Annotated Bibliography of Earthscope Publications

Faulkner, D. R., et al. "A review of recent developments concerning the structure, mechanics and fluid flow properties of fault zones." *Journal of Structural Geology* 32.11 (2010): 1557-1575.

Review key advances in the study of the structure, mechanics and fluid flow properties of fault zones and fault systems. The review concentrates on advances made primarily in the past 10 years, and also on fault zones in the brittle continental crust

- Structure
    - Strain is localized in a fault core made up of gouge and/or cataclasite surrounded by a damage zone of fractures and faulting
        - Damage zone fracture density scales logarithmically with distance from core
        - Number and shape of core segments is observed to vary considerably
    - Structural trends often related to fault zone maturity. Fault core and damage zone widths are observed to scale with fault displacement
- Mechanics
    - Compelling evidence exists for the occurrence of weak faults that are shown to fail in lower stress conditions than what is predicted by Byerlee's law. A few different factors that may be responsible:
        - Pressure solution creep, however its impact is difficult to assess at present
        - Concentration and alignment of phyllosilicate phases in fault core
        - Locally elevated pore fluid pressures driven by permeability and/ or fluid flux from mid-crustal levels
    - Rate and state frictional behavior has recently been reassessed to account for thermal/ state factors
- Fluid Flow
    - Several factors are shown to reduce fault zone permeability
        - Elevated shear strain- can reduce permeability by orders of magnitude
        - Clay fraction
        - Pressure regime
    - The majority of fluid migration in fault zones is typically confined to a few focused flow pathways
    - Fluids play an important role in frictional healing

Fischer, Karen M., et al. "The lithosphere-asthenosphere boundary." *Annual Review of Earth and Planetary Sciences* 38 (2010): 551-575.

- Studies suggest a seismically fast oceanic lithosphere of roughly constant thickness above a layer of radial anisotropy. These results favor a model in which the oceanic lithosphere corresponds to a dry, chemically depleted layer over a hydrated, fertile asthenosphere
- The LAB cannot be explained by thermal gradients alone. A contrast in hydration, fertility, and/or melt is required, perhaps in combination with a vertical gradient in velocity anisotropy.
- Sp and Ps analyses reach divergent conclusions on the sharpness of subcratonic LAB velocity gradients
    - An asthenospheric shear zone persists beneath cratons. This layer is radially anisotropic, but this is typically interpreted as fossil fabric and not indicative of mantle flow
    - Sharpness of gradient is poorly constrained, varies substantially by region

Long, Maureen D., and Thorsten W. Becker. "Mantle dynamics and seismic anisotropy." *Earth and Planetary Science Letters* 297.3-4 (2010): 341-354.

- Circulation models provide reliable large-scale estimates of mantle flow
- A- or E- type olivine LPO, which are both oriented parallel to flow direction, are likely the dominant asthenospheric fabrics
- The role of corner flow in subduction environments is contested
    - complicated by B-type olivine LPO, which develops perpendicular to flow direction and is prevalent in hydrous, relatively high T low P environments
- The concept of of fossil anisotropy preserved in cratonic lithosphere complicates the study of continental anisotropy, which is remarkably variable

Townend, J., and M. D. Zoback. "Regional tectonic stress near the San Andreas fault in central and southern California." *Geophysical Research Letters* 31.15 (2004).

- Compare borehole strainmeter data to geodetic models for maximum horizontal compression
- Find that strike-slip displacement along the SAF and subsidiary structures occurs at an angle of approximately 68° to the axis of maximum horizontal compression in southern California, and as high as 85° in central California
- The lack of systematic variation in angle between fault strike and the axis of maximum horizontal compressive strength implies a degree to which the development and continued activity along the fault aligns with far field processes
- Find a general increase with depth in angle between maximum compressive stress and strike, suggesting a weak fault, strong crust ‘jelly sandwich’ model is applicable to the area

Rawlinson, Nicholas, S. Pozgay, and S. Fishwick. "Seismic tomography: a window into deep Earth." *Physics of the Earth and Planetary Interiors* 178.3-4 (2010): 101-135.

- The relative merits of local versus global parameterization, ray tracing versus wavefront tracking, backprojection versus gradient based inversion, and synthetic testing versus model covariance are explored.
    - A few studies using USArray data are highlighted i.e. ***Shapiro et al. (2005)***, ***Burdick et al. (2008)***, showing the influence of the TA on the development of the field as a whole
- Key application areas including body wave traveltime tomography, surface wave tomography, attenuation tomography, and ambient noise tomography are discussed
- Examines established and emerging trends including finite frequency tomography, full waveform tomography, and adjoint tomography

Zoback, Mark, Stephen Hickman, and William Ellsworth. "Scientific drilling into the San Andreas fault zone." *Eos, Transactions American Geophysical Union* 91.22 (2010): 197-199.

- An approximately 200m- wide damage zone of anomalously low P and S wave velocities and low resistivity is interpreted to be the result of both physical damage and chemical alteration due to faulting
- Two 2-3m wide localized zones of deformation (CDZ and SDZ after central and southwest deforming zones, respectively) have progressively deformed drill casing
    - Thickness and presence of talc & serpentinite in these cores suggests an important role of fluid alteration
- Overall interpretation of strong crust/ weak faul model being the most accurate

Schmid, Ralf, et al. "Generation of a consistent absolute phase-center correction model for GPS receiver and satellite antennas." *Journal of Geodesy* 81.12 (2007): 781-798.

- Presents a new absolute phase center correction model for GPS receiver and satellite antennas
- Use of satellite-specific z-offset calculations reduces tropospheric zenith delay bias as compared to block-specific absolute and relative phase center variations (PCVs)

Yuan, Huaiyu, and Barbara Romanowicz. "Lithospheric layering in the North American craton." *Nature* 466.7310 (2010): 1063.

- Receiver function studies show a craton-wide presence of a mid-lithospheric boundary that separates a highly depleted chemical layer of laterally varying thickness from a less depleted deeper layer bounded below by a relatively flat LAB
- The thermal boundary layer might have been formed in a tectonic context involving predominant eastwest compression, or, alternatively, that it was formed diffusively while responding to northerly plate motion prevalent during the Mesozoic opening of the Atlantic Ocean following the Appalachian orogeny

Tape, Carl, et al. "Seismic tomography of the southern California crust based on spectral-element and adjoint methods." *Geophysical Journal International* 180.1 (2010): 433-462.

- Improves a 3-D tomographic model for the southern California crust using body and surface waveforms in the period range of 2-30s
- Shows multiple across-fault velocity contrasts, however the interpretation of certain features is outside of the scope of the paper
- Two key interpretations:
    - The Coast Ranges, southern San Joaquin basin, and Continental Borderlands are characterized by predominantly slow wave speeds in the upper 15 km.
    - The relatively fast wave speeds beneath the western Transverse Ranges and the western Mojave may be the signatures of underplated oceanic crust related to Farallon subduction.

Schmandt, Brandon, and Eugene Humphreys. "Complex subduction and small-scale convection revealed by body-wave tomography of the western United States upper mantle." *Earth and Planetary Science Letters* 297.3-4 (2010): 435-445.

- Invert teleseismic travel-time residuals from the TA and more than 1700 additional temporary and permanent stations for 3-D velocity perturbations to a depth of 1000 km
- Partially molten mantle is inferred beneath Yellowstone and the eastern Snake River Plain, the Salton Trough, and the Clear Lake volcanic field
    - The inferred depth extent of partial melt is consistent with a generally hydrated upper mantle and elevated temperatures beneath the eastern Snake River Plain and Yellowstone
    - Maximum inferred depth of melt is ~195 km beneath Yellowstone and the eastern SRP, ~125 km under the Salton Trough, Clear Lake volcanic field, northeastern Great Basin, and southern Rio Grande Rift
- Infer patchy and incomplete removal of the flat- subducting Laramide slab and slab tearing associated with Eocene accretion

Lin, Fan-Chi, Michael H. Ritzwoller, and Roel Snieder. "Eikonal tomography: surface wave tomography by phase front tracking across a regional broadband seismic array." *Geophysical Journal International* 177.3 (2009): 1091-1110.

- Present a method of surface wave tomography based on applying the eikonal equation to observed phase traveltime surfaces computed from seismic ambient noise
    - Requires the construction of cross-correlations between each station pair
    - Tracking the gradient of the phase front of a particular wave provides an operator which can be used to compute localized phase slowness without explicitly solving the forward problem
- Show azimuthally heterogeneous phase amplitude, implying a clear way to track directivity/ azimuthal anisotropy

Karlstrom, K. E., et al. "Mantle-driven dynamic uplift of the Rocky Mountains and Colorado Plateau and its surface response: Toward a unified hypothesis." *Lithosphere* 4.1 (2012): 3-22.

- Combine tomographic and receiver function images to resolve a vertical high-seismic-velocity anomaly beneath the west-central plateau that extends more than 200 km in depth
- Suggest a model where low angle subduction of the Farallon slab results in a hydrated unit residing at the base of the lithosphere at the core of the Colorado Plateau
    - Continual downwelling and removal of volatiles from this layer results in mantle convection that drives uplift of the plateau and magmatic activity along its flanks

Lay, T., et al. "Teleseismic inversion for rupture process of the 27 February 2010 Chile (Mw 8.8) earthquake." *Geophysical Research Letters* 37.13 (2010).

- Constrain rupture patch and directivity of 2010 Chile great earthquake
    - Rupture velocity between 2.0 - 2.5 km/s, rupture duration ~130 s
- Ambiguity about the dip of the fault plane leads to some uncertainties in the model inversion

Tembe, Sheryl, David A. Lockner, and Teng-Fong Wong. "Effect of clay content and mineralogy on frictional sliding behavior of simulated gouges: Binary and ternary mixtures of quartz, illite, and montmorillonite." *Journal of Geophysical Research: Solid Earth* 115.B3 (2010).

- Conventional triaxial compression tests conducted at 40 MPa effective normal stress on samples containing mixtures of quartz, montmorillonite, and illite
- frictional strengths of mixtures fall between the end-members of pure quartz (strongest) and clay (weakest).
- Overall trend was a decrease in strength with increasing clay content,

Larson, Kristine M., et al. "GPS multipath and its relation to near-surface soil moisture content." *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 3.1 (2010): 91-99.

- Use of GPS L-band multipath phase measurements to monitor soil moisture content at a particular UNAVCO site in Marshall, CO
- Find that phase offset and multipath reflector height are correlated with soil moisture content
    - Phase offset is more strongly correlated
- Find that phase offset is increased during periods of high precipitation
- Implications for the ability to use continuous GPS data to monitor soil moisture content, process still needs to be refined

Holland, Austin A. "Earthquakes triggered by hydraulic fracturing in south-central Oklahoma." *Bulletin of the Seismological Society of America* 103.3 (2013): 1784-1792.

- Author identifies a sequence of 16 $M_L \geq 2.0$ earthquakes that occur around Picket Unit B Well 4–18 in south-central Oklahoma using TA data
- Using a template matching algorithm, it is determined that no similar waveforms occurred prior to or after the cessation of hydraulic fracturing activities
- The majority of the sequence is shown to have a strong temporal correlation with the onset and duration of a second stage of fracturing
    - Further bolstered by bad weather causing the operation to pause for a few days in between stages 2 and 3, during which time the earthquake sequence ceased

Zielke, Olaf, et al. "Slip in the 1857 and earlier large earthquakes along the Carrizo Plain, San Andreas fault." *Science* 327.5969 (2010): 1119-1122.

- Use a newly-acquired LiDAR dataset to examine offset associated with large earthquakes along the San Andreas fault
    - Present measurements of the lateral surface displacement of well-defined offset stream channels along the Carrizo segment, assuming that the channels displaying the smallest amount of offset are associated with the most recent major EQ
- Find that an offset of ~5m is most likely to be associated with the 1857 Fort Tejon EQ, challenging the common belief of a ~9m associated offset
    - Decreases the associated estimated moment release for the event
    - Challenges the view of the Carrizo segment as being unusually strong, however doesn't preclude the possibility of bimodality to slip nature
- Estimate a 140 □ 46 year interval for large-earthquake recurrence along the Carrizo segment

Lay, Thorne, et al. "The 2009 Samoa–Tonga great earthquake triggered doublet." *Nature* 466.7309 (2010): 964.

- Analyses of the seismic waves for the 29 September 2009 event yielded unusual inconsistency in point-source focal mechanism determinations, with GCMT solutions indicating a non double-couple component
- The R1 Rayleigh wave phase Source-time functions show two strong pulses with negative amplitudes about 70 s and 110 s into the signals, with maximum amplitudes to the east and west
- Back-projections of short period (0.3–5 s) P waves from regional networks were performed to locate secondary sources of radiation
    - Indicate 4 distinct radiation centers that correspond with the great normal event followed by two distinct thrust events, almost certainly triggered by the former
- Rayleigh and Love wave modeling shows a lowered misfit from solutions that include the normal plus two thrust event solution as compared to the W- phase solution

Shen, Weisen, Michael H. Ritzwoller, and Vera Schulte-Pelkum. "A 3-D model of the crust and uppermost mantle beneath the central and western US by joint inversion of receiver functions and surface wave dispersion." *Journal of Geophysical Research: Solid Earth* 118.1 (2013): 262-276.

- Rayleigh wave phase velocity maps from ambient noise and earthquake data are jointly inverted to produce a 3D model of shear wave speeds beneath the central and western US to a depth of 150 km
- Images a number of tectonic features
    - Sedimentary basins, most notably in the Great Valley of California and in the foreland of the Wyoming-Utah-Idaho thrust belt

    - Low-velocity zones interpreted as magmatic underplating beneath the Rio Grande rift and Snake River plane
- Velocity model serves as a baseline for further studies that aim to iteratively improve resolution on smaller scales

Johanson, Ingrid A., et al. "Coseismic and postseismic slip of the 2004 Parkfield earthquake from space-geodetic data." *Bulletin of the Seismological Society of America* 96.4B (2006): S269-S282.

- Use a combination of GPS and InSAR datasets to characterize slip distribution along the SAF during the 2004 Parkfield EQ
- Locate two distinct asperities upon which coseismic slip occurred
- Image a clear migration of slip from the coseismic to postseismic periods, generally trending along strike and downdip from each of the asperities as well as a diffuse distribution of postseismic slip along the shallow portion of the fault
- Models indicate that surface slip occurred mostly during the postseismic period and that ~66% - 75% of total moment release occurred aseismically

Ikari, Matt J., Chris Marone, and Demian M. Saffer. "On the relation between fault strength and frictional stability." *Geology* 39.1 (2011): 83-86.

- Present laboratory experimental evidence for a systematic relationship between frictional strength and friction rate dependence
- Find that frictionally weak gouges (coefficient of sliding friction, $\mu < 0.5$) composed of phyllosilicate minerals exhibit velocity-strengthening behavior
- Gouges with higher frictional strength exhibit both velocity-weakening and velocity-strengthening frictional behavior.
- Find that frictional velocity dependence evolves systematically with shear strain, such that a critical shear strain is required to allow slip instability
    - Suggests that seismic behavior and the mode of fault slip may evolve predictably as a function of accumulated offset

Bock, Yehuda, Diego Melgar, and Brendan W. Crowell. "Real-time strong-motion broadband displacements from collocated GPS and accelerometers." *Bulletin of the Seismological Society of America* 101.6 (2011): 2904-2925.

- Present a new methodology to estimate very high-rate displacements in real time from a combination of 1 Hz GPS displacements and 100 Hz raw accelerometer data using a Kalman filter
- Methodology is tested using the Shake table at UCSD and applied to the 2010 El Mayor–Cucapah Earthquake
- Implications for use of a combination of continuous GPS stations and accelerometers as an earthquake early warning system, as well as providing observations of associated coseismic and postseismic deformation in near real time

Zavorotny, Valery U., et al. "A physical model for GPS multipath caused by land reflections: Toward bare soil moisture retrievals." *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 3.1 (2010): 100-110.

- Build an electrodynamic model of GPS multipath that has a bare-soil model as the input and the total GPS received power as the output
- Modeling does not take into account the effects of surface topography and vegetation

Meghan S. Miller, Leland J. O'Driscoll, Robert W. Porritt, Sarah M. Roeske; Multiscale crustal architecture of Alaska inferred from P receiver functions. *Lithosphere* ; 10 (2): 267–278.

- Uses Common Convergence Point stacking, individual receiver function stacks, and receiver gathers for viewing and imaging P-wave receiver functions of early data gathered from TA stations in Alaska
- Find a general correlation between crustal thickness and topography for long-wavelength structures
- Find a significant offset of moho depth across the Denali fault in the oroclinal bend of the Alaska range (shallows northward by 5-15 km)

Moschetti, M. P., et al. "Seismic evidence for widespread western-US deep-crustal deformation caused by extension." *Nature* 464.7290 (2010): 885.

- Observations from ambient noise tomography in the western United States reveal strong deep (middle to lower)-crustal radial anisotropy that is confined mainly to the geological provinces that have undergone significant extension during the last ~65 Ma
    - Driving mechanism assumed to be lattice-preferred orientation of anisotropic crustal minerals caused by extensional deformation
- Deformation is relatively uniform at large, regional scales. Most prevalent in the Basin and Range & Omineca belt

Frohlich, Cliff, et al. "The Dallas–Fort Worth earthquake sequence: October 2008 through May 2009." *Bulletin of the Seismological Society of America* 101.1 (2011): 327-340.

- Identifies a sequence of ~180 EQs $M_L \leq 3.3$ occurring in the Dallas Fort Worth Area
- Vast majority of events occur in a set of 4 distinct temporal clusters, one of which is well imaged by a rapid-deployment temporary array
    - Cluster of 11 EQs is well located to have all originated within 0.5 km of a brine disposal well that commenced fluid injection activities 1 month prior to the onset of all observed seismicity and 2 months prior to the set of seismicity that is well imaged by the temporary network
    - Cluster is also shown to be roughly coincident with a mapped normal fault in the area
- General conclusion that the observed seismicity is most likely the result of fluid injection activities

Obrebski, Mathias, et al. "Slab‐plume interaction beneath the Pacific Northwest." *Geophysical Research Letters* 37.14 (2010).

- Uses body wave tomography to show the existence of a continuous, whole- mantle plume beneath the Yellowstone Snake River Plane
- Shows that the presumed subducted Juan de Fuca (Farallon) slab is fragmented or absent beneath Oregon
- Suggests that plume emplacement at ~ 19 Ma altered the nature of the Cascadia subduction zone, promoting tearing of the downgoing slab and decreasing the convergence rate due to a reduction in slab pull forces

Li, Yong-Gang, et al. "Seismic evidence for rock damage and healing on the San Andreas fault associated with the 2004 M 6.0 Parkfield earthquake." *Bulletin of the Seismological Society of America* 96.4B (2006): S349-S363.

- Deploy an array of seismometers along strike of the SAF a week after the 2004 M6.0 Parkfield EQ to image aftershocks

- Also image reflections from 2 active source explosions colocated with those of a study conducted by the authors 2 years previously
    - Shows a 1.0 - 1.5% decrease in seismic velocity within a 200m-wide zone along the fault strike and a smaller 0.2 - 0.5% velocity decrease outside of this region -> decrease attributed to coseismic damage
    - Damage zone is shown to be asymmetric, extending further on the southwest side
    - Seismic velocities show a 0.7 - 1.1% increase 3 months after the main shock, implying fault zone healing via crack closure, assumed to be imaged by aftershock sequence
- Seismicity attributed to fault healing is shown to colocate with areas of mapped slip and be most prominent at shallow depths < 7km

Shelly, David R. "Migrating tremors illuminate complex deformation beneath the seismogenic San Andreas fault." *Nature* 463.7281 (2010): 648.

- Investigates the occurrence of tectonic tremor beneath the San Andreas fault, assumed to be down-dip extensions of tectonic activity. Evidence for a localized shear zone at depth.
- Find that tremors can migrate over 20km along strike, traveling at speeds of 15-80 km/hr
- Classifies tremor signal into different 'families' using a template scheme and shows that these have different recurrence patterns which are shown to vary around the M 6.0 Parkfield earthquake

Lin, Fan-Chi, et al. "Complex and variable crustal and uppermost mantle seismic anisotropy in the western United States." *Nature Geoscience* 4.1 (2011): 55.

- Mantle flow field beneath the western US is dominated by motion of the NA plate and subduction of the Juan de Fuca and Farallon slab systems
- Anisotropy in the crust and upper mantle are largely uncorrelated
    - Crustal anisotropy correlates with geologic provinces
    - Mantle anisotropy controlled by temperature variations

Zhao, Li, et al. "Fréchet kernels for imaging regional earth structure based on three-dimensional reference models." *Bulletin of the Seismological Society of America* 95.6 (2005): 2066-2080.

- Develops an algorithm in order to accurately compute the Frechet kernels that linearly relate phase and amplitude measurements to perturbations of the seismic structure
    - Important that the method relies on iterative improvement of reference models
- Allows for a practical means of iteratively solving nonlinear regional tomography problems using Earthscope TA data

Lu, Zhong, et al. "Ground surface deformation patterns, magma supply, and magma storage at Okmok volcano, Alaska, from InSAR analysis: 1. Intereruption deformation, 1997–2008." *Journal of Geophysical Research: Solid Earth* 115.B5 (2010).

- InSAR images of deformation trends at Okmok between 1997-2008 suggest a relatively consistent Mogi inflation source with a radius of 1 km centered at 3.5 km depth beneath the caldera floor
    - Potential slight migration of the source along the x-component observed
- Inflation rate is variable in time and tied to the pressure gradient between the feeder source and magma chamber

Schleicher, A. M., Bo A. van der Pluijm, and L. N. Warr. "Nanocoatings of clay and creep of the San Andreas fault at Parkfield, California." *Geology* 38.7 (2010): 667-670.

- Electron microscopy and X-ray diffraction study of fault gouge surfaces reveal the occurrence of neocrystallized thin film clay coatings containing illite-smectite (I-S) and chlorite-smectite (C-S) minerals
    - Most likely the result of fluid alteration, as ages of clay minerals correlate to deformation episodes of the fault
- Propose that the majority of slow fault creep is controlled by the high density of thin (<100 nm thick) nanocoatings on fracture surfaces, which are sufficiently smectite-rich and interconnected at low angles to accommodate slip with minimal breakage of stronger matrix clasts`
- These clay minerals are known to precipitate at up to ~250^{o}C, meaning they could be prevalent at depths greater than the SAFOD borehole (up to ~10 km)

Bensen, G. D., M. H. Ritzwoller, and Y. Yang. "A 3-D shear velocity model of the crust and uppermost mantle beneath the United States from ambient seismic noise." *Geophysical Journal International* 177.3 (2009): 1177-1196.

- Invert Rayleigh and Love wave shear wave velocities in the 8 - 70 s and 8 -20 s period respectively in order to obtain crustal thickness estimates and shear wave speed maps for the crust. Maximum depth of presented velocity model is 120 km.
- Use TA data to generate a 3-D nationwide coarse grid populated by 0.5^{o} x 0.5^{o} points
- Find that the model systematically misfits Rayleigh and Love wave speeds between 10 and 20 s period in some regions, overpredicting Rayleigh wave speeds and underpredicting Love wave speeds.
    - Argue that this Rayleigh–Love discrepancy probably results from radial anisotropy in the middle and/or lower crust

Skoumal, Robert J., Michael R. Brudzinski, and Brian S. Currie. "Earthquakes induced by hydraulic fracturing in Poland Township, Ohio." *Bulletin of the Seismological Society of America* 105.1 (2015): 189-197.

- Use a multi-station cross correlation template-matching routine in order to identify microseismicity surrounding hydraulic fracturing operations
    - Identify EQs of M_L ~1 - 3
    - Find a strong spatial and temporal correlation to fracturing activities
- Find that observed seismicity preferentially occurs along pre-existing faults and that focal mechanisms align with the regional stress field.

Small, Eric E., Kristine M. Larson, and John J. Braun. "Sensing vegetation growth with reflected GPS signals." *Geophysical Research Letters* 37.12 (2010).

- Find that GPS multipath reflection signals are sensitive to a ~1000m^2 area around continuous stations
    - Reflections sensitive to vegetation height and soil moisture content
- Able to use results to bolster other remote sensing data surrounding vegetation growth in non-forested regions

Hornbach, Matthew J., et al. "Causal factors for seismicity near Azle, Texas." *Nature communications* 6 (2015): 6728.

- Image a sequence of earthquakes of M_L 1.0 - 3.6 that occurred between early November 2013 and January 2014 near a series of hydraulic fracturing wells
- Model pore fluid pressure changes as a result of injection activities, find that an increase in modelled pore pressure both spatially and temporally corresponds with the observed seismicity

- Underscores the importance of monitoring microseismicity near hydraulic fracturing operations, points out a general lack of such instrumentation in certain areas of Texas

Tong, Xiaopeng, David T. Sandwell, and Yuri Fialko. "Coseismic slip model of the 2008 Wenchuan earthquake derived from joint inversion of interferometric synthetic aperture radar, GPS, and field data." ***Journal of Geophysical Research: Solid Earth*** **115.B4 (2010).**

- Present a model for coseismic slip in the 2008 Wenchuan Earthquake, synthesizing a series of interferograms, field measurements of fault scarp, and GPS vectors
    - Find a high compatibility of inSAR and GPS vectors, combined inversion leads to a ~93% variance reduction
- Best fit models include relatively equal partitioning of motion between dip slip and dextral strike slip
- Observe that most coseismic displacement was confined to the uppermost 10 km of the crust, with aftershocks concentrating in the 10 - 20 km depth range directly underneath the coseismic displacement

Meqbel, Naser M., et al. "Deep electrical resistivity structure of the northwestern US derived from 3-D inversion of USArray magnetotelluric data." ***Earth and Planetary Science Letters*****402 (2014): 290-304.**

- Develop a broad image of the electrical resistivity structure of the northwestern U.S.
- Imaging the transition from the tectonically active margin to North American craton.
- Conductivities are related to fluids and partial melts in the active area.

Schmidt, D. A., and H. Gao. "Source parameters and time‐dependent slip distributions of slow slip events on the Cascadia subduction zone from 1998 to 2008." ***Journal of Geophysical Research: Solid Earth*** **115.B4 (2010).**

- Identify 16 conspicuous slow slip transients from the Cascadia subduction zone from GPS time series
    - Invert for slip behavior using a Kalman filter, resolving slip behavior at the downdip end of the seismogenic zone
- Find a maximum in SSE occurrence and total strain release near Port Angeles, WA -> correlates with along-strike bend of the subduction zone
    - Underscores the importance of plate geometry in determining the along-strike behavior of the subduction zone

Audet, Pascal, et al. "Slab morphology in the Cascadia forearc and its relation to episodic tremor and slip." ***Journal of Geophysical Research: Solid Earth*** **115.B4 (2010)**

- Use stacked receiver functions from four seismic lines to image the along-strike geometry of the downgoing slab in the Cascadia subduction zone
- Find conformal depth contours from northern California into Northern Oregon
- Propose a model for ETS:
    - Dehydration of the downgoing slab causes fluids to pool at the interface with the overriding plate, where they localize overpressure and decrease the effective normal stress
    - Eventually this causes slow slip and tremor which propagates until the hydrofracturing of the overriding seal and the permeability increase due to slow slip relieve localized overpressure.

Rubinstein, Justin L., et al. "The 2001–present induced earthquake sequence in the Raton Basin of northern New Mexico and southern Colorado." *Bulletin of the Seismological Society of America* 104.5 (2014): 2162-2181.

- Find a clear correlation between the seismicity in the Raton basin and wastewater injection activities in a nearby coal-bed methane field
- Find an occurrence of 12 M ≥ 4 events in the time span 2000 - 2013 whereas only one between 1972 - 2001
    - Determine a 3% likelihood of such a rate change occurring in a system with truly randomly distributed seismicity
- Observe the occurrence of a M 5.3 EQ in August 2011, which as of 2014 was the second largest induced EQ to be instrumentally recorded

Huang, Hsin-Hua, et al. "The Yellowstone magmatic system from the mantle plume to the upper crust." *Science* 348.6236 (2015): 773-776.

- Find a large east-northeast–west-southwest elongated Low Velocity Body (LVB) beneath the Yellowstone caldera at depths shallower than 20 km
- Image a second, distinct body between 20 - 50 km
    - Existence and separation from the shallowerbody validated through finite frequency and synthetic tests
    - Find that this body is concentrated right above the ~45 km Moho in the region
- Present a model whereby the shallower body is composed of rhyolitic partial melt and the deeper body is composed of basaltic partial melt, with various hydrothermal fluid pathways permeating into the uppermost crust. These systems are fed by a mantle plume, which pools at the base of the uppermost mantle

Lin, Fan-Chi, and Michael H. Ritzwoller. "Helmholtz surface wave tomography for isotropic and azimuthally anisotropic structure." *Geophysical Journal International* 186.3 (2011): 1104-1120.

- Present a new method of surface wave tomography for use with the TA. Based on the eikonal equations
- Suggest using amplitude measurements to construct geographically localized finite frequency corrections via the Helmholtz equation
- Show an improvement at long periods of the resolution of small scale structures and that this method reduces scattering effects of directionally dependent phase velocity measurements

Levander, Alan, and Meghan S. Miller. "Evolutionary aspects of lithosphere discontinuity structure in the western US." *Geochemistry, Geophysics, Geosystems* 13.7 (2012).

- Use common conversion point stacked Ps and Sp receiver functions to image volumes of the Moho and lithosphere-asthenosphere boundary (LAB) beneath the western United States
    - Find a fairly continuous, well-imaged moho
- LAB depth varies significantly, becoming about 50% deeper past the Cordilleran hingeline which is here defined as the lateral extent of the formerly passive margin that was modified in the mid-late Mesozoic by Farallon subduction and various pulses of orogenic activity
- Find that depth to the LAB correlates with surface heat flow measurements, supporting the hypothesis of the lithosphere acting as a thermal boundary layer

Unsworth, Martyn, and Paul A. Bedrosian. "Electrical resistivity structure at the SAFOD site from magnetotelluric exploration." *Geophysical research letters* 31.12 (2004).

- Image a ‘fault zone conductor’ interpreted as a porous damaged region of low resistivity that extends to 2-3 km depth right along the San Andreas fault trace
    - Low resistivity is reflective of pore fluid content, not lithology
- Image an ‘Eastern Conductor’ within the Great Valley and Franciscan formations to the East of the SAF
    - Suggest layers of serpentinite in these sequences may confine a regional aquifer
    - Occurrence of serpentinite layers corresponds with field observations and gravity data
    - Suggest that this conductor may be responsible for the entry of fluids into the fault zone

Luo, Yinhe, et al. "Unraveling overtone interferences in Love-wave phase velocity measurements by radon transform." ***Geophysical Journal International*** **203.1 (2015): 327-333.**

- Apply a linear radon transform in order to characterize station-pair energy density of higher mode surface wave oscillations
- Objective is to isolate the fundamental mode in order to reduce bias of surface wave tomographic inversions
- Show that the technique can be applied to larger arrays

Imanishi, Kazutoshi, and William L. Ellsworth. "Source scaling relationships of microearthquakes at Parkfield, CA, determined using the SAFOD pilot hole seismic array." ***Earthquakes: Radiated Energy and the Physics of Faulting*** **170 (2006): 81-90.**

- Model spectral ratios of small (M -0.2 to M 2.1) earthquakes detected in the SAFOD borehole to determine seismic moments and corner frequencies
- Show that both static stress drops and apparent stresses of microearthquakes at Parkfield do not depend on earthquake size and are similar to those of moderate to large magnitude events

Becken, Michael, et al. "Correlation between deep fluids, tremor and creep along the central San Andreas fault." ***Nature*** **480.7375 (2011): 87.**

- Invert for resistivity structure along a series of profiles that transect the SAF
- Image an aquifer at depth to the west of the fault trace that is variably connected to the fault strand along strike
    - Find the Salinas block to be a low-permeability confining layer that restricts fluids from entering the fault strand
- Find a correlation between seismic tremor and the juxtaposition of the confining layer with the aquifer
    - Infer that fluid overpressure generated by movement away from the aquifer at depth underneath the fault strand is a likely mechanism

Ritzwoller, Michael H., Fan-Chi Lin, and Weisen Shen. "Ambient noise tomography with a large seismic array." ***Comptes Rendus Geoscience*** **343.8-9 (2011): 558-570.**

- Discuss the methods and advantages of eikonal tomography
    - Find that the method extracts information from ambient noise (generated by teleseismic earthquakes) at high resolution about isotropic wave speeds as well as azimuthal anisotropy at periods from less than 10 s to about 40 s
    - Find that the method when applied to periods less than 20s (waves sensitive to the earth’s upper ~ 25km) can provide unique constraints about velocity structure and account for wave bending around sharp structural contrasts

Thurber, C., et al. "Earthquake locations and three-dimensional fault zone structure along the creeping section of the San Andreas fault near Parkfield, CA: Preparing for SAFOD." *Geophysical Research Letters* 30.3 (2003).

- Invert for V_p and V_p/V_s using a catalogue of ~450 local EQs and 6 explosions
- Find that almost all local EQs occur either beneath or close to the fault strand
- Find a substantial velocity contrast across the fault zone
- Find an elevated V_p/V_s SW of the fault zone that corresponds with a fluid-rich body imaged in MT studies
- Discuss a repeating sequence of M ~ 2 earthquake as a target for the final stage of the SAFOD drilling
    - Perform a series of inversions in order to assess location uncertainty

Gratier, J-P., et al. "Aseismic sliding of active faults by pressure solution creep: Evidence from the San Andreas Fault Observatory at Depth." *Geology* 39.12 (2011): 1131-1134.

- Propose that pressure solution creep, a mechanism by which minerals at grain contact boundaries under relatively high stress dissolve in a pore fluid and remineralize along lower-stress boundaries, can account for observed aseismic creep in the SAF
- Base their interpretations on microstructural analyses of SAFOD samples. Use elemental distribution maps to infer sections of samples affected by pressure solution. Show that deformed zones are most affected by pressure solution.
- Show that this mechanism can accommodate about 20 mm/yr of aseismic displacement

Outerbridge, Kimberly C., et al. "A tremor and slip event on the Cocos-Caribbean subduction zone as measured by a global positioning system (GPS) and seismic network on the Nicoya Peninsula, Costa Rica." *Journal of Geophysical Research: Solid Earth* 115.B10 (2010).

- Present geodetic and seismic evidence for the existence of ETS in the Cocos-Caribbean subduction segment of the Middle America Trench
    - SSE lasted for about 40 days
- Invert for slip distribution in the SSE, preferred model has two patches of slip somewhat offset along strike
    - One at 25-30 km depth, at the base of the seismogenic zone
    - Another way updip at ~6km depth, near the frictional transition zone
- Find a good temporal correlation between slow slip and tremor, but not a good spatial correlation
- Find that the temperature of the subducting interface is not a controlling factor in the occurrence of ETS
    - Compare models for the thermal structure of the downgoing Cocos plate, which is ~200^{o}C cooler than the slabs in Cascadia and Japan

Hudnut, K. W., et al. "High-resolution topography along surface rupture of the 16 October 1999 Hector Mine, California, earthquake (M W 7.1) from airborne laser swath mapping." *Bulletin of the Seismological Society of America*92.4 (2002): 1570-1576.

- Scan the surface rupture trace of the Hector mine earthquake in order to study geomorphic features
    - Goal to quantify surface ruptures for a known magnitude earthquake and then extend this framework back in time to examine slip history

Schaeffer, A. J., and S. Lebedev. "Imaging the North American continent using waveform inversion of global and USArray data." ***Earth and Planetary Science Letters*** **402 (2014): 26-41.**

- Present a new S_v velocity model of the North American continent, using a very large set of waveform fits of both global and USArray stations
- Model offers higher resolution of cratonic structure and boundaries
- Find no correlation between occurrence of kimberlites and any particular Archean cratonic province or gradient in the velocity field
- Show a clear separation of the Greenland lithospheric root from that of North America, with no evidence of modern or recent ridge activity within the Labrador Sea and Baffin Bay
- Show high velocities beneath northwestern Northwest Territories, between the Great Bear Arc and the Beaufort Sea, provide convincing evidence for the recently proposed “MacKenzie Craton”