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Comment Received From: Matthew d'Alessio
Submitted On: 6/5/2017
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Comment about seismic safety of Aliso Canyon and impact on summer reliability

Additional submitted attachment is included below.

CSUN | CALIFORNIA STATE UNIVERSITY NORTHRIDGE

June 5, 2017

Robert Weisenmiller
Chair, California Energy Commission

Dear Chair Weisenmiller,

On February 6, 2016, I provided public comment to DOGGR about the Aliso Canyon Comprehensive Safety Review (see attached). As a geologist with expertise in active tectonics, I want to share those comments with the CEC and ensure that they are considered as part of the 2017 summer reliability study.

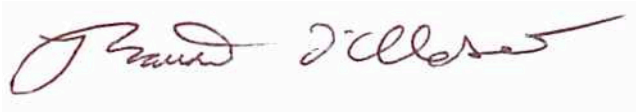
SoCalGas seems very risk averse in its hydraulic modeling and desires for short term electric reliability, but downplays the risk of seismic hazard at the site. SoCalGas stated, "Since November of 2015, SoCalGas has complied with mandated safety regulations at Aliso Canyon and the field is ready for normal operation."[1] I disagree that the field is 'ready for normal operations.' It is up to CPUC and DOGGR to certify that the field is ready for normal operation, and these agencies clearly indicated that:

> "The inspection team found Checklist #4 and the on-site conditions are compliant, **conditioned upon further study as recommended by subject matter experts at the Berkeley, Sandia and Lawrence Livermore National Laboratories** (National Laboratories). Additional study in conjunction with the National Laboratories to evaluate seismic risk mitigation measures will be undertaken beginning in 2017."[2] [emphasis added]

It is important that these studies be completed and added to the public record where their methodology can be reviewed and discussed. Once the risk is properly quantified, policy makers can weigh the relative risks, costs, and mitigation options.

The financial impact of another blowout at Aliso Canyon is much larger than the cost of a short-term electrical curtailment. While I recognize that there are difficulties mitigating against a short term curtailment, it is also a daunting challenge to protect the facility from the massive movements expected in an earthquake along the Santa Susana fault. Continued aggressive investment in mitigation strategies such as demand response and energy efficiency are more likely to be ensure both short and long-term reliability than depending on Aliso Canyon.

Sincerely,



Matthew d'Alessio
Associate Professor, Department of Geological Sciences

[1] SoCalGas, Presentation by Rodger Schwecke with Southern California Gas, http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-11/TN217673_20170522T082453_Joint_Agency_Workshop_on_Energy_Reliability_in_Southern_Califor.pdf, slide 11

[2] Letter to SoCalGas from DOGGR dated January 17, 2017. http://www.conservation.ca.gov/dog/Documents/Aliso/2017.1.17_DOGGR_Letter_of_Findings_regarding_Aliso_Canyon_Storage_Facility.pdf.

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February 6, 2016

Department of Conservation
Division of Oil, Gas, and Geothermal Resources
Attn.: Ken Harris, Supervisor
801 K Street, MS 24-02
Sacramento, CA 95814
Via Email to Alisocomments@conservation.ca.gov

RE: Aliso Canyon Comprehensive Safety Review

Dear Mr. Harris and DOGGR:

Summary

Seismic hazards are significant at Aliso Canyon and should be quantified and mitigated before Aliso Canyon is permitted to reopen. SoCalGas should submit results showing the effects of ground shaking and fault rupture on the surface and underground facilities. Once they have fully identified these risks, they should be required to mitigate them before the facility is permitted to operate. Mitigation measures should include the installation of subsurface safety valves that protect against leaks caused by seismic events.

Background

The Aliso Canyon gas storage facility is located directly above the Santa Susana fault and associated structures. The state recognizes this fault as active and has designated an Alquist-Priolo special study zone around the fault. The state maps have a note that the precise surface expression has not been officially investigated in the area of Aliso Canyon. However, we can see evidence of numerous subsurface fault crossings in the mud logs of the oil and gas wells drilled at Aliso Canyon. The wells cross the north strand of the Santa Susana fault around 1000 feet, the southern strand around 2500 feet, the Frew fault around 4500 feet, and various other unnamed structures at depth. These faults appear on geologic cross sections specifically because we know of their existence from where the oil and gas wells crossed them. If these wells were houses being built at the surface, the state would mandate a special study and specific mitigation measures. I prepared the attached geologic cross section graphic to illustrate the faults underlying Aliso Canyon.

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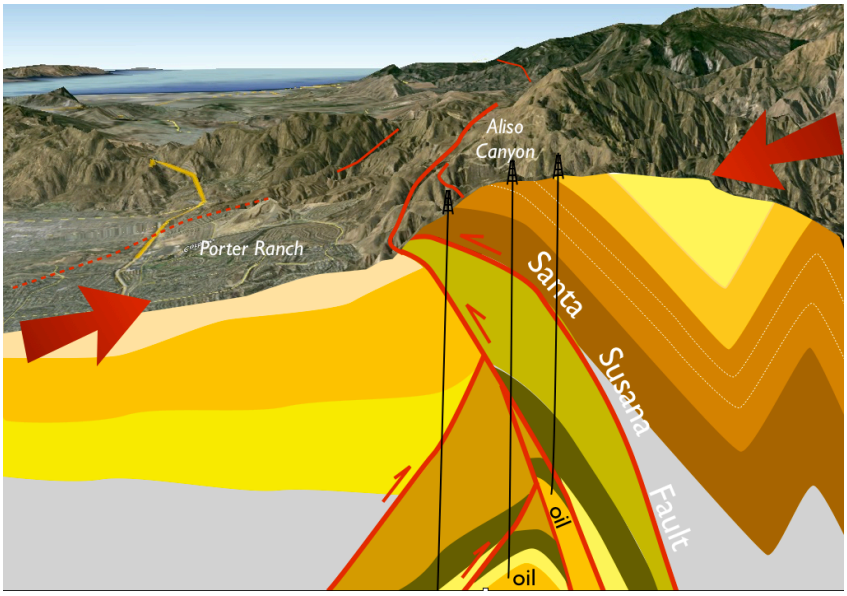

Geologic cross section through the Santa Susana mountains by Diblee (1992)[1] overlain on a Google Earth perspective view.

According to the Uniform California Earthquake Rupture Forecast (UCERF3) developed by the USGS[2], the Santa Susana fault is capable of producing a M7 earthquake, and we know that the eastern section of the fault ruptured in 1971, terminating just east of the Aliso Canyon field. We currently have no information about the last rupture of the section beneath Aliso Canyon. Based on standard models[3], the average slip along the Santa Susana fault will be approximately three feet in size during the next large earthquake and could easily be twice that amount in certain locations.

How would a gas well handle being sheared by three to six feet? We don't have a lot of examples, but in 1949, 200 wells in the Wilmington oil field were damaged when a fault slipped less than one foot and tore the casing apart. In 1983, 14 wells failed by casing collapse or shearing due to shaking in the Coalinga earthquake even though they were not in the immediate epicentral area. And in 1961, an earthquake as tiny as M3.5 damaged nearly 150 wells in Wilmington. While modern casing is improved, 2-6% of the wells at Belridge fail every year from subsidence-induced shearing even in the 21st century[4]. In Table 1, I listed examples of earthquakes in southern California damaged oil and gas wells.

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[1] Dibblee, T. W. (1992). *Geologic Map of the Oat Mountain and Canoga Park (north 1/2) Quadrangles: Los Angeles County, California*. H. E. Ehrenspeck (Ed.). Dibblee Geological Foundation. http://www.dtsc-ssfl.com/files/maps/Geologic%20Map%20of%20Oat%20Mountain%20and%20Canoga%20Park%20-%20North%20Half.pdf

[2] USGS Open File Report 2013-1165. https://pubs.usgs.gov/of/2013/1165/pdf/ofr2013-1165.pdf

[3] Wells, D. L., & Coppersmith, K. J. (1994). New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement. *Bulletin of the seismological Society of America*, *84*(4), 974-1002.

[4] Fredrich, J. T., Arguello, J. G., Deitrick, G. L., & De Rouffignac, E. P. (2000). Geomechanical modeling of reservoir compaction, surface subsidence, and casing damage at the Belridge diatomite field. *SPE*

The risk of damage is so real that the Aliso Canyon field has already experienced such damage. In the 1994 Northridge earthquake (which did not rupture the Santa Susana fault line that runs under Aliso Canyon) SoCalGas reports that well SS-4O collapsed at the Aliso Canyon field. According to their submission, the casing collapse thankfully sealed the well so that there was no uncontrolled leak. As I discuss in recommendation 6 (below), SoCalGas has not provided sufficient evidence that we can always expect such a favorable outcome.

Department of Energy Letter

Recommendation 1) Perform the actions recommended by DOE scientists
Six scientists from the Department of Energy signed a letter to DOGGR dated December 12, 2016. They agree that that "a risk exists from ground shaking and direct shearing/deformation of well casings." The letter suggests several actions and I concur with all of them:

Recommendation 1.1) Perform Probabilistic Seismic Hazard Analysis (PSHA) and probabilistic fault displacement analysis (PFDA).

Recommendation 1.2) **Calculate site-specific shaking hazard rather than relying on the USGS PSHA map**. The 2009 data set present shaking estimates for the entire coterminous 48 states providing regional-scale estimates of shaking. The maps are smoothed and present data at resolution of about 5 km, which is too coarse in an area as geologically complex as Aliso Canyon. Shaking can vary dramatically within a 5 km radius based on the local geology, and DOGGR should require more localized models for a critical facility like this one.

Recommendation 1.3) **Determine a critical threshold for fault slippage as a result of fluid-injection**. Injection wells in Oklahoma have famously triggered earthquakes because of mismanagement of injection pressures. What volume of gas or injection pressure at Aliso Canyon is likely to trigger an earthquake? Supplement #2 includes a page of geomechanical equations and assumptions but never actually presents any findings, indicating that "the stability of the Aliso Canyon faults *will be* assessed…" (p. 8, emphasis on the future tense added).

Recommendation 1.4) **Carry out a detailed analysis of formation-wellbore interaction under seismic loading**. This is an essential step in quantifying seismic risk, but it will be very challenging. Because there is no industry-standard methodology for this, I have concerns that it will be too easy for an applicant like SoCalGas to make assumptions that favor decreased mitigation costs. The process

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Reservoir Evaluation & Engineering, *3*(04), 348-359. https://www.onepetro.org/journal-paper/SPE-65354-PA

will require extensive peer review and consultation between those in the industry and outside to develop a reasonable methodology.

Recommendation 2) Quantitative Seismic Risk Analysis Should Not Wait

The DOE scientists state that necessary seismic studies "should be planned and executed in a deliberate manner" but claim that the studies can be done later. I strongly disagree. The DOE scientists base their judgement on professional instinct, but not on any specific data or quantification of known risk.

The risks and hazards of seismic events at Aliso Canyon requires immediate investigation and analysis before gas is reinjected at high pressure. We wouldn't allow a school to be built near an active fault, allow students to enroll in it, and then schedule a seismic hazard analysis to be completed at a later date. In fact, schools, hospitals, nuclear power plants, dams, housing developments, and even natural gas pipelines at the surface are all required by state or federal regulations to perform such analyses before they are allowed to operate. Gas storage facilities had fallen through the cracks when it comes to regulation, but state law SB380 now requires Aliso Canyon to remain closed to injection until DOGGR's "duty to prevent damage to life, health, property, and natural resources … is satisfied." This duty clearly cannot be satisfied without quantifying and mitigating the seismic risks.

Supplement to SoCalGas' Storage Risk Management Plan #2

In their October 11, 2016 supplement, SoCalGas has set forth a long list of hazards faced at the facility. However, simply listing them is not sufficient to fully address them. Below, I outline several additional recommendations:

Recommendation 3) SoCalGas should be required to act on the mitigation measures spelled out in Section 3.3.10 regarding tectonic/seismic induced failure *prior* to reopening the facility.

Supplement #2 states, "Mitigating casing deformation and tectonically induced failure can be enhanced by well design and monitoring in new wells. Heavy wall, higher strength pipe and good casing cement jobs add strength to resist tectonic forces. The use of liners in existing damaged wells can add resistive strength." (p. 14)

Commentary: This section is entirely written in the hypothetical. These measures do nothing to mitigate the current risk exposure since they have not been implemented in the field.

Recommendation 4) SoCalGas needs to use the results of well integrity tests to calculate the risk of casing deformation.

Supplement #2 states, "The well integrity program currently being performed on the wells should determine if casing deformation is a significant threat to well integrity." (p. 14).

Commentary: Since the well integrity program is nearly complete, SoCalGas should provide a determination. Does casing deformation pose a significant threat?

Recommendation 5) SoCalGas should install Subsurface Safety Valves in Aliso Canyon

Supplement #2 states, "Also, SoCalGas supports the State's interest in examining the feasibility and efficacy of subsurface safety valves for gas storage fields, to address hazards and risks, and to determine if and what types of valves might be appropriate." (p. 14)

Commentary: It is time for DOGGR to act on this important issue. In the July 2016 working group in Denver about well integrity, the discussion consensus was, "One thing that is becoming clear after presentation: There are going to be places where there is a need for safety valves, but there are places where one can mitigate risk without safety valves."[5] With Aliso Canyon located on top of the active Santa Susana fault and having a 78% chance of a major earthquake nearby in the next 50 years, Aliso Canyon should be one of those places where downhole safety valves *are* necessary. The risk from intense ground shaking, landslides and subsurface fault rupture are very real at Aliso Canyon, and SoCalGas acknowledges this.

It appears that the main concern is over the cost and operational down time of the valves. To perform a true cost-benefit analysis, SoCalGas needs to quantify the risks (and potential costs) from seismic hazards. The cost of a single well failure on SS-25 has been hundreds of millions of dollars. An earthquake can cause the failure of multiple wells simultaneously. Further, the actual costs of safety valves may be much smaller in the long term than operators anticipate. Discussion at the July working group on well integrity noted that safety valves manufactured today have higher reliability than they did in the past (i.e., operators may be working with a false preconception about their actual performance), and that "with time and work, they will also be able to manufacture ideas you currently may have only in your mind."[6] In other words, requiring safety valves *now* may spur innovations that will enhance safety at significantly lower future costs.

Recommendation 6) SoCalGas needs to quantify the possible outcomes of casing/tubing damage.

Supplement #2 states, "The tectonically induced casing/tubing damage described above normally does not result in loss of hydrocarbon containment outside of the wellbore. Casing collapse and shear, by nature of the failure, pinches off the casing (and tubing) significantly reducing and often stopping flow potential." (p.11)

Commentary: This claim needs to be supported with references and quantified. Does 'normally' mean that wells get sealed 90% of the time they collapse? Or does normally imply 51%? And in the wells that do have a leak, is the flow reduced by 90%? Or is it more like 25% reduction. These numbers make a difference; if 90% of the wells are sealed but the remaining 10% of wells leak at just 10% of their normal flow rate, the result would still be a leak *bigger* than the SS-25 event (114 * 0.1 * 0.1 = 1.14). And unlike the SS-25 failure which was sealed with a single relief well, it would take months to deploy enough rigs to eliminate these simultaneous well failures.

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[5] https://energy.gov/sites/prod/files/2016/12/f34/Appendix%20I%20-%20Well%20Integrity%20Working%20Group%20Report.pdf, p. 19

[6] Ibid.

Conclusion

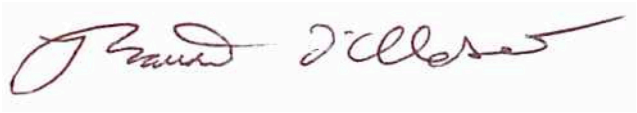
Under the current proposal, Aliso Canyon will store 29 billion cubic feet of flammable, climate-destroying, and health-disrupting natural gas. The state has responded to last year's gas leak with a range of productive safety enhancements, and they should be applauded for those regulatory improvements. However, DOGGR should require SoCalGas to finish the job and complete a seismic hazard analysis followed by appropriate mitigation measures before a decision is made about re-opening the facility.

Qualifications

I have a Ph.D. in Geology from the University of California, Berkeley with an emphasis on active tectonics. I have studied the San Andreas fault system as a researcher and postdoctoral fellow with the U.S. Geological Survey Earthquake Hazards Team and as a visiting professor at the University of Tokyo. Findings from my research are part of the input to the USGS UCERF 3 model of fault rupture hazards for California. I currently teach in the Department of Geological Sciences at California State University Northridge. I have attached a copy of my CV.

I request a written response to my comments prior to any final decision on approving gas injections at Aliso Canyon. Thank you for your consideration.

Sincerely,



Matthew d'Alessio
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Enclosure: CV

Table 1: Previous Earthquake-induced Damage to Oil and Gas Wells in Southern California

Year	EQ Mag	Oil Field	Damage	Source
1941	4.9	Dominguez	15 Wells Damaged	[7]
1944	4.5	Rosecrans	16 wells found damaged by subsurface movement	[8]
1949	4.4	Wilmington	200 wells went out of production, many permanently d displacements of about 20 cm at ~500m depth.	[9]
1952	7.5	Tejon Ranch	6 wells had tubing that couldn't be pulled and had to h drilled next to them. 1 Well at South Coles Levee collap	[10]
1961	3.5	Wilmington	~130 wells failed, and another ~20 damaged	[11]
1963	3.4	Inglewood	Three wells damaged	[12]
1971	6.7	San Fernando	"A few wells" reported minor damage	[13]
1983	6.2	Coalinga	14 wells failed by casing collapse	[14]
1994	6.7	Aliso Canyon	1 well failed by casing collapse; landslides, cracked well cellars, tank farm damage, and pipe support damage	[15]

[7] USGS Professional Paper 0679 (1969), p. 64; Bravinder (1942) http://pubs.usgs.gov/pp/0679/report.pdf

[8] USGS Professional Paper 0679 (1969), p. 64; Martner (1948) http://pubs.usgs.gov/pp/0679/report.pdf

[9] Kovach, 1974, http://www.bssaonline.org/content/64/3-1/699.full.pdf+html; Nicholson and Wesson (1992), p. 572, http://earthquake.usgs.gov/research/induced/pdf/Nicholson-Wesson-1992-Pure-and-Applied-Geophysics.pdf

[10] http://www.bssaonline.org/content/44/2B/201.full.pdf+html

[11] Dusseault, M. B., Bruno, M. S., & Barrera, J. (1998). Casing shear: causes, cases, cures. In *SPE International Oil and Gas Conference and Exhibition in China*. Society of Petroleum Engineers. http://www.geomechanicstechnologies.com/article/spe72060.pdf

[12] USGS Professional Paper 0679 (1969), p. 65; Hudson and Scott (1965), http://pubs.usgs.gov/pp/0679/report.pdf

[13] USGS Professional Paper 0733, p. 118. http://pubs.usgs.gov/pp/0733/report.pdf

[14] USGS Professional Paper 1487, p. 400 http://pubs.usgs.gov/pp/1487/report.pdf

[15] SoCalGas Risk Management Plan, Supplement #2, p. 6. ftp://ftp.consrv.ca.gov/pub/oil/SCG_Attachment/B/4_supplement_socalgas_storage_risk_management_plan2_10-11-2016.pdf