Title
Methane emissions from the 2015 Aliso Canyon blowout in Los Angeles, CA.

Permalink
https://escholarship.org/uc/item/3zt2j8q8

Journal
Science (New York, N.Y.), 351(6279)

ISSN
0036-8075

Authors
Conley, S
Franco, G
Faloona, I
et al.

Publication Date
2016-03-01

DOI
10.1126/science.aaf2348

Copyright Information
This work is made available under the terms of a Creative Commons Attribution License, available at https://creativecommons.org/licenses/by/4.0/

Peer reviewed
In conclusion, pure H\(_4\) conduction was realized in the La\(_{2-x}\)Sr\(_x\)TiO\(_3\)-oxyhydride to act as an H\(_4\) diffusion confirms not only the capability of the oxyhydride to act as an H\(_4\) solid electrolyte but also the possibility of developing electrochemical solid devices based on H\(_4\) conduction.

REFERENCES AND NOTES

1. N. Kamaya et al., Nat. Mater. 10, 682–686 (2011).
2. L. Malavasi, C. A. J. Fisher, M. S. Islam, Chem. Soc. Rev. 39, 4370–4387 (2010).
3. S. Hull, Rep. Prog. Phys. 67, 1233–1334 (2004).
4. R. Kanno, Y. Takeda, Y. Oda, H. Ikeda, O. Yamamoto, Solid State Ion. 18–19, 1056–1072 (1986).
5. G. Dénès, G. Milová, M. C. Madamba, M. Perfiliev, Solid State Ion. 86–88, 77–82 (1996).
6. P. F. Lang, B. C. Smith, Dalton Trans. 39, 7786–7791 (2010).
7. H. Iwahara, H. Uchida, K. One, K. Ogaki, J. Electrochem. Soc. 159, 529–533 (2008).
8. A. F. Andreesen, A. J. Maeland, D. Stofleth-Ellingsen, J. Solid State Chem. 20, 93–101 (1977).
9. B. Wegner, R. Essmann, J. Bock, H. Jacobs, Eur. J. Solid State Inorg. Chem. 29, 1217–1227 (1992).
10. F. Attorfer et al., Solid State Ion. 70–71, 272–277 (1994).
11. B. Zhu, X. Liu, Electrochem. Commun. 2, 10–14 (2000).
12. M. C. Verbraeken, E. Suard, J. T. S. Irvine, Mater. Chem. 19, 2766–2770 (2009).
13. M. C. Verbraeken, C. Cheung, E. Suard, J. T. S. Irvine, Nat. Mater. 14, 95–100 (2015).
14. M. A. Hayward et al., Science 295, 1882–1884 (2002).
15. R. M. Helper, S. H. Rees, M. A. Hayward, Inorg. Chem. 11, 11062–11068 (2010).
16. Y. Kobayashi et al., Nat. Mater. 11, 507–511 (2012).
17. T. Sakaguchi et al., Inorg. Chem. 51, 11571–11576 (2012).
18. H. Schwarz, thesis, Univ. Karlsruhe (1991).
19. J. Bang et al., J. Am. Chem. Soc. 136, 7221–7224 (2014).
20. K. Hayashi, S. Matsuishi, T. Kamiya, M. Hirano, H. Hosono, Nature 419, 462–465 (2002).
21. K. Hayashi, P. V. Sushko, A. L. Shluger, M. Hirano, H. Hosono, J. Phys. Chem. B 109, 23838–23842 (2005).
22. S. Matsuishi, K. Hayashi, M. Hirano, H. Hosono, J. Am. Chem. Soc. 127, 12454–12455 (2005).
23. C. G. Van de Walle, Phys. Rev. Lett. 85, 1012–1015 (2000).
24. G. Chris, Nature 423, 626–628 (2003).
25. J. Zhang, G. Gou, B. Pan, J. Phys. Chem. C 118, 17254–17259 (2014).
26. Details of synthesis condition for the oxyhydrides are described in supplemental materials.
27. J. P. Attfield, G. Ferey, Solid State Ion. 80309, 80 (1989).
28. B. J. Neudecker, W. Wepner, J. Electrochem. Soc. 143, 2198–2203 (1996).
29. A. San-Martin, F. D. Manchester, Ball. Alloy Phase Diagrams 8, 30–42 (1987).

ACKNOWLEDGMENTS

This research was supported by JST, PRESTO, and Grant-in-Aid for Young Scientists (A) no. 19H05497 and (B) no. 24700209. Grant-in-Aid for Challenging Exploratory Research nos. 15K13803, 23655191, and 25602180, and Grant-in-Aid for Scientific Research on Innovative Areas nos. 25200025 and 25000209, from the Japan Society for the Promotion of Science. Synchrotron and neutron radiation experiments were carried out as four projects approved by the Japan Synchrotron Radiation Research Institute (JASRI). (Proposal no. 2013A11704, the Japan Proton Accelerator Research Complex (J-PARC) (Proposal no. 2010A04058), the Spallation Neutron Source (SNS) in the Oakridge National Laboratory (Proposal no. IPTS1058), and the Neutron Scattering Program Advisory Committee of IMS (Proposal no. 2010A4250). A part of neutron experiments (Proposal no. 2010A4250) was performed at BL09 Special environment neutron powder diffractometer (SPICA) developed by the Research and Development Initiative for Scientific Innovation of New Generation Batteries (RISING) project of the New Energy and Industrial Technology Development Organization (NEDO). Supercomputing time on the Academic Center for Computing and Media Studies (ACCMS) at Kyoto University is gratefully acknowledged. Further information regarding the materials and methods is included in the supplementary materials, G.X., A.W., M.H., and R.K. have filed for a patent application with the Japan Patent Office under no. JP2015-22888 on the H\(_4\) conductive oxyhydride system and its manufacture.

GAS INFRASTRUCTURE

Methane emissions from the 2015 Aliso Canyon blowout in Los Angeles, CA

S. Conley,1,2* G. Franco,3 I. Falano,2 D. R. Blake,4 J. Peischl,5,6 T. B. Ryerson6†

Single-point failures of natural gas infrastructure can hamper methane emission control strategies designed to mitigate climate change. The 23 October 2015 blowout of a well connected to the Aliso Canyon underground storage facility in California resulted in a massive release of natural gas. Analysis of methane and ethane data from dozens of plume transects, collected during 13 research-aircraft flights between 7 November 2015 and 13 February 2016, shows atmospheric leak rates of up to 60 metric tons of methane and 4.5 metric tons of ethane per hour. At its peak, this blowout effectively doubled the methane emission rate of the entire Los Angeles basin and, in total, released 97,100 metric tons of methane to the atmosphere.

large volumes of processed natural gas are stored underground to accommodate variability in energy demand on diurnal to seasonal time scales. Underground storage facilities constitute strategic gas reserves in many countries worldwide, with a volume equal to 10% of global annual consumption (7). Roughly 86% of stockpiled natural gas in the United States is stored at high pressure in depleted subsurface oil reservoirs (2). The Aliso Canyon storage facility, a depleted subsurface oil reservoir in the San Fernando Valley 40 km northwest of Los Angeles, CA, has a total capacity of 168 billion standard cubic feet (SCF) (4.79 × 10\(^9\) m\(^3\)) at standard temperature and pressure, of which only 86 billion SCF (2.5 × 10\(^8\) m\(^3\)) is working capacity (8). The “working capacity” is routinely accessed for commercial use (9). It is the fourth largest facility of its kind in the United States, accounting for 2.1% of the total U.S. natural gas storage in 2014 (10). Processed natural gas is composed primarily of methane (CH\(_4\)), a powerful greenhouse gas, and ethane (C\(_2\)H\(_6\)) both of which can lead to background tropospheric ozone production; at sufficiently high concentrations, natural gas leaks pose an explosion hazard and, if inhaled, can induce nausea, headaches, and impaired coordination. Exposure to odorants that are added to natural gas, which are typically sulfur-containing compounds such as tetrahydrothiophene ([CH\(_2\)S]\(_4\)) and 2-methylpropane-2-thiol [\(\text{CH}_3\text{CH}_2\text{SH}\)] can cause short-term loss of the sense of smell, headaches, and respiratory tract irritation. Major natural gas leaks therefore can have adverse impacts on climate, air quality, and human health.

On 23 October 2015, a major natural gas leak of indeterminate size was reported in the Aliso Canyon area and was later identified as originating from SS-25, one of 115 wells connected to the subsurface storage reservoir. The SS-25 well began oil production in 1954 and was converted to a gas storage well in 1973 (3). Seven unsuccessful attempts to close the leak have been reported. A relief well intercepted the leaking pipe at a depth of ~2600 m below the subsurface breach; heavy fluid injection (“a bottom kill’) temporarily halted the leak on 11 February 2016, and cement injection sealed the well on 18 February 2016 (4).

We deployed a chemically instrumented Mooney aircraft in 13 flights from 7 November 2015 to 13 February 2016. We measured CH\(_4\) and C\(_2\)H\(_6\) to quantify the atmospheric leak rate and to assess air quality downwind of the leaking well (5). Ground-based whole-air sampling (WAS) with stainless steel canisters on 23 December 2015, followed by laboratory analysis, provided information on the chemical speciation of the leaking hydrocarbon mixture. We used the continuous airborne data and the ground-based WAS canister
data to fingerprint the plume's chemical composition, quantify the atmospheric leak rate, and document trends in the leak rate over time.

The airborne chemical data showed the continuing transport on northerly winds of exceptionally high concentrations of CH\(_4\) and C\(_2\)H\(_6\) into the densely populated San Fernando Valley, a few kilometers south of the leaking well (Fig. 1). The plume C\(_2\)H\(_6\)-to-CH\(_4\) enhancement ratio (ER) derived from linear least-squares regression fits to the 23 December 2015 continuous airborne data is identical, within total uncertainties propagated by quadrature addition of errors (6), to the plume ER derived from WAS canister data taken at the same day (Fig. 2A).

The hydrocarbon composition of WAS canister samples taken at surface locations in the San Fernando Valley (Fig. 1) on 23 December 2015 (5) is consistent with a leak of pipeline-quality processed natural gas with a hydrocarbon composition of ~95% CH\(_4\), ~4% C\(_2\)H\(_6\), and ~0.3% propane (C\(_3\)H\(_8\)) (table S1). Plume enhancements of natural gas liquids (ethane, propane, and butanes) and condensates (pentanes and longer-chain hydrocarbons that are liquid at ambient temperature and pressure) were detected (table S1) and were probably responsible for reports of oily deposits on surfaces in downwind residential areas. Trace enhancements of benzene, toluene, ethylbenzene, and xylenes (the so-called BTEX compounds) were also detected at ratios of 0.001% or lower relative to CH\(_4\) (table S1).

Benzene is a known human carcinogen (7); thus, population exposure to benzene from the Aliso Canyon leak has received particular attention. Composition data from the WAS canisters indicate a benzene-to-CH\(_4\) enhancement ratio of (5.2 ± 0.1) × 10\(^{-6}\) (uncertainties throughout are ±1 SEM), which is broadly consistent with an ER of ~7 × 10\(^{-6}\) found in highly concentrated samples that were collected ~3 m downwind of the SS-25 well site (8). Together, these samples suggest minimal variation over time in the benzene composition of the leaking gas. Publicly available benzene data, reported in near-daily 12-hour air samples (9), were often below the detection limit of 1 nmol/mol [or 1 part per billion (ppb)] of the contract laboratories used for the analyses, but these data also show a relatively constant ER over time. Plume benzene enhancements can be estimated from the abundant CH\(_4\) data by multiplying plume CH\(_4\) enhancements by the benzene-to-CH\(_4\) ER determined using the research-grade WAS canister samples. Sulfur-containing odorants were not measured, but concentrations above the odor threshold can be estimated similarly (Fig. 1) from observed CH\(_4\) enhancements by assuming an industry-standard value of ~5 parts per million (ppm) of total odorant in processed natural gas (10).

Continuous airborne CH\(_4\) and C\(_2\)H\(_6\) data were taken on each flight between 11 AM and 3:30 PM (local time) with a resolution of 30 m along-track during repeated crosswind transects at multiple altitudes from 60 to 1400 m above ground. These data define the horizontal and vertical extent of the leaking natural gas plume on each flight (Fig. 1 and fig. S1). The flights provided highly spatially resolved data from which an atmospheric mass flux can be accurately calculated (11) within well-defined uncertainties (12). Plumes from nearby landfills have low concentrations of CH\(_4\) are easily identified by their lack of co-emitted C\(_2\)H\(_6\), and were eliminated from further analysis. Background levels of CH\(_4\) and C\(_2\)H\(_6\) were measured during aircraft transects on multiple flights immediately upwind, confirming the SS-25 well as the dominant source of enhanced natural gas to the region. Operational restrictions on aircraft flight patterns were imposed by the elevated terrain at the leak site, the highly controlled airspace of the San Fernando Valley, and the proximity to approach corridors of the nearby Van Nuys Airport (Fig. 1). These restrictions were overcome by performing crosswind transects at multiple altitudes immediately downwind of the leak site.
suggest an average leak rate of 53 ± 3 metric tons x 10^3 metric tons x 10^3

CH4 released, 0 to day 43, an exponential decrease between days 43 and 80, and an average leak rate thereafter to day 112, when control was restored. (C) The total amount of CH4 released (in metric tons), calculated from the fit in (B). Error bars indicate ±1 SEM.

Fig. 2. Time series of the Aliso Canyon natural gas leak. (A) Plume C2H6-to-CH4 ERs from airborne measurements (open circles) and ground-based WAS measurements (red square). (B) Leak rates (in metric tons per hour) of CH4 (open circles) and C2H6 (blue circles), determined from airborne measurements. The red line is a fit to the airborne CH4 data, assuming an average leak rate from the blowout (day 0) to day 43, an exponential decrease between days 43 and 80, and an average leak rate thereafter to day 112, when control was restored. (C) The total amount of CH4 released (in metric tons), calculated from the fit in (B). Error bars indicate ±1 SEM.

which enabled accurate reconstruction of a vertical concentration profile, even before the plume had completely mixed throughout the full vertical extent of the atmospheric boundary layer (5).

The chemical data show that the airborne sampling captured the full vertical extent of the lofted plumes on each flight day (fig. S1). Atmospheric mass fluxes calculated from the chemical data from each transect collected downwind (5) suggest an average leak rate of 33 ± 3 metric tons of CH4 and 3.9 ± 0.3 metric tons of C2H6 per hour for the first six weeks of the leak, decreasing thereafter (Fig. 2B and table S2). The decreasing trend, which began around the first week of December 2015 (Fig. 2B and table S2), is consistent with decreasing reservoir pressure in response to the withdrawal of gas through other wells, before the reservoir was completely exhausted to the atmosphere. (5, 34).

Aliso Canyon will have the largest climate impacts of major unanticipated chemical releases in the United States (28). The volume of CH4 released represents only 3% of the total capacity of the Aliso Canyon storage facility, raising the possibility of substantial additional emissions if the leaking SS-25 well had not been sealed, or if the remaining natural gas had not been withdrawn through other wells, before the reservoir was completely exhausted to the atmosphere.

The agreement reached at the 21st Conference of the Parties (COP21) to the UN Framework Convention on Climate Change (29) includes specific requirements for the Parties to account for anthropogenic GHG emissions with accuracy and completeness. In the post-COP21 world, rapid evaluation of episodic GHG release events, such as the Aliso Canyon blowout, will be an essential contribution to meeting these requirements.

Our analysis quantifies a massive CH4 release using a rapid, direct, and repeatable method with known accuracy. As such, results from this method serve as reference values for less direct and timely estimates that use retrievals of surface (30, 31), airborne (32), and/or satellite remote sensing observations (33). For example, our airborne method offers a priori estimates of the Aliso Canyon leak rates that can be used for inverse modeling analysis of continuous in situ CH4 monitoring data from fixed ground sites (15, 34). This incident highlights the utility of rapid-response airborne chemical sampling in providing an independent, time-critical, accurate, and temporally resolved leak rate, as well as in ascertaining the source location and plume chemical composition. Such information can help to document human exposure, formulate optimal well-control intervention strategies, quantify the efficacy of deliberate control measures, and assess the climate and air quality impacts of major unanticipated chemical releases to the atmosphere (35, 36).

REFERENCES AND NOTES

1. S. Conrot-Gandolphe, Underground Gas Storage in the World 2013: Executive Summary (Centre International d’Information sur le Gaz Naturel et tous Hydrocarbures Gazeux, Rueil-Malmaison, France, 2013).
2. Natural Gas Annual Responder Query System (U.S. Energy Information Administration, 2015); www.eia.gov/iafppps/ngppsys/NGPPSysReportRIP?
3. State of California Department of Conservation, Division of Oil and Gas, Report on Proposed Change of Well Designation (1991); ftp://ftp.consrv.ca.gov/pub/oil/Standard_Sanctions_25-API/037-00776_Well_03700776_DATA_03-10-2008.pdf.
4. SoCalGas, press release (18 February 2016); www.socalpurposes.com/144373851730/press-release-dogrn-confirms-en.pdf.
5. Materials and methods are available as supplementary materials on Science Online.
6. P. R. Bevington, D. K. Robinson, Data Reduction and Error Analysis in the Physical Sciences (McGraw-Hill, ed. 3, 2003).
7. U.S. Environmental Protection Agency (EPA), “Benzene” (2014); http://epa.gov/iris2/chemicallanding.cfm?subject_name=rn=276.
8. South Coast Air Quality Management District, “Laboratory results” (2016); www.scaqmd.gov/home/regulations/compliance/aliso-canyon-updates/gas-sample-near-leaking-well/laboratory-results [accessed 13 February 2016].
9. SoCalGas, “Aliso Canyon air sample results” (2016); www.socalgas.com/newsroom/aliso-canyon-updates/aliso-canyon-air-sample-results.
10. Pacific Gas and Electric Company, “Gas system sulfur survey results” (2015); www.pge.com/pipeline/operations/surveys/sulfur_info_values/index.page.
11. W. H. White et al., Science 194, 187–189 (1976).
12. T. B. Ryerson et al., Science 292, 719–723 (2001).
13. SoCalGas, press release (11 February 2016); www.socalpurposes.com/1443738468372/SoCalGas-Temporarily-Controls-Flow-of-Gas-021116-2.pdf.
14. U.S. EPA (2014); http://ghgdata.epa.gov/ghgp/service/html/.
15. S. Jeong et al., J. Geophys. Res. 117, D11306 (2012).
16. J. Peischl et al., J. Geophys. Res. Atmospheres 118, 4974–4990 (2013).
17. Total, press release (11 March 2013); www.elgin.total.com/elgin/pressrelease.
18. A. Karian et al., Environ. Sci. Technol. 49, 8124–8131 (2015).
19. J. Peischl et al., J. Geophys. Res. 120, 2191–2139 (2015).
20. A. R. Brandt et al., Science 343, 733–735 (2014).
21. A. Karian et al., Geophys. Res. Lett. 40, 4393–4397 (2013).
22. F. A. Kort et al., Geophys. Res. Lett. 41, 6898–6903 (2014).
23. G. Petron et al., J. Geophys. Res. 119, 6836–6852 (2014).
24. T. B. Ryerson et al., J. Geophys. Res. 108, 4249 (2003).
25. B. Miyazaki, in Underground Gas Storage: Worldwide Experiences and Future Developments in the UK and Europe (D. J. Evans, R. A. Chadwick, Eds. (Geological Society, vol. 313, London, 2009), pp. 163–172.
26. California Environmental Protection Agency Air Resource Board. “Assembly Bill 32 overview” (2014). www.arb.ca.gov/cc/ab32/ab32.htm.
27. EDGAR - Emission Database for Global Atmospheric Research (European Commission Joint Research Centre, 2016). http://edgar.jrc.ec.europa.eu/datasets_grid_list/4272010.php?4272010Edgar_database=CH4.
28. U.S. EPA, Greenhouse Gas Emissions from a Typical Passenger Vehicle (2014).
29. UN Framework Convention on Climate Change, Adoption of the Paris Agreement (2015). http://unfccc.int/resource/docs/2015/cop11/eng/0901.pdf.
30. R. A. Washenfelder, P. O. Wennberg, G. C. Toon, Geophys. Res. Lett. 30, 3225 (2003).
31. K. W. Wong et al., Atmos. Chem. Phys. 15, 241–252 (2015).
32. R. O. Green et al., Remote Sens. Environ. 65, 227–248 (1998).
33. A. Buzì et al., Geophys. Res. Lett. 38, L14812 (2011).
34. S. M. Miller et al., Proc. Natl. Acad. Sci. U.S.A. 109, 20018–20022 (2013).
35. M. K. McNeil et al., Proc. Natl. Acad. Sci. U.S.A. 109, 20256–20267 (2012).
36. T. B. Ryerson et al., Proc. Natl. Acad. Sci. U.S.A. 109, 20246–20253 (2012).

ACKNOWLEDGMENTS

The first two Scientific Aviation flights were funded by the California Energy Commission through University California-Davis project #20140820. Subsequent flights were funded by the Southern California Gas Company, the operator of the Aliso Canyon storage facility. I.F. was supported in part by the California Agricultural Experiment Station Hitch project GA-D-LAW-2229-H. J.P. and T.R. were supported in part by the NOAA Climate Program Office and the NOAA Atmospheric Chemistry, Carbon Cycle, and Climate program. We acknowledge the contributions of M. Trainer for scientific input and K. Akin and S. Wolter for time-critical technical support. The views expressed here are those of the authors and do not constitute endorsement by their funding agencies. Data used in this report are posted at esrl.noaa.gov/csd/scientificaviation.

SUPPLEMENTARY MATERIALS

www.sciencemag.org/content/351/6279/1371/suppl/DC1
Materials and Methods
Figs. S1 and S2
Tables S1 and S2
References (37–44)

11 January 2016; accepted 17 February 2016
Published online 25 February 2016
10.1126/science.aaf2348

BIOCHEMISTRY

Fine-tuning of a radical-based reaction by radical S-adenosyl-L-methionine tryptophan lyase

Giuseppe Sicoli,1,2Jean-Marie Mousacea,1,2 Laura Zeppieri,3 Patricia Amara,3 Lydie Martin,9 Anne-Laur Barra,4 Juan C. Fontecilla-Camps,5 Serge Gambarelli,1,2* Yvain Nicolet2*

The radical S-adenosyl-L-methionine tryptophan lyase NosL converts L-trypthphan into 3-methylindolic acid, which is a precursor in the synthesis of the thiopetide antibiotic nosiheptide. Using electron paramagnetic resonance spectroscopy and multiple L-trypthphan isotoologues, we trapped and characterized radical intermediates that indicate a carboxyl fragment migration mechanism for NosL. This is in contrast to a proposed fragmentation-recombination mechanism that implied Co–C bond cleavage of L-trypthphan. Although NosL resembles related tyrosine lyases, subtle substrate motions in its active site are responsible for a fine-tuned radical chemistry, which selects the Co–C bond for disruption. This mechanism highlights evolutionary adaptation to structural constraints in proteins as a route to alternative enzyme function.

Nosiheptide, produced by Streptomyces actiuosus, is a highly modified, sulfur-rich, polythiazoyl macrocyclic peptide antibiotic (I). This compound exhibits highly potent activity against multidrug-resistant strains of several gram-positive pathogens (2–5). Originating from a 13-residue-long, ribosomally synthesized peptide, nosiheptide contains a central tetra-substituted pyridine ring, five thiazole rings, and an unusual indolic acid (6, 7). The latter is produced by the tryptophan lyase (NosL) enzyme, which converts L-trypthphan to the methylnindolic acid (MIA) precursor that is subsequently inserted into the thiopetide (8, 9). NosL belongs to the radical S-adenosyl-L-methionine (SAM) protein superfamilly, which uses a reduced [Fe4S4]+ cluster and SAM to initiate a 5′-deoxyadenosyl radical (5′-dA•)-based reaction (10). Homologous tyrosine lyases (CoH, ThH, and HydG) cleave the Co–C bond of tyrosine, producing a p-cresyl radical and dehydroglycine (DHG) (11–15).

Because of the prevalence of tyrosol and tryptophanyl radicals in proteins, it was initially proposed that the H-atom abstraction from L-tyrosine and L-trypthphan by the highly reactive 5′-dA• should take place at the L-tyrosine phenol group and at the L-trypthphan indole nitrogen, respectively (9, 12, 14). However, a recent NosL structure in complex with L-trypthphan (16) indicates that the H-atom abstraction takes place at the amino nitrogen atom (Fig. 1A). Biochemical studies confirmed that this abstraction in NosL is the first step in the conversion of L-trypthphan into MIA. NosL can perform β-scissions from the amino-centered radical intermediate at either Co–C or Co–C when using L-trypthphan analogs (17, 18). These observations suggest a relative propensity of NosL for substrate promiscuity that, combined with slight differences in

1Université Grenoble–Alpes, Institut Nanosciences et Cryogénie (INAC)–Service de Chimie Inorganique et Biologique (SCIB)/Laboratoire de Résonance Magnétique (LRM), F-38000 Grenoble, France. 2Commissariat à l’Énergie Atomique et aux Énergies Alternatives (CEA), INAC-SCIB/LRM, F-38000 Grenoble, France. 3Laboratoire de Physique des Proteines Unif, Institut de Biologie Structurale, CEA, CNRS, Université Grenoble-Alpes, 71, Avenue des Martyrs, 38044 Grenoble Cedex 9, France. 4Laboratoire National des Champs Magnétiques Intenses, UPR CNRS 3228, F-38048 Grenoble, France.
*Corresponding author. E-mail: yvain.nicolet@bs.fr (Y.N.); serge.gambarelli@cea.fr (S.G.)

Downloaded from http://science.sciencemag.org/ on February 5, 2020
Methane emissions from the 2015 Aliso Canyon blowout in Los Angeles, CA

S. Conley, G. Franco, I. Falloon, D. R. Blake, J. Peischl and T. B. Ryerson

Science 351 (6279), 1317-1320.
DOI: 10.1126/science.aaf2348originally published online February 25, 2016

The magnitude of a major methane leak

The Aliso Canyon underground gas storage facility outside Los Angeles, CA, houses enormous natural gas reserves. One well at the site experienced a blowout in late October 2015 and began leaking gas until it was sealed in February 2016. Over the course of 13 flights in the region, Conley et al. sampled the air column and determined daily release rates of methane (a powerful greenhouse gas) and ethane throughout the leak. The methane release rates were nearly double that of the entire Los Angeles region combined. Thus, single vulnerabilities can have major implications for state and federal climate policy.

Science, this issue p. 1317