Terry Engelder

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**The Pennsylvania State University**

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**Bio**

Terry Engelder, a leading authority on the recent Marcellus gas shale play, holds degrees from Penn State B.S. (’68), Yale M.S. (’72) and Texas A&M, Ph.D. (‘73).  He is currently a Professor of Geosciences at Penn State and has previously served on the staffs of the US Geological Survey, Texaco, and Columbia University.  Short-term academic appointments include those of Visiting Professor at Graz University in Austria and Visiting Professor at the University of Perugia in Italy.  Other academic distinctions include a Fulbright Senior Fellowship in Australia, Penn State’s Wilson Distinguished Teaching Award and Penn State’s Wilson Distinguished Research Award, membership in a US earth science delegation to visit the Soviet Union immediately following Nixon-Brezhnev dêtente, and the singular honor of helping Walter Alvarez collect the samples that led to the famous theory for dinosaur extinction by large meteorite impact.  He has written 160 research papers, many focused on Appalachia, and a book, the research monograph "Stress Regimes in the Lithosphere". His research focus for the past 35 years has been the interaction between earth stress and rock fracture. His work on gas shales first caught industry attention in the late 1970s and industry has engaged him ever since in learning how to recover gas from black shale. In the international arena, he has worked on exploration and production problems with companies including Saudi Aramco, Royal Dutch Shell, Total, Agip, and Petrobras. In 2011 he was named to the Foreign Policy Magazine’s list of Top 100 Global Thinkers for drawing international attention to the value of gas shale as an energy source. Non-academic distinctions based on his work with the Marcellus gas shale include an appearance on NPR’s ‘This American Life’ (Episode 440) and a TED talk, ‘The Fracking Debate’ (>30,000 views).

**Education**

1968 B.S. in Geology, Pennsylvania State University

1972 M.S. in Geology, Yale University

1973 Ph.D. in Geology, Texas A&M University

**Professional Experience**

1965 Geologist, Bradley Producing Co., Wellsville, New York

1966- Hydrologist, U. S. Geological Survey, Albany, New York,

1967 GS-4

1968 Geologist, Texaco, Inc.

1970- Research Assistant, Center for Tectonophysics, Texas

1973 A&M University

1973- Research Scientist, Lamont-Doherty Geological

1974 Observatory of Columbia University

1974- Research Associate, Lamont-Doherty Geological

1979 Observatory of Columbia University

1979- Lecturer, Columbia University

1980

1979- Senior Research Associate, Lamont-Doherty Geological

1983 Observatory of Columbia University

1983- Senior Research Scientist, Lamont-Doherty Geological

1985 Observatory of Columbia University

1985- Associate Professor of Geosciences, Pennsylvania State

1990 University

1990- Professor of Geosciences, Pennsylvania State University

2017

2008- Owner, Appalachian Fracture Systems

Present

2017- Professor Emeritus of Geosciences, Pennsylvania State University

Present

**Distinctions**

Fellowship - Geological Society of America, 1989

Penn State’s Wilson Distinguished Teaching Award - The Pennsylvania State University, 1992

Geological Society of Washington - Second Place Paper, 1992

John and Cynthia Oualline Lecturer in Geological Sciences, University of Texas, 1993

Tudor Lecturer in Geological Sciences, Indiana University, 2013

Donald Levandowski Memorial Lecture, Department of Earth, Atmosphere, and Planetary Sciences, Purdue University 2015

J.L. Frank ’58 Graduate Seminar, Department of Petroleum Engineering, Texas A&M University, 2015

SPE Distinguished Lecturer – Saudi Arabia, 2016

AAPG Distinguished Lecturer: 2007-2008 (North America), 2013-2014 (Europe) 2015 (Middle East and Africa), 2016 (Nigeria)

Penn State’s Wilson Distinguished Research Award - The Pennsylvania State University, 2017

**Honors and Awards**

Phi Eta Sigma - Honor Society, 1965

Phi Kappa Phi – Honor Society, 2004

Foreign Policy Magazine: Top 100 Global Thinker, 2011

AAPG Eastern Section - Gordon H. Wood, Jr. Memorial Award, 2015

**Fellowships**:

Fulbright Senior Fellowship, Macquarie University, Syndey, Australia, 1984

French-American Foundation Fellowship, Pau, France, 2001-2002

**Guest Professorship**:

Erherzog Johann Technical University, Graz, Austria, 1999

Università di Perugia, Perugia, Italy, 2004

**Visiting Scholar**:

TotalFinaElf, CSTJF Pau, France, 2001-2002

QRI Group, Houston, TX, 2011-present

**Editorships, National Committees, Peer Review Panels**

Co-Editor-in-Chief, Tectonophysics, 1993-1999

Associate Editor, Journal of Geophysical Research, 1980-1982

Associate Editor, Geological Society of America Bulletin, 1980-1982

Associate Editor, Tectonophysics, 1986-1993

U.S. National Committee for Rock Mechanics, Study on Research

Requirements for Rock Mechanics, 1980

AGU Representative to the National Committee for Rock Mechanics,

1979-1982

Glomar Explorer Downhole Experiments Panel, 1980

Conference Organizer: Geological Society of America, Penrose

Conference on “Pressure Solution and Dissolution Phenomena in

Geology”, 1980

Program Chairman: American Geophysical Union, Tectonophysics

Program Chairman, Eastern AGU meeting, 1982, 1983

Peer Review Panels: U.S. Geological Survey Earthquake Prediction Program, 1978, 1979;

The U.S. Department of Energy, Office of Basic Energy Sciences Contracts Program, 1992, 1993

Board of Directors - DOSECC, 1989-1991

Panelist: US-EPA Environmental Safety associated with Fracking, 2010

Committee Member: Governor’s Marcellus Shale Advisory Commission, 2011

# Former Graduate Students

**Degree Employers**

1. Richard Plumb Ph.D. 82' Geologist, Schlumberger, Cambridge, UK then Houston, TX, now retired

2. Stephen Marshak Ph.D. 83' Ass. then Assoc. then Professor then Dept. Head, Univ. of Illinois, Urbanna, ILL

3. Paul Scott M.S. 89' Geologist, British Petroleum, Houston, TX then earth science teacher Schenectady, NY

4. Alfred Lacazette Ph.D. 91' Texaco Research, Houston, then Western Atlas, Houston, then Global Geophysical

5. Amy Freeman M.S. 91' Engineer, Williamsport, PA., then minority recruiting for College of Engineering, PSU

6. Irene Meglis Ph.D. 92' Postdoctoral Fellow, Queens Univ. ONT, Canada then Memorial University NFLD

7. John Leftwich Ph.D. 93' Ass. Professor, Old Dominion, Norfolk, VA, then Shell Offshore, New Orleans, then Halliburton, Houston, TX

8. Michael Gross Ph.D. 93' Ass. then Assoc. Prof., Florida International U., Miami, FL, then Shell E&P, Houston, TX

9. Mark Fischer Ph.D. 94' EXXON Production Res.,Houston then Ass. & Assoc. Prof., U. North. Illinois, Dekalb, ILL

10. Staci Loewy M.S. 95' Geologist, EXXON Production Res., Houston then Ph.D. Univ. Texas, Austin then adjunct faculty at U. of North Carolina.

11. Amgad Younes Ph.D. 96' Postdoc. Fell., Royal Holloway, London then Stanford, CA, then Marathon Oil, Denver, CO, then Royal Dutch Shell, Netherlands

12. David McConaughy M.S. 97’ Shell Offshore, New Orleans then environmental firm, Pittsburgh

13. Laura Silliphant M.S, 98’ Geologist, Anadarko Petroleum, Houston, TX and Alaska then consultant Alaska Geological Survey

14. Michael Scanlin Ph.D. 00’ Assoc. Prof., Elizabethtown College, Elizabethown, PA

15. Christie Rogers M.S., 02’ Exxon-Mobil, Houston

16. Laura Savalli M.S., 03’ Chevron-Texaco, Houston, then Encana, Denver, then Anadarko, Denver

17. Redescal Uzcategui Ph.D. 04’ Assoc. Prof., Simon Bolivar U., Caracus, Ven.

18. Amy Whitaker Ph.D. 04’ Chevron-Texaco, Houston

19. Meryl Towarak M.S. 06’ US Bureau of Land Management

20. Brett Nadan M.S. 06’ Boston School District

21. David Cannon M.S. 08’ Samson, Tulsa

22. LaMichelle Arnold M.S. 10’ Chevron, Houston

23. Murat Aydin M.S. 11’ Turkish Petroleum, Ankara

24. Travis Call M.S. 12’ Newfield, Houston

25. Thomas Johnston M.S. 14’ Noble, Houston

26. Yunhui Tan Ph.D. 15’ Chevron, Houston

**Former Undergraduate Theses (after 1992)**

**Degree Thesis Title**

1 .David A. Cox B.S. 93’ The effect of local fold anomalies on the geologic nature of the Tusseyville Fault, Centre Hall, Pennsylvania

2. Jennifer A. Mullen B.S. 93’ Strain analysis of Axemann Limestone using the Fry method

3. Paul D. Pinkerton B.S. 96’ Petrographic characteristics of the Elk Basin sandstones and their correlation with joint spacing

4. Paul N. Hagin B.S. 97’ Joint spacing statistics in thick, homogeneous shales of the Catskill Delta Complex on the Appalachian Plateau: Finger Lakes Region, New York

5. Diana K. Latta B.S. 97’ The role of flexural slip during the formation of folds in Devonian clastic rocks of the Appalachian Plateau

6. Jason C. Ruf B.S. 97’ Analysis of joint and vein spacing in the Brallier Formation, Huntingdon, PA

7. Megan M. Kovach B.S. 98’ The effect of Lithology on the persistence of joint orientations through marine to fluvial depositional environments in the Catskill Delta near Port Matilda, PA

8. Ben. Haith B.S. 99’ Origin of slip along systematic cross-fold joints in the Genesee Group of the Finger Lakes District, New York

9. Brian M. Gaul B.S. 99’ Effect of bedding dip on elevation of sandstone ridges in the vicinity of State College, Pennsylvania.

10. Douglas A. Myers B.S. 01’ Relative age of a smaller-scale joint set formed between large-scale jint zones in the Navajo sandstone at Zion National Park, Utah: Analysis based on joint spacing statistics and joint interaction

11. Jennifer K. Bobich B.S.,02’ The role of tectonically driven fluids in the formation of the Ouachita fold and thrust belt: Characterization and relative timing of quartz veins

12. Ryan J. McAleer B.S. 04’ Concretions in the Llewellyn Formation, Bear Valley strip mine, Shamokin, PA: Ridge inclusions in a deformable matrix

13. Travis Call B.S. 10’ Fracture mechanics of the Marcellus gas shale

14. Chris Campbell B.S. 10’ Relationship between grain size distribution, mineralogy, and gamma ray signature in the Mahantango Formation

15. Jessica M. Hayward B.S. 10’ Stratigraphic and structural characteristics of the Mahantango Formation in Selinsgrove, Pennsylvania

16. Abdul. Al Belushi B.S. 11’ Classification and correlation of five Tioga bentonite samples in the Marcellus Shale of Central Pennsylvania

17. Wan Abdul Rahman B.S. 11’ Strain analysis of Devonian gas shale in the Appalachian Plateau based on pyrite pressure shadows.

18. Gregory Bailey B.S. 13’ The nature of slip surfaces in the Geneseo-Burkett.

19. Shane McWilliams B.S. 13’ Hydraulic fracturing flowback trends in the Marcellus shale

20. Nathan Bachik B.S. 14’ Joint analysis of the Bald Eagle/Howard core

21. Sirui Ma B.S. 15’ Microseismic location uncertainty using a perforation shot

22. Peter J. Vigilante B.S. 15’ Structural petrology of calcite veins in the Oatka Creek Formation

23. Andrew M. Pickett B.S. 16’ A study of natural gas production in Bradford County, PA

24. Brandon Grau B.S. 16’ Analysis of the Mahantango to Marcellus transition in SGL 252 core

**RESEARCH INTERESTS**

**Laboratory Research**

1. mechanical properties of rocks affecting strain relaxation (1974-1996)

2. fluid transport of properties of rocks, mainly permeability of joints (1976-1985)

3. geochemistry of rock-water interaction (1980-1985)

1. experiments in fracture toughness in rocks (1987-present)

5. microfabric of crystalline rocks (1980-present)

**Field Research**

1. A study of the characteristics of fault zones in the Cordilleran Region,

1971-72, 1979-80

2. Strain relaxation and hydraulic fracture in situ stress measurements in

northeastern United States and California, 1974-1993

3. In situ ultrasonic properties of rock, 1978-1995

4. Fracture Analysis - Appalachian Basin, NY-PA-Virginia, Salt Range (Pakistan), Monterey Formation, CA, Michigan Basin, MI, Elk Basin, WY, Bristol Channel, Somerset (England), Paradox Basin, UT, Zion National Park, UT, Dinosaur National Monument, UT, 1978-present

5. Strain Analysis in foreland fold and thrust belts - Appalachian Basin, Apennines (Italy), Patagonian Andes (Chile), 1976-present

1. In situ conditions in overpressured sedimentary basins, 1989-present
2. Regional patterns in rift and grain of New England granites, 2002-present
3. Gas shale, 2007-present

**Theoretical Analyses**

1. Development of natural hydraulic fractures 1985 - present
2. Development of stress in overpressured sedimentary basins, 1989 – present
3. Mechanical properties of rock controlling fracture spacing (1985-present)
4. Coupling between pore pressure and stress in basins (1994-present)
5. Decline curves in the Marcellus (2007-present)

**TERRY ENGELDER**

**PUBLICATION VITA**

**I. THESIS**

Engelder, T. , 1973, Quartz fault gouge: Its generation and effect on the frictional properties of sandstones, Ph.D. dissertation, Texas A&M University, College Station, Texas, 153 p.

**II. BOOKS**

Engelder, T., 1993, Stress Regimes in the Lithosphere: Princeton Press, Princeton, New Jersey, 451 p.

**III. MAJOR VOLUMES AS EDITOR OR CO-EDITOR**

The Oertel Volume: Engelder, T., ed, 1995, 30 Years of Tectonophysics, A Volume in Honour of Gerhard Oertel: Tectonophysics, v. 247, Nos 1-4.

The Logan Volume: Chester, F.M., Engelder, T. and Shimamoto, T., eds, 1998, Rock Deformation: The Logan Volume: Tectonophysics, v. 295, Nos 1-2.

The Hancock Volume: Cosgrove, J.W. and Engelder, T., eds, 2004, The Initiation, Propagation, and Arrest of Joints and Other Fractures: Geological Society, London, Special Publications, 231.

The Nickelsen-Groshong Volume: Engelder, T., Ferrell, D.A., Gray, M.B., Wiltschko, D.V., and Dunne, W.M., eds. 2009, Low-temperature deformation mechanisms and their interpretation: Journal of Structural Geology, v. 31, No. 9.

**IV. PAPERS: PEER-REVIEWED JOURNALS**

Engelder, T., 1974, Cataclasis and the generation of fault gouge, Geol. Soc. Amer. Bull., 85, 1515-1522.

Engelder, T., 1974, Microscopic wear grooves on slickensides: Indicators of paleoseismicity, J. Geophys. Res., 79, 4387-4392. LDGO #2130.

Engelder, T., J. M. Logan and J. Handin, 1975, The sliding characteristics of sandstone on quartz fault-gouge, Pure Appl. Geophys., 113, 69-86.

Engelder, T. and M. L. Sbar, 1976, Evidence for uniform strain orientation in the Potsdam sandstone, northern New York, from in situ measurements, J. Geophys. Res., 81, 3013-3017. LDGO #2288.

Scholz, C. H. and T. Engelder, 1976, The role of asperity indentation and ploughing in rock friction, 1: Asperity creep and stickslip, Int. J. Rock Mech. Mining Sci., 13, 149-154. LDGO #2336.

Engelder, T. and C. H. Scholz, 1976, The role of asperity indentation and ploughing in rock friction, 2: Influence of relative hardness and normal load, Int. J. Rock Mech. Mining Sci., 13, 155-163. LDGO #2339.

Alvarez, W., T. Engelder and W. Lowrie, 1976, Formation of spaced cleavage and folds in brittle limestone by dissolution, Geology, 4, 698-701. LDGO #2377.

Brock, W. G. and T. Engelder, 1977, Deformation associated with the movement of the Muddy Mountain overthrust in the Buffington window, southeastern Nevada, Geol. Soc. Amer. Bull., 88, 1667-1677. LDGO #2491.

Engelder, T., M. L. Sbar and R. Kranz, 1977, A mechanism for strain relaxation of Barre granite: Opening of microfractures, Pure Appl. Geophys., 115, 27-40. LDGO #2455.

Engelder, T. and M. L. Sbar, 1977, The relationship between in situ strain relaxation and outcrop fractures in the Potsdam sandstone, Alexandria Bay, New York, Pure Appl. Geophys., 115, 41-55. LDGO #2456.

Engelder, T. and R. Engelder, 1977, Fossil distortion and decollement tectonics of the Appalachian Plateau, Geology, 5, 457-460. LDGO #2519.

Engelder, T., 1978, Aspects of asperity-surface interaction and surface damage of rock during experimental frictional sliding. Pure Appl. Geophys., 116, 705-716. LDGO #2620.

Alvarez, W., T. Engelder and P. Geiser, 1978, Classification of solution cleavage in pelagic limestones, Geology, 6, 263-266. LDGO #2646.

Sbar, M. L., T. Engelder, R. Plumb and S. Marshak, 1979, Stress pattern near the San Andreas fault, Plamdale, California, from near-surface in situ measurements,

J. Geophys. Res., 84, 156-164. LDGO #2750.

Engelder, T., 1979, The nature of deformation within the outer limits of the central Appalachian foreland fold and thrust belt in New York State, Tectonophysics, 55, 289-310. LDGO #2778.

Engelder, T., 1979, Mechanisms for strain within the Upper Devonian clastic sequence of the Appalachian plateau, western New York, Amer. J. Sci., 279, 527-542. LDGO #2796.

Kranz, R. L., A.D. Frankel, T. Engelder and C. H. Scholz, 1979, The permeability of whole and jointed Barre granite, Int. J. Rock Mech. Mining Sci., 16, 225-234. LDGO #2830.

Engelder, T. and P. Geiser, 1979, The relationship between pencil cleavage and lateral shortening within the Devonian section of the Appalachian Plateau, New York, Geology, 7, 460-464. LDGO #2871.

Engelder, T. and P. Geiser, 1980, On the use of regional joint sets as trajectories of paleostress fields during the development of the appalachian plateau, New York, J. Geophys. Res., 85, 6319-6341. LDGO #3022.

Engelder, T., P. Geiser and W. Alvarez, 1981, Penrose Conference Report: The role of pressure solution and dissolution in geology, Geology, 9, 46-47.

Engelder, T., 1981, General characteristics of strain relaxation: A note on sample preparation for large-scale tests, Geophys. Res. Lett., 8, 687-689. LDGO #3166.

Engelder, T., 1982, A natural example of the simultaneous operation of free-face dissolution and pressure solution, Geochimica et Cosmochimica Acta, 46, 69-74. LDGO #3235.

Marshak, S., P. A. Geiser, W. Alvarez and T. Engelder, 1982, Mesoscopic fault array of the northern Umbrian Apennines foldbelt, Italy: Geometry of conjugate shear by pressure-solution slip, Geol. Soc., Amer. Bull., 93, 1013-1022. LDGO #3351.

Engelder, T., 1982, Is there a relationship between regional joints and contemporary stress within the lithosphere of North America?, Tectonics, 1, 161-177. LDGO #3299.

Bahat, D. and T. Engelder, 1984, Surface Morphology of Joints of the Appalachian Plateau, New York and Pennsylvania, Tectonophysics, 104, 299-313. LDGO #3542.

Engelder, T., 1984, The Apparent Role of Pore-Water Migration During the Deformation of Foreland Fold and Thrust Belts, J. Geophys. Res., 89, 4319-4325. LDGO #3586.

Lomando, T. and T. Engelder, 1984, Strain Indicated by Calcite Twinning, implications for Deformation of the Triassic Newark Basin, New York, Northeastern Geology, 6, 192-195. LDGO #3726.

Engelder, T. and M. L. Sbar, 1984, Near Surface In Situ Stress: Introduction, J. Geophys. Res., 89, 9321-9322.

Sbar, M., R. M. Richardson, C. Flaccus and T. Engelder, Near Surface In Situ Stress Part I: Strain Relaxation Measurements along the San Andreas Fault in Southern California, J. Geophys. Res., 89, 9323-9332. LDGO #3697.

Plumb, R., T. Engelder and M. Sbar, 1984, Near Surface In Situ Stress Part II: A comparison with Stress Directions inferred from Earthquakes, Joints, and Topography near Blue Mountain, New York, J. Geophys. Res., 89, 9333-9349. LDGO #3698.

Plumb, R., T. Engelder and D. Yale, 1984, Near Surface In Situ Stress Part III: Microcrack Fabric within the New Hampshire Granites, J. Geophys. Res., 89, 9350-9364. LDGO #3699.

Engelder, T. and P. Geiser, 1984, Near Surface In Situ Stress Part IV: Residual Stress on the Tully Limestone, Appalachian Plateau, New York, J. Geophys. Res., 89, 9365-9370. LDGO #3700.

Engelder, T. and R. Plumb,. 1984, Changes in In Situ Ultrasonic Properties of Rock on Strain Relaxation, Int. J. Rock Mech. Min. Sci., 21, 75-82. LDGO #3588.

Engelder, T., 1984, The Time-Dependent Strain Relaxation of Algerie Granite, Int. J. Rock Mech. Min. Sci., 21, 63-73. LDGO #3587.

Wise D. U., D. E. Dunn, T. Engelder, P. A. Geiser, R. D. Hatcher, S. A. Kish, O. L. Odom and S. Schamel, 1984, Fault-related rocks: Suggestions for Terminology, Geology, 12, 391-394.

Marshak, S. and T. Engelder, 1985, Development and distribution of tectonic cleavage and stylolites in limestones of a fold-thrust belt in eastern New York State, J. of Structural Geology, 7, 345-359.

Engelder, T. and S. Marshak, 1985, Disjunctive cleavage formed at shallow depths in sedimentary rocks, J. of Structural Geology, 7, 327-343.

Engelder, T., 1985, Loading paths to joint propagation during a tectonic cycle: an example from the Appalachian Plateau, J. of Structural Geology, 7, 459-476.

Davis, D. M. and T. Engelder, 1985, The role of salt in fold-and-thrust belts, Tectonophysics, 119, 67-88.

Engelder, T. and G. Oertel, 1985, The correlation between under-compaction and tectonic jointing within the Devonian Catskill Delta, Geology, 13, 863-866.

Hatcher, R. D., A. L. Odom, T., Engelder, D. E. Dunn, D. U. Wise, P. A. Geiser, S. Schamel and S. A. Kish, 1988, Characterization of Appalachian faults, Geology 16, 178-181.

Evans, K. F., Scholz, C. H. and Engelder, T. 1988, An analysis of horizontal fracture initiation during hydrofrac stress measurements in granite at North Conway, New Hampshire, Geophysical Journal, v. 93, p. 251-264.

Marone, C., Rubinstone, J. and Engelder, T., 1988, Mass transport through rock: An experimental study of permeability and fluid chemistry in jointed Marble: Journal of Geophysical Research, v. 93, p. 13, 763-775.

Evans, K., Engelder, T. and Plumb, R. A., 1989, A detailed description of in situ stress variations in Devonian Shales of the Appalachian Plateau: Journal of Geophysical Research, v. 94, p. 7125-7154.

Evans, K., Oertel, G. and Engelder, T., 1989, Correlated anomalies of in situ stress and compaction in Devonian shales of the Appalachian Plateau: An insight into the nature of Alleghanian deformation, Journal of Geophysical Research, v. 94, p. 7155-7170.

Engelder, T., 1989, The analysis of pinnate joints in the Mount Desert Island Granite: Implications for post-intrusion kinematics in the coastal volcanic belt, Maine: Geology ,v. 17, p. 564-567.

Hancock, P. L. and Engelder, T., 1989, Neotectonic Joints: Geological Society of America Bulletin, v. 101, p. 1197-1208.

Oertel, G., Engelder, T. and Evans, K., 1989, A comparison of the strain of crinoid columnals with that of their enclosing silty and shaly matrix on the Appalachian Plateau, New York, Journal of Structural Geology, v. 11, p. 975-993.

Evans, K., and Engelder, T., 1989, Some problems in estimating horizontal stress magnitudes in "thrust" regimes, International Journal of Rock Mechanics and Mining Sciences v. 26, p. 647-660.

Srivastava, D., and Engelder, T., 1990, Crack-propagation sequence and pore-fluid conditions during fault-bend folding in the Appalachian Valley and Ridge, Central Pennsylvania: Geological Society of America v. 102, p. 116-128.

Gross, M., and Engelder, T., 1991, A case for neotectonic joints along the Niagara Escarpment: Tectonics v. 10,. p. 631-641.

Meglis, I.L., Engelder, T., and Graham, E.K., 1991, The effect of stress-relief on ambient microcrack porosity in core samples from the Kent Cliffs (New York) and Moodus (Connecticut) scientific research boreholes, Tectonophyiscs, v. 186, p. 163-173.

Srivastava, D., and Engelder, T., 1991, Fluid evolution history of brittle-ductile shear zones on the hanging wall of the Yellow Springs thrust, Valley and Ridge Province, Pennsylvania, U.S.A.: Tectonophysics, v. 198, p. 23-34.

Plumb, R.A., Evans, K. F., and Engelder, T., 1991, Geophysical log responses and their correlation with the bed-to bed stress contrasts in Paleozoic rocks of the Appalachian Plateau, New York: Journal of Geophysical Research, v. 96, p. 14,509-14,528.

Weedman, S. D., Guber, A. L., and Engelder, T., 1992, Pore pressure variation within the Tuscaloosa trend: Morganza and Moore-Sams Fields, Louisiana Gulf Coast: Journal of Geophysical Research, v. 97. p. 7193-7202.

Gross, M., Engelder, T., and Poulson, S., 1992, Veins in the Lockport Dolomite: Evidence for an Acadian fluid circulation system: Geology, v. 20, p. 971-974.

Engelder, T., and Gross, M., 1993, Curving cross joints and the neotectonic stress field in eastern North America, Geology, v. 21, p. 817-820.

Engelder, T., 1994, Deviatoric stressitis: A virus infecting the earth science community: EOS, v. 75, p. 209-212.

Engelder, T., and Fischer, M.P., 1994, Influence of poroelastic behavior on the magnitude of minimum horizontal stress, Sh, in overpressured parts of sedimentary basins: Geology, v. 22, p. 949-952.

Arboleya, M.L. and Engelder, T., 1995, Concentrated slip zones with subsidiary shears: their development on three scales in the Cerro Brass fault zone, Appalachian Valley and Ridge: Journal of Structural Geology, v. 17, p. 519-532.

Gross, M.R., and Engelder, T., 1995, Strain accommodated by brittle failure in adjacent unites of the Monterey Formation, U.S.A.: Scale effects and evidence for uniform displacement boundary conditions: Journal of Structural Geology, v. 17, p. 1303-1318.

Hirt, A.M., Evans, K.F., and Engelder, T., 1995, Correlation between magnetic anisotropy and fabric for Devonian shales on the Appalachian Plateau: Tectonophysics, v. 247, p. 121-132.

Fischer, M., Gross, M.R., Engelder, T., and Greenfield, R.J., 1995, Finite element analysis of the stress distribution around a pressurized crack in a layered elastic medium: Implications for the spacing of fluid-driven joints in bedded sedimentary rock: Tectonophysics, v. 247, p. 49-64.

Fischer, M., Alley, R.B., and Engelder, T., 1995, Fracture toughness of ice and firn determined from the modified ring test: Journal of Glaciology, v. 41, p. 383-394.

Fischer, M., Elsworth, D., Alley, R.B., and Engelder, T., 1996, Finite element analysis of the modified ring test for determining mode I fracture toughness: International Journal of Rock Mechanics and Mining Science, v. 33, p. 1-15,

Meglis, I.L., Greenfield, R.J., Engelder, T, and Graham, E.K., 1996, Pressure dependence of velocity and attenuation and its relationship to crack closure in crystalline rocks, Journal of Geophysical Research, v. 101, p. 17,523-17,533.

Engelder, T., and Fischer, M.P., 1996, Loading configurations and driving mechanisms for joints based on the Griffith energy-balance concept: Tectonophysics, v. 256 , p. 253-277.

Ruf, J.C., Rust, K.A., and Engelder, T., 1998, Investigating the effect of mechanical discontinuities on joint spacing: Tectonophysics, v. 295, p. 245-257.

Younes, A., and Engelder, T., 1999, Fringe cracks: Key structures for the interpretation of progressive Alleghanian deformation of the Appalachian Plateau: Geological Society of America Bulletin, v. 111, p. 219-239.

McConaughy, D.T., and Engelder, T., 1999, Joint interaction with embedded concretions: Joint loading configurations inferred from propagation paths: Journal of Structural Geology, v. 21, p. 1637-1652.

Engelder, T., 1999, The transitional-tensile fracture: A status report: Journal of Structural Geology, v. 21, p. 1049-1055.

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Engelder, T., 1992, Pressure Compartments: Final Report to GRI Contract 5088-260-1746, 220 p.

**XIV. FIELD GUIDEBOOKS:**

Engelder, T., Loewy, S., McConaughy, D.T., and Younes, A., 1998, The Catskill Delta Complex: Analog for modern continental shelf and delta sequences containing overpressured sections: 13th Annual Appalachian Tectonics Studies Group Guidebook, 100 p.

Engelder, T., 2006, The Fractography of Joints: natural analogs for failure in glasses and ceramics: Guidebook for Fractography of Glasses and Ceramics V, Rochester Conference Sponsored by the American Ceramics Society, 21 p.

Engelder T., 2008, Structural geology of the Marcellus and other Devonian gas shales: Geological conundrums involving joints, layer-parallel shortening strain, and the contemporary tectonic stress field: Field Guidebook for Pittsburgh Association of Petroleum Geologists Field Trip (Sept. 12-13, 2008) and for the AAPG-SEC Eastern Section Meeting Field Trip (Oct. 11-12, 2008), 91 p.

**XV. Books, most from Major publishing houses, that document T.E.’s activities as a geologist (11):**

Alvarez, W., 1998, T-Rex and the Creator of Doom, Knopf Doubleday Publishing Group, 208 p.

Alvarez, W., 2009, The Mountains of Saint Francis: Discovering the Geologic Events That Shaped Our Earth (St. Francis), W.W. Norton and Co, 291 p.

Billings, L., 2013, Five Billion Years of Solitude: The search for life among the stars, Current/The Penguin Group, 294, p.

Brasch, W.M., 2013, Fracking in Pennsylvania: Flirting with Disaster, Greeley & Stone, Publishers, LLC, 259.

Gold, R., 2014, The Boom*.* How Fracking Ignited the American Energy Revolution and Changed the World, Simon and Schuster, 366 p.

Graves, J., 2012, Fracking: America's Alternative Energy Revolution, Safe Harbor International Publishing, 320 p.

McGraw, S., 2011, The End of Country, Random House, 245 p.

Powers, B., 2013, Cold, Hungry and in the Dark: Exploding the natural gas supply myth, New Society Publishers, 313 p.

Waples, D.A., 2012, The Natural Gas Industry in Appalachia: A History from the First Discovery to the Tapping of the Marcellus Shale, McFarland & Company, Inc., 367 p.

Wilber, T., 2012, Under the Surface: Fracking, Fortunes, and the fate of the Marcellus Shale, Cornell University Press, 272 p.

Zuckerman, G., 2013, The Frackers: The outrageous inside story of the new billionaire wildcatters, Portfolio/Penguin, 404 p.

**XVII. service to the community as a proponent for gas shale:**

(Summer 2007 to January 2016)

**TED Talks**:

The Fracking Debate (15,896 views)

**Interviews with Journalists (2008 to present -- National)**:

**507**  (this number does not count multiple interviews with the same journalist)

**Interviews with Journalists (2008 to present -- Interntional)**:

**76** (this number does not count multiple interviews with the same journalist)

**Seminars and Workshops on Gas Shale (2007 to present):**

**423** (last three international talks given in Lagos, Nigeria, Barcelona, Spain and Nairobi, Kenya)

Cumulative attendance through 423 talks: **> 30,000**.

**XVIII. Google Scholar Citation INDEX**

(through early Spring of 2021)

This list includes only those **37** papers or books that have been cited over **100** times according to Google Scholar. Note that Google Scholar includes citations in out-of-field publications such Petroleum Engineering in general and SPE publications in particular. This can lead to a citation rate for Google Scholar that is twice the rate as Web of Science.

Google Scholar H-index (number of papers = number of citations): **62**

Web of Science H-index (number of papers = number of citations): **45**

Google Scholar Citations: **13,268** Web of Science Citations: **6,078**

**XIX. Co-authorship with scientists who have been featured in Time Magazine cover stories**

Chris Scholz - Earthquake prediction cover story (1975)

Walter Alvarez - Dinosaur extension cover story (1989)

Richard Alley – Global Climate Change (approx. 2000)

Tony Ingraffea - Gas shale cover story (2011).