continued until the late 1990s when he retired. Bob’s primary focus as a consultant was exploration of the Sacramento Valley where he has had over 100 wells drilled, with the discovering several new fields and pools in the Delta of the Sacramento Basin and in the Northern San Joaquin. These include the discovery of part of French Camp field, the extension of Conway Ranch Field, discovery of Tremont field, the extension of Rio Jesus field, discovery of the Sugarfield field, discovery of Fremont Landing field and a portion of the Karnak Field, discovery of the Grays Bend field, extension of the McMullin Ranch field and discovery of the Verona field. The Rio Jesus field was the first seismic “bright spot” discovery in the Sacramento Valley but Bob recognized the potential of this gorge prospect before the seismic was available. The area had been leased by Shell, but based on Bob’s prospect the area to the east was leased and later developed, extending the field boundaries.

Bob Hoffman at Owl Creek Canyon, Rainbow Basin Field Trip, February 3, 2007. Photo by Glen Gregory.

In addition to the Sacramento Valley, Bob has had success in the southern San Joaquin Valley with new pool discoveries that were based on his work. One was in the Santa Margarita of the Mountain View Field, the result of one of his first consulting jobs in the southern San Joaquin. Later, while writing a report on the Race Track Field for a client, he recognized the oil potential in the Santa Margarita and that also resulted in an extension of an underdeveloped pool.

A member of the Pacific Section AAPG since 1953, Bob has been consistently involved with the Pacific Section and the San Joaquin Geological Society. He has shared his understanding of the Sacramento Basin geology by presenting several talks at the Pacific Section AAPG Conventions and through publication in the Selected Papers published by the San Joaquin Geological Society. He shares his knowledge freely with his peers and with the lay person as well, whether at a San Joaquin Geological Society Meeting, a Pacific Section AAPG Convention or on a road trip in California. In addition to his geological expertise, Bob served as the Treasurer and then the President of the San Joaquin Geological Society in the early 1970s.

In addition to his passions for geology and his family, Bob was a dedicated bridge player, an avid handball player, an outdoor rambler and a good martini maker. Friends and family will sorely miss his dry wit and gentle heart.

He was predeceased by his wife Dolores and is survived by his children, Laurel Winzler, Susan Hoffman, Diana Oertel, Steve Hoffman and Mark Hoffman, as well as three grandchildren, nieces and nephews.

Laura M. Bazeley

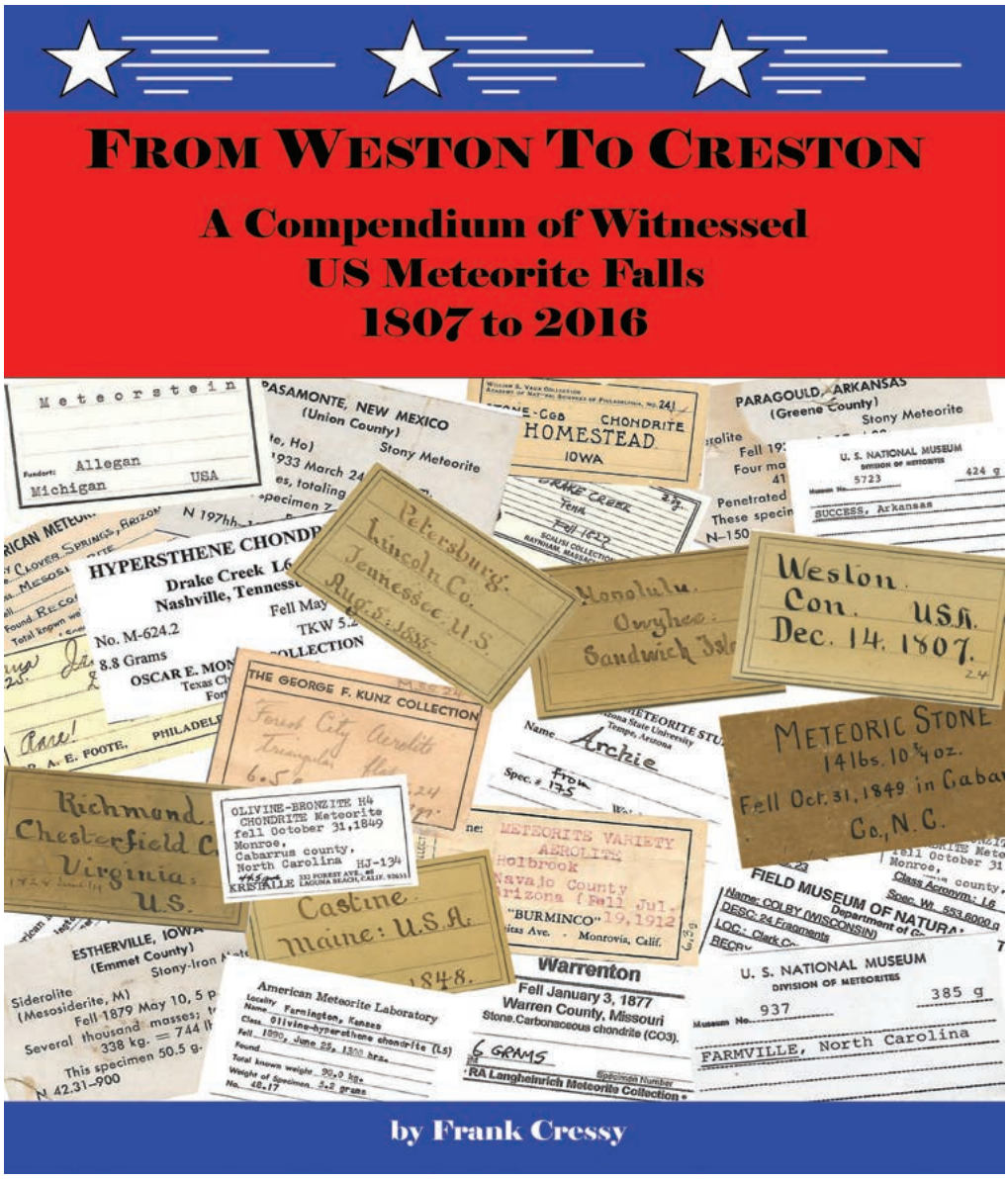
New Publication

"FROM WESTON TO CRESTON – A Compendium of Witnessed US Meteorite Falls – 1807 to 2016"

by **Frank Cressy**

The violent display of blazing light and explosive sounds ending with meteorites crashing to the ground is an unforgettable event to those who witness it firsthand. This book summarizes the fall histories of nearly 170 witnessed meteorite falls that have occurred in the United States since the first documented fall at Weston, Connecticut in 1807. It is written not only for the collector of these rare objects, but also for those interested in the history and the growth of the branch of science known as Meteoritics. The accounts of the fall phenomena and recoveries associated with these extraordinary events are the focus of the book. However, the book is more. The reader will learn about those individuals responsible for the growth of the science and their contributions, together with interesting facts and coincidences about these visitors from space; 257 pages with over 300 color photos plus maps, figures and illustrations.

Soft Cover books $36.00; for ordering, contact: fcressy@prodigy.net



Third Edition Now Available

Geologic Guidebook to the Long Valley-Mono Craters Region of Eastern California

by Steven R. Lipshie

397 + xxviii pages, with 136 figures (91 in color), 11 tables, and 13 stop location maps (in color)

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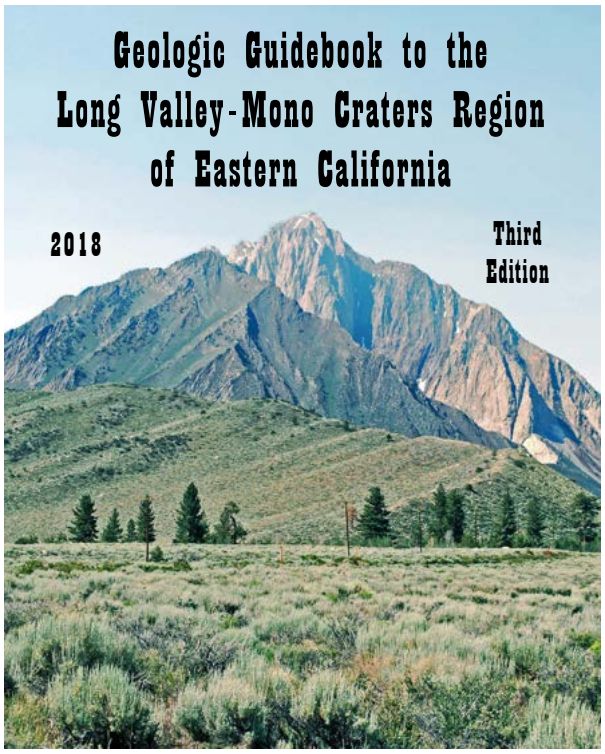


PSAAPG Membership Directory

The PSAAPG website will have a members-only password-protected membership directory available as of March 1, 2018

Please email SKChehal2@aeraenergy.com if you do not want your name listed. There will also be a checkbox for this on the PSAAPG membership renewal form that goes out before the end of this year.

Announcement

Larry Knauer

Larry Knauer of PSAAPG is looking for copies of the PSAAPG newsletters.

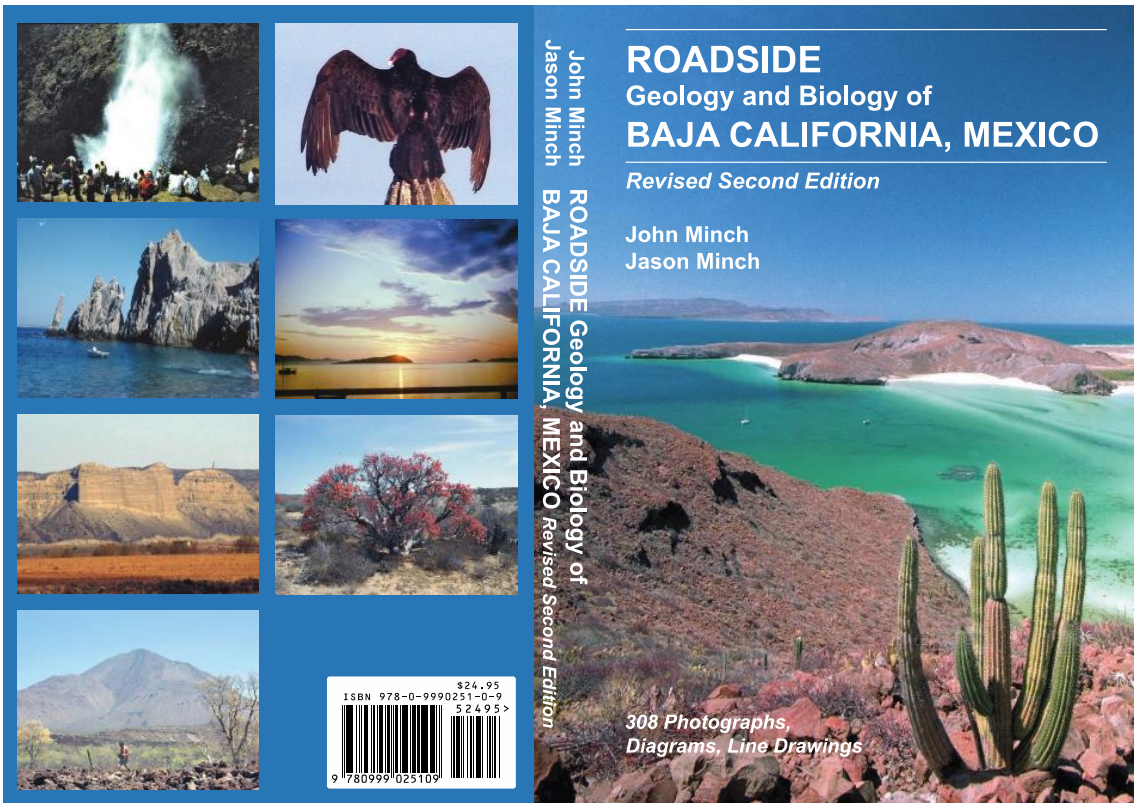
Issues: (March/April 2006) (March/April 2007), and (May/June 2007).

You can contact him at laknauer@gmail.com or laknauer@aol.com or call 661-205-4463.

Be a part of the PSAAPG Newsletter!!

The PSAAPG Newsletter is always looking to highlight its members' insights and expertise. Be a part of the bi-monthly newsletter by sending in your technical articles to:
editor@psaapg.org

Articles for the newsletter should be no more than 7 pages in total. Any figures or images (graphics, photos, and scans) must be at least 300 dpi resolution. Scanned photos, illustrations (line art) should preferably be submitted as a .tif, .gif, or .bmp; .jpeg format and should include titles and captions.



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AAPG Needs Visiting Geoscientists

The AAPG Visiting Geoscientist Program needs volunteers to give talks at colleges, universities and local societies.

https://www.aapg.org/career/training/in-person/visiting-geoscientists

Because travel time and cost is the largest impediment to getting good people to where they are needed, it is best to have a reservoir of good, interesting speakers available in each region.

The Pacific Section needs you!

To become a Visiting Geoscientist an individual must be:

- Be a current AAPG Member.
- Have five or more years of geology experience.
- Active in the petroleum geology field.
- Interested in encouraging career development in geology.
- Make at least one visit per fiscal year.

https://www.aapg.org/career/training/in-person/visiting-geoscientists/become-vg

Please register and apply to be an AAPG Visiting Geoscientist!

From the California Department of Conservation:

California Oil & Gas Regulator Has New Name, Focus

SACRAMENTO – Effective January 1, 2020, California's regulatory entity for oil, gas, and geothermal production has an updated focus and a new name: the California Geologic Energy Management Division (CalGEM).

Housed within the California Department of Conservation, CalGEM replaces the Division of Oil, Gas, and Geothermal Resources (DOGGR). This change comes as a result of Assembly Bill 1057 (Assemblymember Limón, D-Santa Barbara), which was signed by Governor Newsom on October 12, 2019.

"This division began in 1915, when the focus was on the development and production of petroleum resources," DOC Director David Shabazian said. "This mission has since evolved, and protection of public health, safety, and the environment is a heightened priority. As we continue to focus on this enhanced priority, we are also helping to guide the broader transition to a low-carbon future."

In addition to changing the division's name and elevating the focus on health, safety, and the environment, the legislation:

- Requires CalGEM to reduce and mitigate greenhouse gas emissions associated with the development of hydrocarbon and geothermal resources in a manner that meets the energy needs of the state.
- Provides CalGEM the authority to require increased financial assurances from onshore operators if existing assurances are inadequate.
- Mandates additional documentation from operators when ownership of wells or facilities changes, such as proof of sale and lease agreements.

"We will continue to focus on ensuring compliance with California's laws and regulations while increasing our health, safety, and environmental efforts," said Uduak-Joe Ntuk, State Supervisor of Oil and Gas. "Concurrently, we will oversee energy production in a manner that aligns with the state's clean energy and climate goals."

Oil became a commercial commodity in California in the mid-1850s. The Los Angeles City oil field was discovered in 1893, and many other significant fields in Kern County were producing by 1910.

California established CalGEM's predecessor in 1915 to permit the drilling, operation, and closure of oil and gas wells, and to track information about production. CalGEM is the repository of more than 170,000 well records, production and injection statistics, well logs, and field maps. The standards for permanently closing old wells – an important step in protecting drinking and agricultural water – have become more protective over the years.

California remains one of the country's largest oil-producing states, but production has declined dramatically since 1985, when the state's fields produced 424 million barrels. A preliminary report for 2018 puts California's production at 161.8 million barrels.

Contact:
Public Affairs Office
pao@conservation.ca.gov
(916) 323-1886

Geology of the Transition Zone Reservoir, West Tejon Area, Tejon Oil Field

Excerpts from the *Transition Zone Aquifer Exemption Application, West Tejon Field*

Editor's Note: Aquifer Exemptions are public documents available for viewing and downloading from the CalGEM website (https://www.conservation.ca.gov/calgem/Pages/Aquifer-Exemptions-Status.aspx#tejon). Aquifer exemption applications contain a wealth of new geologic and reservoir information much of which has never been presented at technical conferences or in journals. The Transition Zone discussion below is reproduced from Section 4.1 of the aquifer exemption application and is edited for clarity and conciseness. Figures are renumbered to match the edited discussion. The application was submitted to DOGGR on July 12, 2016 and approved by EPA on February 9, 2017.

Section 4: Aquifer Characterization

4.1 Transition Zone

Topography in the vicinity of the West Tejon field is relatively flat with a very gentle dip to the north-northeast and elevations of about 1,000 to 1,170 feet (Figure 1). There are no outcrops in the Tejon fields, and the surface is covered with alluvial sediments (Figure 2). Older Quaternary sediments (mapped as the Tulare Formation) outcrop a mile to the northwest in the Wheeler Ridge oil field, and older sediments outcrop three miles to the south in the San Emigdio Mountains (Figure 2).

4.1.1 Geology

Stratigraphy

Near-surface soils in the vicinity of the West Tejon field include unconsolidated Quaternary alluvium consisting of older stream and terrace deposits and more recent flood basin deposits, and the undifferentiated Plio-Pleistocene sedimentary deposits of the Kern River Formation (Todd Engineers, 2007). The Kern River Formation consists of poorly sorted lenticular deposits of clay, silt, sand, and gravel derived primarily from the San Emigdio and Tehachapi Mountains. The Kern River Formation is considered to be stratigraphically equivalent to the Tulare Formation, seen further to the north and west-northwest in the San Joaquin Valley Basin. The unconsolidated Quaternary alluvium, which comprises the upper portion of the primary aquifer system, consists of moderately to highly permeable older stream and terrace deposits and younger poorly permeable flood basin deposits (Todd Engineers, 2007). The Kern River Formation is known to be highly permeable and yield moderate to large quantities of water to wells (BE, 1995).

The Chanac Formation underlies the Kern River Formation, though the two formations are undifferentiated in the West Tejon field area with a combined thickness of about 2,000 to 2,500 feet. The Transition Zone is believed to represent the basal Chanac and is the only productive and permeable part of the Chanac Formation in the Tejon area.

The "Transition Zone" is a local informal designation for the sandstone that conformably lies between the Chanac Formation and the underlying Santa Margarita Formation as shown on the type log (Figure 3) and geologic cross-sections A-A', B-B' and C-C' (Figures 4 through 6). The cross-section line locations are shown superimposed on the Figure 7. The base of the Transition Zone is defined as the top of the Santa Margarita. Correlations

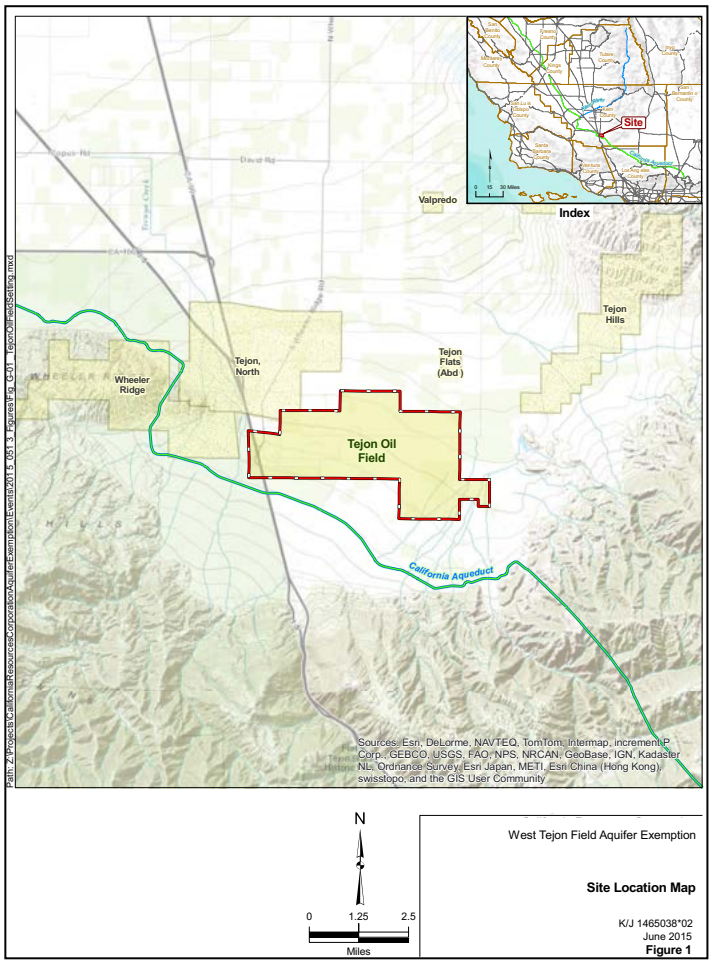

Figure 1. Location map for the Tejon Oil Field

are based on mapping by previous geologists in the West and Central Tejon fields. The shale layer defining the top of the Santa Margarita in the west and southwest portions of the West Tejon field and further east in portions of the Central Tejon field is not consistently present across the field as discussed further below. The Fruitvale Formation underlies the Santa Margarita Formation, and the "Reserve Sand" is an informal designation for the local oil-bearing sandstone present at the base of the Fruitvale (Figure 3).

The Transition Zone is an upper Miocene shelf sand, which grades into turbidite deposits further north into the basin and to non-marine deposits to the south-southeast where they ultimately are truncated against the San Emigdio Mountains (Figure 2). In the West Tejon field, the Transition Zone is extremely sand-rich, consisting of poorly consolidated, friable sandstone that is very fine to very coarse. Pebbles and cobbles are occasionally

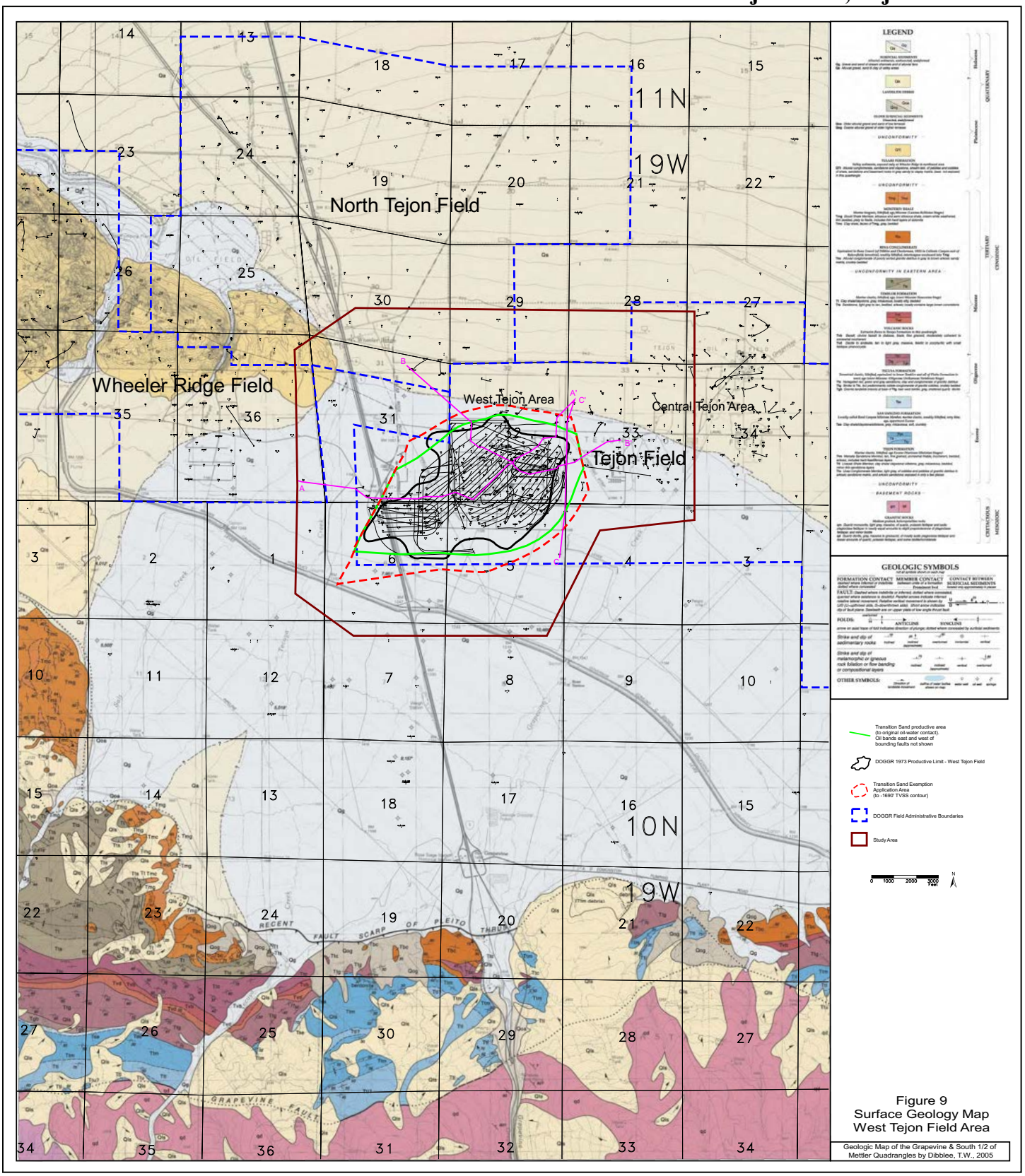

Figure 2. Surface geologic map of the West Tejon Area of the Tejon Oil Field. Geology from Dibblee (2005)

observed in rock cores and drill cuttings, as well as very thin, locally dolomitized sandstone layers. Silt content is highly variable, but clay content is typically low, ranging from 6 to 13 percent, based on x-ray diffraction data.

Porosity of the Transition Zone ranges from 11.2 to 32.7 percent percent (average of 26.4 percent), and permeabilities range from 2 millidarcies to 4,203 millidarcies, with an average of 1,032 millidarcies. Conventional core samples indicate that permeabilities are fairly consistent across the field laterally and vertically.

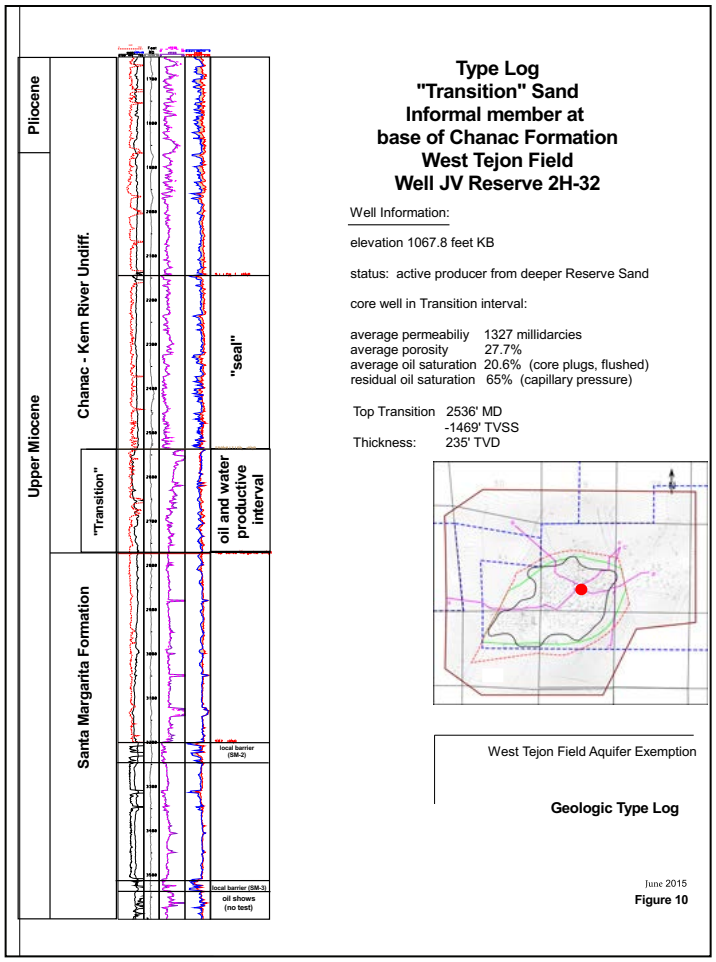

Figure 3. Type log for the West Tejon Area.

In the West Tejon field, the lower Chanac Formation represents a seal, trapping fluid movement above the Transition Zone as evidenced by the large hydrocarbon accumulation in that interval. The lower Chanac is primarily non-marine grading downward into shallow marine shelf sands of the Transition Zone and Santa Margarita Formation. Based on limited core descriptions, the lower Chanac is a very fine grained (occasionally very coarse), very silty, clayey, sometimes pebbly sandstone with variable clay content to a very silty, slightly calcareous mudstone. No oil staining, oil saturations, or other hydrocarbon indicators are observed in the Chanac Formation, except in some of the sand stringers present immediately above the mapped top of the Transition Zone. X-ray diffraction data from well JV Reserve 2H-32 indicate that the lower Chanac is extremely clay-rich, 50 to 52 percent by weight smectite and illite-smectite, effectively creating a seal to vertical fluid flow. The gross thickness of the seal layer at the top of the Transition Zone ranges from approximately 270 to 475 feet within the exemption area, and increases to the east.

Structure

The proposed aquifer exemption area within the Transition Zone is bounded to the west by a northeast-striking fault that extends through Sections 6 and 31, and to the east by a northwest- striking fault that extends through Sections 32, 33, and 4 (Figure 7). The field is bounded to the north and south by the limbs of the anticlinal fold, with the overlying fine-grained rocks (e.g., shale and mudstones) of the Chanac Formation dipping more steeply to the north in Section 32, and to the south in Section 5. Maximum dips appear to be about six degrees in either direction.

The fault locations are based on significant oil-water contact differences, and are interpreted to be barriers to lateral fluid flow, based on the oil column differences. The easterly fault trends northwest-southeast and may have a lateral component of movement, but the apparent displacement is normal and down to the east. Historical oil production immediately to the east confirms the deeper oil-water contact originally interpreted in section 33 at about -1700 feet TVSS (possibly deeper) compared to -1620 feet TVSS in West Tejon field. The fault defining the western edge of the exemption area is a normal fault trending northeast- southwest; oil shows and log response define the lower oil-water contact in the western fault block at about -1685' TVDSS (Figure 4).

The top of the Transition interval ranges in elevation from -1465 feet TVDSS at the crest of the dome in the West Tejon field (Figure 7) to about -2500 feet TVDSS much further to the north in the North Tejon field. Dips are very low with a maximum of about six degrees on the flanks. There is a small subsidiary domal structure in the southwest portion of West Tejon field, which is also very gently dipping. Less than one mile west of the West Tejon field, the top of the Transition interval starts to increase in elevation towards the eastern edge of the Wheeler Ridge field. A little over three miles to the south, the upper Miocene rocks equivalent to the Transition Zone are absent and the Quaternary sediments unconformably overlie the middle Miocene (Luisian-Relizian) Gould Shale Member of the Monterey Formation (Figure 2). To the east, the top of the Transition is defined by an east-west trending anticlinal high in the Central Tejon area (Figure 7). The gross thickness of the Transition Zone is fairly consistent in the subsurface and ranges from about 210 to 270 feet within the requested exemption area.

Containment of Injected Water

Fluids injected into the proposed aquifer exemption area are contained by the bounding faults to the east and west of the field, by the fine-grained rocks of the Chanac Formation overlying the Transition Zone sands, and by an inwardly-directed pressure gradient brought on by maintaining a net-negative fluid balance in the field.

In general, more fluids are produced from the Transition Zone than are injected (oil and water are produced, and only water is returned to the formation), thus maintaining a generally inward gradient. Figure 8 is a graph comparing the volume of fluids extracted from the Transition Zone annually to the volume of produced water injected

In addition to the east and west faults bounding the field, additional faults mapped by Goodman and Malin (1992) may provide structural containment to the north and south of the West Tejon field. Their geologic study of the subsurface in the Tejon and surrounding areas show that the Tejon field is in a faulted graben; northeast striking normal faults are mapped on either side of the West Tejon area and are indicated to penetrate into the Chanac Formation.

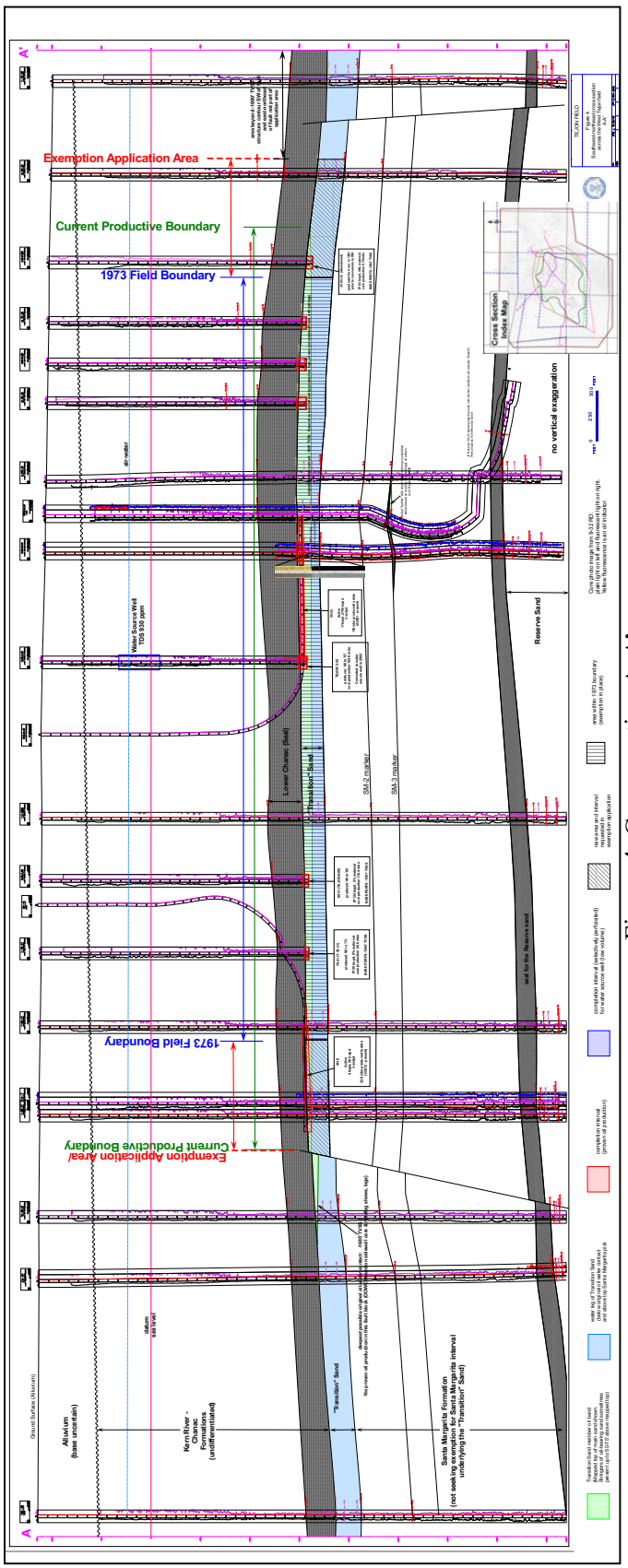

Figure 4. Cross section A-A'.

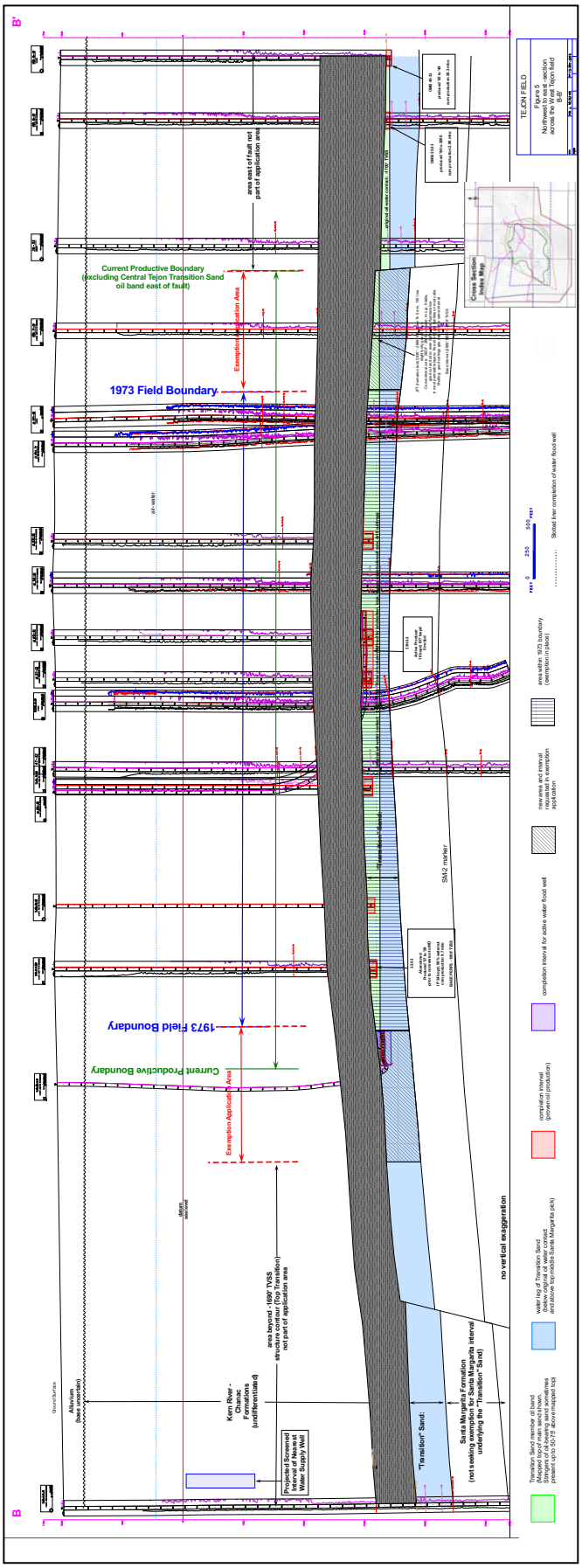

Figure 5. Cross Section B-B'.

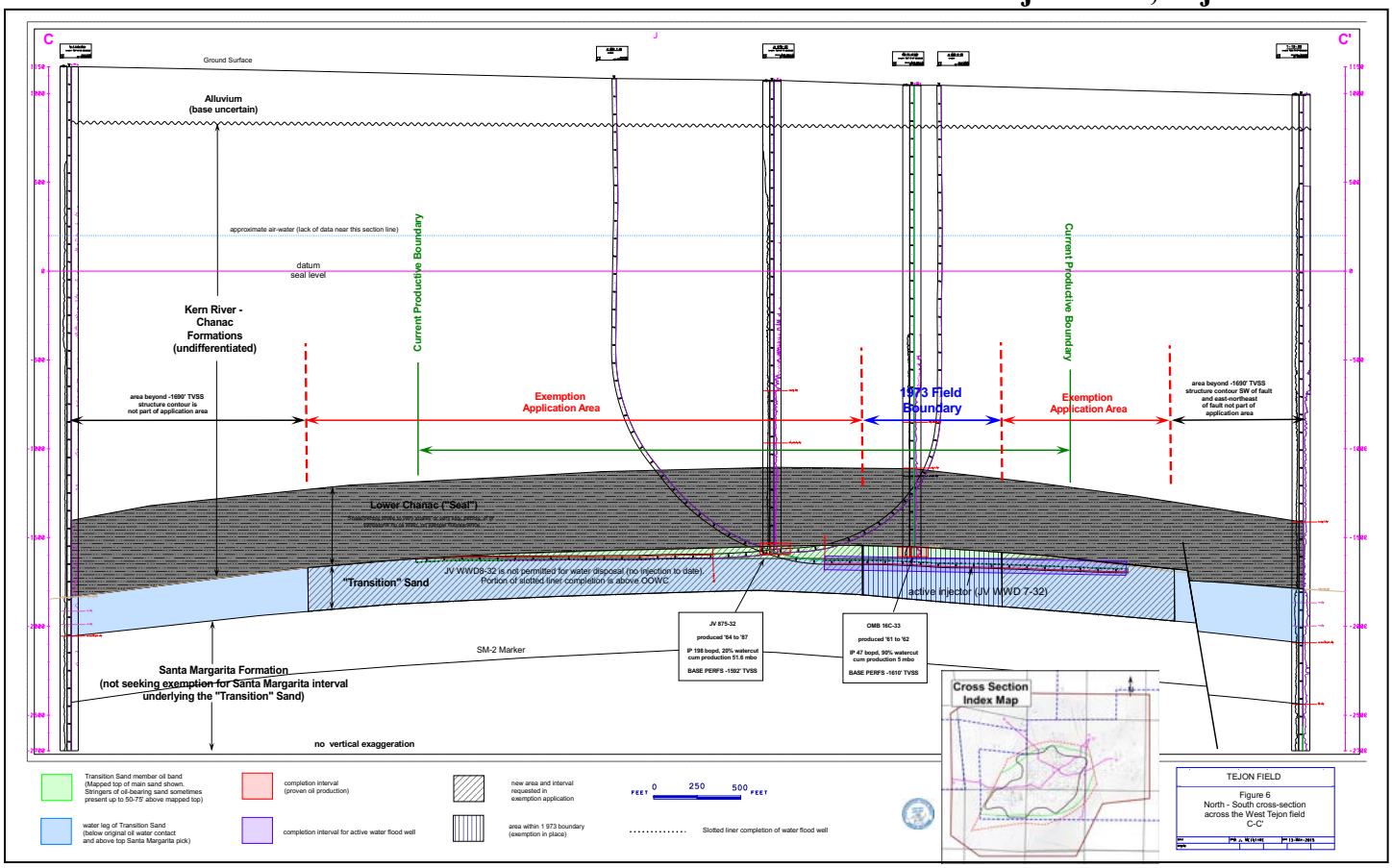

Figure 6. Cross Section C-C'.

There is a lack of laterally extensive internal clay-rich layers that act as barriers to vertical fluid movement within the West Tejon field Transition Zone. Lower pressures created by withdrawal of hydrocarbons create a pressure sink resulting in water movement towards the center of the anticlinal structure (referred to as a "bottom water drive"); the lack of effective barriers makes this flow possible.

4.1.5 Other Criteria – Hydrocarbon Production

The first discovery in the Tejon area was Reserve Oil and Gas Company well No. 2-1 in section 2, T10N, R19W in June 1935 in the East Tejon field; the well produced from the Transition Zone. Two years later, the first discovery in the Central Tejon field was Reserve Oil and Gas Company's well No. 33-3, which initially produced gas from the Reserve sand interval in the lower Fruitvale; the first Transition sand production began in November 1944 with completion of well No. 33-7 in section 33. The West Tejon field discovery was in December 1945 from a Transition sand well, Tejon Ranch 41-5 in section 5, T10N, R19W. Initial production was in excess of 200 barrels per day of 16.5 degree API gravity oil. The productive zones of the older Reserve and Valv sands were discovered in December 1949 and October 1957, respectively, in the West Tejon field.

West Tejon was developed with vertical wells in the 1940s through 1960s reaching peak oil production in the mid-1950s; there was minimal drilling activity in the 1970s through early 1990s. In 1998, horizontal redevelopment of the Transition sand began and rejuvenated the field, initially effectively reducing water-cut (the percent of water measured in the produced fluids). However, water-cuts have steadily increased since the late 1990s and currently exceed 90 percent throughout the field. Installation of horizontal production wells continues today, with five wells completed in 2014.

Operations in the Transition Zone sands include 76 active producing wells and 9 active water injection wells. Production wells currently extract approximately 993 barrels of oil and 49,275 barrels of water per day (based on 2014 totals). The water is separated from the oil and injected back into the Transition Zone sands, from which it was extracted, for the purposes of injection for secondary recovery. Injection is above the base of the Transition Zone, at -1686 TVSS or higher.

Oil Shows

Hydrocarbon shows from core and sidewall cores also confirm the presence of oil down to the oil-water contact. Several wells with deeper penetrations of the Transition sand, generally on the periphery of the field near or just outside of the 1973 field boundary, had good hydrocarbon indicators documented in conventional core descriptions, sidewall core descriptions, and/or mud log drill cuttings descriptions Well 17-33 had a drill stem test in the same interval as the core, and offset well 16C-33 produced from the Transition Zone at similar depths. Well 9-32 RD has core through the oil-water contact (as of 2005); oil shows on the core photos demonstrate brown oil staining in plain light and bright yellow fluorescence in ultraviolet light, both indicating the presence of oil in the core. Production from this well shows good correlation between oil shows in core data and production. The mud log from idle injection well WWD 8-32 shows that the well was drilled through the upper portion

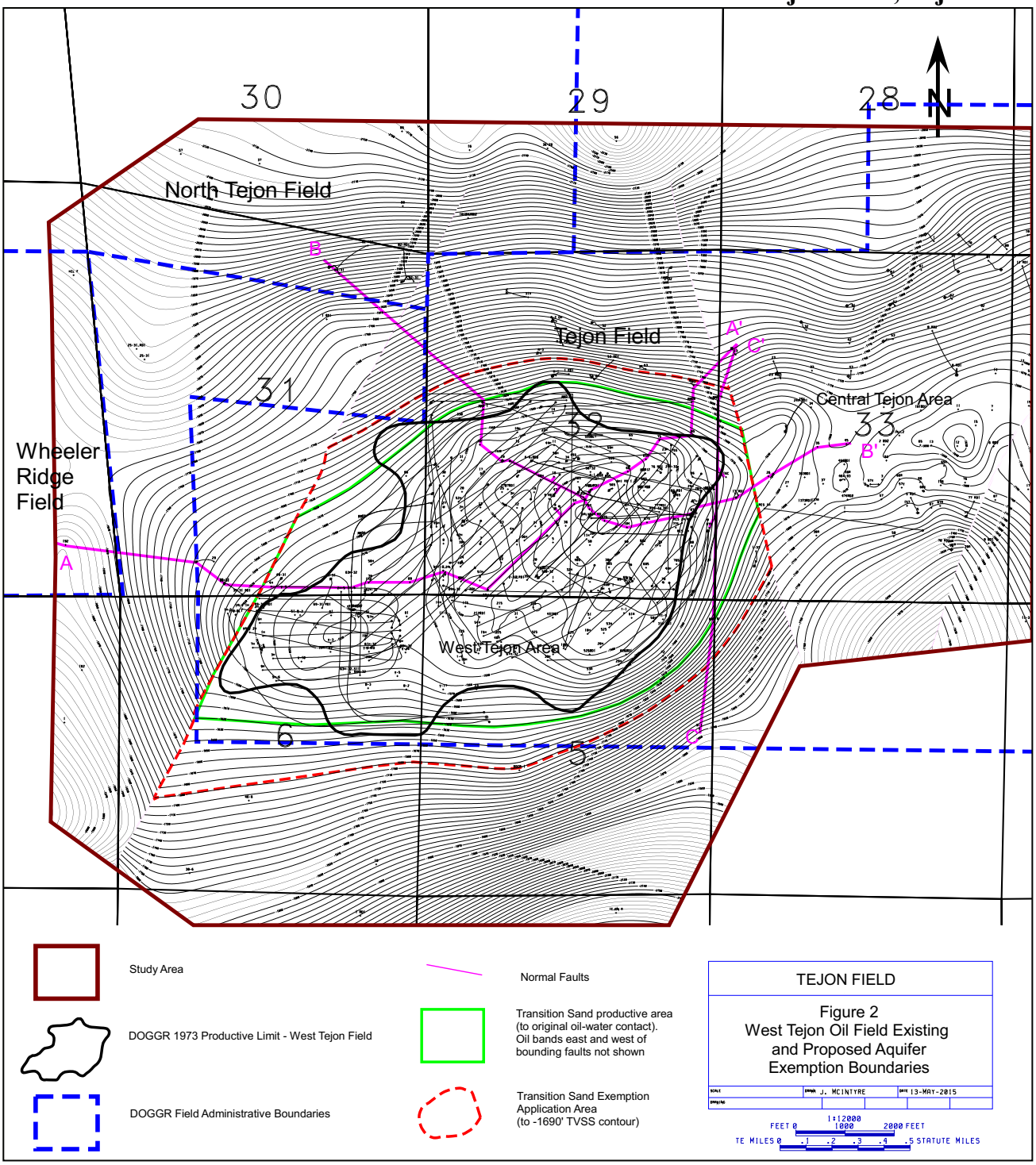

Figure 7. Structure contour map of the top of the Transition Zone. Contour interval is 10 feet.

of the oil band in the build section of the horizontal well, and the shallower portion of the slotted liner completion (Figure 6) is still within the oil band, just above the original oil- water contact. Drill cuttings descriptions starting at about 2815 feet (top of Transition Zone) describe numerous increasing oil shows after this depth including free oil, bright yellow-gold sample fluorescence, bright cut fluorescence, and petroleum odor.

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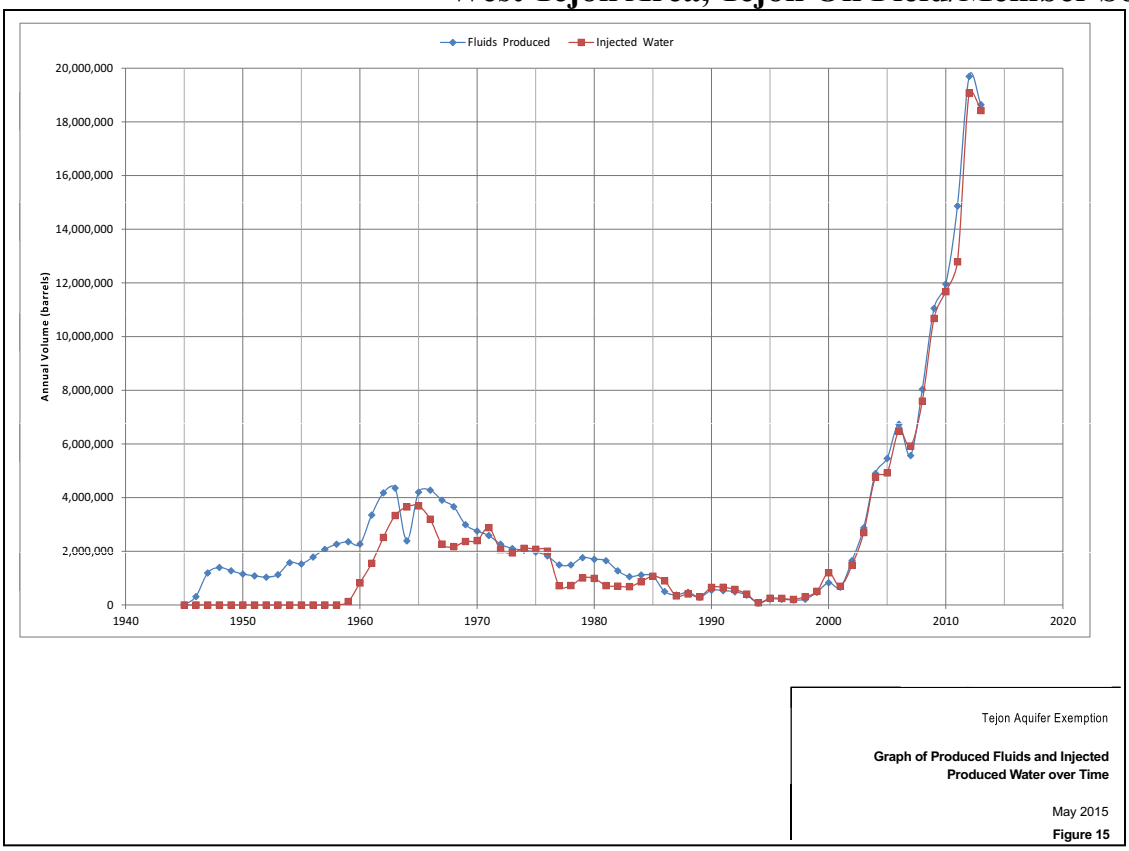

Figure 8. Graph of annual fluid production and water injection.

Member Society News

Alaska Geological Society

February 18, 2020, Tuesday

Speaker: TBA

Topic: TBA

March 17, 2020, Tuesday

Speaker: Dave Buthman, Hilcorp

Topic: Cook Inlet Exploration: Past, Present, and Future

April 17-18, 2020, Friday - Saturday all days

2020 AGS & UAF Technical Conference - Website

2020 Vision: "Standing with the University of Alaska Geosciences"

University of Alaska, Fairbanks, Reichardt Building

May 21, 2020, Thursday

Speaker: Tom Douglas, Cold Regions Research and Engineering Laboratory

Topic: TBA

Coast Geological Society

February 18, 2020

Speaker: Jeff Kimber

Topic: CalGEM UIC

March 17, 2020: TBD

April 21, 2020
Speaker: Gregg Wilkerson
Topic: Known Geologic Structure Program

L.A. Basin Geological Society

February 28, 2020: TBA

Northern California Geological Society

November 20th, 2019
Speaker: Dr. David P. Schwartz — USGS
Topic: Earthquakes in the East Bay

Northwest Energy Association

Thursday February 20, 2020: TBA
Thursday March 19, 2020: TBA
Thursday April 16, 2020: TBA
Thursday May 21, 2020: TBA

Sacramento

FEBRUARY 19, 2020
Speakers: Mike Cummings, Roland Bain, Scott Hector
Topic:"The History of Natural Gas Development and Use in the Sacramento and Northern San Joaquin Basins, California", followed by "Drilling Highlights of 2020"
MARCH 18, 2020
Speaker: Robert G. Lindblom
Topic: TO BE ANNOUNCED
APRIL 15, 2020
Speaker: Robert Sterling
Topic: "What Is Next for the "Mature" Sacramento Basin? The West Side Story, A Brief Look into the Lower Cretaceous and Upper Jurassic Sediments"
May 20, 2020
Speaker: Dr. Jeff Unruh
Topic: "Deformation of the Ancestral Forearc During Late Cretaceous-Early Tertiary Blueschist Exhumation, Mt. Diablo Region"

San Joaqiun Geological Society

February 12, 2020
Speaker: Janis Hernandez
Topic: The recent Ridgecrest Earthquakes
This is our Valentines Dinner Meeting so spouses are welcomed and encouraged.

Alaska Geological Society

www.alaskageology.org

P. O . Box 101288
Anchorage, AK 99510

Contact: Keith Torrance
ktorrance@gci.net

Geology meetings/talks are held monthly September through May, usually on the third Thursday of the month, at the BP Energy Center (1014 Energy Court) from 11:30 am to 1:00 pm. Open To The Public. No Charge to Attend.

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Coast Geological Society

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805-628-2312

Dinner meetings are held monthly September through May, on the third Tuesday of the month, at Poinsettia Pavilion, 3451 Foothill Road in Ventura. Social hour starts at 6:00 p.m., dinner is served at 7:00 p.m., and the talk starts at 8:00 p.m.
The cost of dinner with reservations is $20 (members), $25 (non-members), or $10 (students and K-12 teachers).
For reservations, please email Shelby Fredrickson (secretary@coastgeologicalsociety.org), and should be made by 4:00 p.m. on the Friday before the meeting.

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Los Angeles Basin Geological Society

www.labgs.org

Contact: Bert Vogler
949-585-3103

Luncheon meetings are held monthly September and October; and January through June, usually on the fourth Thursday of the month, at The Grand at Willow Street Conference Centre (4101 E. Willow Street) in Long Beach. Lunch is served at 11:30 a.m., and the talk starts at 12:15 p.m. The cost is $30 (with reservations), $40 (without reservations), $20 for retired members, and $5 for students. "Reservations can be made online at www.labgs.org or by contacting Wanjiru Njuguna at wanjiru.njuguna@gmail.com. Reservations are best made prior to Tuesday before the meeting.

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Northern California Geological Society

www.ncgeolsoc.org

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Hercules, CA 94547-1938

Contact: Barbara Matz
barbara.matz@aptim.com

Evening meetings are held monthly September through May, usually on the last Wednesday of the month, at the Masonic Center (9 Altarinda Road) in Orinda. Social hour starts at 6:30 p.m., and the talk starts at 7:00 p.m. (no dinner).
For reservations, contact Dan Day at danday94@pacbell.net before the meeting.
Cost is $5 per regular member; $1 per student member; and $1 per K-12 teachers.

(Continued on next page)

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Northwest Energy Association
www.nwenergy.us

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Portland, OR 97228

Contact:
Jim Jackson or John Armentrout

Luncheon meetings are held monthly September through May, on the third Thursday of the month, at the Multnomah Athletic Club (1849 SW. Salmon Street) in Portland, Oregon. Meeting time is at 11:45 AM to 1:00 PM (speaker about 12:15 PM). The cost is $25 for members and $30 for non-members. For information or reservations email NWEnergyAssociation@gmail.com, or our Postal Box: Northwest Energy Association, P.O. Box 6679, Portland, Oregon 97228-6679.

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Sacramento Petroleum Association

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Folsom, CA 95630

Contact: Pam Ceccarelli
916-439-0400

Luncheon meetings held monthly January through November, on the third Wednesday of the month. Location: Club Pheasant Restaurant in West Sacramento. The meetings start at noon. The cost is $16 - $20. For information or reservations, contact Pam Ceccarelli.

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San Joaquin Geological Society
www.sanjoaquingeologicalsociety.org

P. O. Box 1056
Bakersfield, CA 93302

Contact: Jennifer Prosser
jprosser@envirotechteam.com

We have dinner meetings on the second Tuesday of the month, October through June, at the American Legion Hall (Post 26) at 2020 H Street, Bakersfield, CA 93301. There is an icebreaker at 6:00 p.m., dinner at 7:00 p.m., and a talk at 8:00 p.m. Dinner is $30 for members with reservations, $35 for nonmembers and members without reservations and $15 for Students.

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