



F-TRG newsletter September 2018

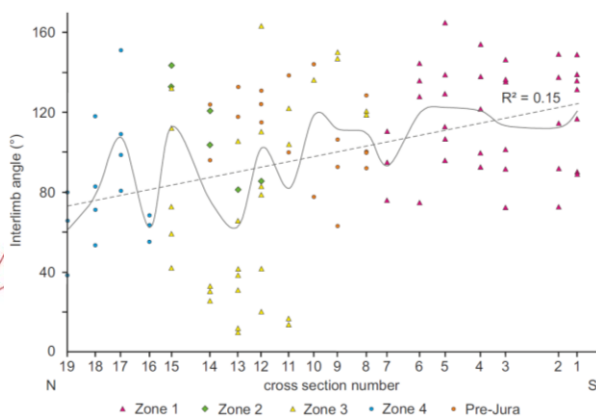
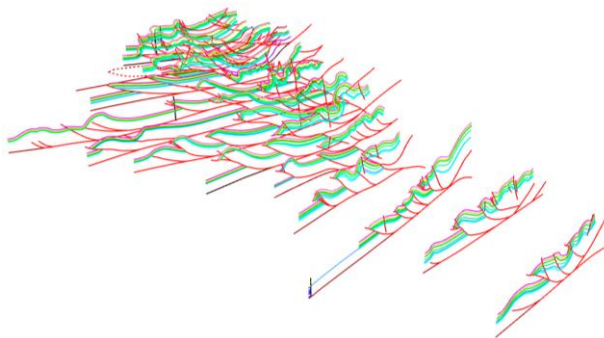
This issue...

This is the final newsletter for F-TRG phase 1; the newsletter outlines ongoing and completed research projects, the recent cross section training course, a summary of F-TRG phase 1 outcomes, an introduction to phase 2 plans, a reminder of the F-TRG knowledge exchange content, recent/relevant publications and some useful links. We thank our sponsors for their support over the past three years.

Ongoing/completed research

Controls on structural style in the French Subalpine chains

F-TRG have been working on characterising structural style and investigating the controls on fold geometry in the French Subalpine chains. The project is focussed around 19 cross sections that span a 160 km length of the French foreland thrust belt. The controls of thrust displacement, shortening and mechanical stratigraphy on fold geometry are explored. A project summary is available on our knowledge exchange website.



Above left: cross sections through the French Subalpine chains. Above right: analysis of fold interlimb angle.

Interpreting structural geometry in fold thrust belts: Why style matters

We have recently published an article in the Journal of Structural Geology that discusses structural style and interpretation in fold thrust belts. The article is available on our knowledge exchange website, and can be accessed here:

<https://www.sciencedirect.com/science/article/pii/S019181411830289X>

Articles in review

F-TRG have produced a review article titled '**Fold-thrust structures - where have all the buckles gone?**' that is currently in review. The article uses case studies from the Bolivian Subandean chain, the Canadian Cordillera and the French and Swiss Subalpine chains to discuss the distinction and



integration of buckle fold versus fault-related folding models. The manuscript is available on our knowledge exchange website.

In addition we have an article titled '**Fracture distribution on the Swift Reservoir Anticline, Montana: implications for structural and lithological controls on fracture intensity**' in review. In this paper we explore how changes in fold curvature, bedding dip and lithology may influence fracture intensity on a carbonate anticline (the Swift Reservoir Anticline, Sawtooth Range, Montana). The manuscript is available on our knowledge exchange website.

Cross section construction and restoration in fold-thrust belts training course



F-TRG ran a training course on 14th-16th August 2018, led by Hannah Watkins and Clare Bond from the University of Aberdeen. 20 attendees from Oil Search and Santos convened at the Santos Centre in Adelaide to take part in this 'Cross section construction and restoration in fold-thrust belts' training course. The course involved a field excursion to

Hallett Cove to the south of Adelaide, where attendees collected field data and constructed sketch cross sections of folded Precambrian sandstones and siltstones. For the remainder of the course attendees used practical exercises to practice cross section construction and restoration techniques using datasets from Wyoming (USA), the French Subalpine chains, the Orange Basin (offshore Namibia) and offshore NW Borneo. Exercises, presentations and all other material relating to the course can be found on the F-TRG knowledge exchange website (see link below).



Above left: data collection on the folds of Hallett Cove Beach. Above right: cross section group exercises.

F-TRG phase 1

Phase 1 of the Fold-Thrust Research Group (F-TRG) ran from September 2015 – September 2018. The main achievements of phase 1 are outlined below:



- Overview of current understanding of the structure of thrust systems, strategies for management of interpretation uncertainty and practices for limiting drilling surprises.
- Description of regional lateral variations in fold-thrust geometry at outcrop, in the Subalpine Chains of SE France and in the Laramide belt of Montana.
- Distillation of thrust belt interpretations from worldwide outcrop examples, tied to satellite imagery.
- Descriptions of damage styles, related to large-scale geometry (Montana & Subalpine chains).
- Integration with ongoing research on thrust system geometry in Aberdeen, and exposure to findings from this research through webinars and at sponsor meetings.
- Creation of sharepoint web resource for knowledge exchange with partners, including webinar presentations, newsletters, literature highlights, analogue examples, field trip photos, a Google Earth resource of georeferenced fold-thrust belt cross-sections.
- Delivery of field-based training (Alps, SW Wales) and webinars.
- Delivery of an in-house training course on 'Cross section construction and restoration in fold-thrust belts'.
- Maps and cross-sections through key parts of the field case studies.
- Thrust displacement vs lateral extent relationships & statistics.

In addition the following publications have arisen from F-TRG phase 1:

- Butler, R.W.H., Bond, C.E., Cooper, M.A. & Watkins, H., 2018. Interpreting structural geometry in fold-thrust belts: why style matters. *Journal of Structural Geology*, 114, 251-273.
- Butler, R.W.H., Bond, C.E., Cooper, M.A. & Watkins, H. (in review). Fold-thrust structures – where have all the buckles gone? In: *Folding and Fracturing of Rocks: 50 Years of Research since the Seminal Text Book of J. G. Ramsay*. Special Publications of the Geological Society, London.
- Watkins, H., Bond, C. E., Cawood, A. J., Cooper, M. A. & Warren, M. J. (in review). Fracture distribution on the Swift Reservoir Anticline, Montana: implications for structural and lithological controls on fracture intensity. In: *Folding and Fracturing of Rocks: 50 Years of Research since the Seminal Text Book of J. G. Ramsay*. Special Publications of the Geological Society, London.
- Watkins, H.M., Butler, R.W.H. & Bond, C.E. 2017. Using laterally compatible cross sections to infer fault growth and linkage models in foreland thrust belts. *Journal of Structural Geology*, 96, 102-11
- Watkins, H., Healy, D., Bond, C.E., & Butler, R.W.H, 2018. Implications of heterogeneous fracture distribution on reservoir quality; an analogue from the Torridon Group sandstone, Moine Thrust Belt, NW Scotland. *Journal of Structural Geology* 108, 180-197.



F-TRG phase 2

The F-TRG is about to launch phase 2 and currently have an open call for clients to join us. F-TRG phase 2 will include components of training, knowledge exchange and original research and will focus on increasing the availability of structural models for fold-thrust interaction and quantifying the effectiveness of models to approximate real structures. In addition we will investigate new approaches for forecasting structural complexity by integrating known structural geometries to other geological attributes (e.g. stratigraphy, inherited heterogeneities). Current sponsors have been sent the full phase 2 proposal. For more information please see our website.

<https://www.abdn.ac.uk/geosciences/departments/geology/ftrg-phase-2-1381.php>

F-TRG knowledge exchange

All material from F-TRG phase 1 has been uploaded to our knowledge exchange website:

<https://365abdn.sharepoint.com/sites/cops/research/foldthrust/SitePages/Home.aspx>

This material will be available for sponsors to download until October 2019 using their current login accounts. We advise sponsors to download material from the site before October 2019; beyond this time access to the site will no longer be possible.

Site content includes:

- F-TRG annual **sponsor meeting material**, including business meeting documents, seminars & field excursion material for the December 2015 kick-off meeting (Sydney); the French Alps workshop (October 2016) and the Pembrokeshire meeting (October 2017) and material from the August 2018 training course and business meeting.
- Selected F-TRG **conference presentations** on relevant fold-thrust topics.
- F-TRG **newsletters** (September 2015-September 2018).
- Google Earth files: updated **Global analogues** file containing georeferenced cross sections and selected field photographs.
- Mendeley database (exported as an excel spreadsheet).
- **Thrust length vs. displacement/throw data** from published examples and F-TRG cross sections.
- Move files including **global analogues** for different regions (French Subalpine analogues; Rockies and Montana analogues; Salt Ranges, Pakistan analogues; Zagros analogues) with georeferenced cross sections (and maps where possible); F-TRG Subalpine chains **cross sections** and data (French Subalpine chains cross sections F-TRG); 3D models and cross sections of selected structures (Bargy anticline,; Swift Reservoir anticline, Montana; Torridon, NW Scotland).
- **Masters projects** overseen by F-TRG, some of which use data supplied by sponsors. Topics include interpretation of Papua New Guinea datasets and interpretation of along strike



variation, using petrophysical analysis to identify detachments, and identifying the thermal structure of thrust belts using Raman Spectroscopy.

- Recent **papers/publications** authored by F-TRG members.
- Material from the 2017-2018 **webinar** series.
- Information sheets on Raman Spectroscopy and a workflow for loading cross sections into google earth.
- Project overview for the French Subalpine chains including a Raman Spectroscopy workflow.

Recent/relevant publications

Azeez, K. K. A., Athul, C. & Thiel, S., 2018. Reservoir characterization and basement estimates in the Papuan Fold belt (Papua New Guinea-PNG), from reanalysis of the PNG MT data set. *Marine and Petroleum Geology*, 98, 133-145.

Beaudoin, N. & Lacombe, O., 2018. Recent and future trends in paleopiezometry in the diagenetic domain: Insights into the tectonic paleostress and burial depth history of fold-and-thrust belts and sedimentary basins. *Journal of Structural Geology*, 114, 357-365.

Briki, H., Ahmadi, R., Smida, R. & Rekhiss, F., 2018. Structural evolution and tectonic style of the Tunisian central Atlas; role of inherited faults in compressive tectonics (Ghoulguia anticline). *Tectonophysics*, 731-732, 48-63.

Butler, R. W. H., Bond, C. E., Cooper, M. A. & Watkins, H., 2018. Interpreting structural geometry in fold-thrust belts: Why style matters. *Journal of Structural Geology*, 114, 251-273.

Caër, T., Souloumiac, P., Maillot, B., Leturmy, P. & Nussbaum, C., 2018. Propagation of a fold-and-thrust belt over a basement graben. *Journal of Structural Geology*, 115, 121-131.

Chu, Y. & Lin, W., 2018. Strain analysis of the Xuefengshan Belt, South China: From internal strain variation to formation of the orogenic curvature. *Journal of Structural Geology*, 116, 131-145.

Duffy, O. B., Dooley, T. P., Hudec, M. R., Jackson, M. P. A., Fernandez, N., Jackson, C. A-L. & Soto, J. I., 2018. Structural evolution of salt-influenced fold-and-thrust belts: A synthesis and new insights from basins containing isolated salt diapirs. *Journal of Structural Geology*, 114, 206-221.

Gao, B., Flemings, P. B., Nikolinakou, M. A., Saffer, D. M. & Heidari, M., 2018. Mechanics of Fold-and-Thrust Belts Based on Geomechanical Modeling. *Journal of Geophysical Research: Solid Earth*, 123, 4454-4474.

Ghani, H., Zeilinger, G., Sobel, E. R. & Heidarzadeh, G., 2018. Structural variation within the Himalayan fold and thrust belt: A case study from the Kohat-Potwar Fold Thrust Belt of Pakistan. *Journal of Structural Geology*, 116, 34-46.

Ghosh, S., Rodrigues, S., Kumar Varma, A., Esterle, J., Patra, S. & Dirghangi, S. S., 2018. Petrographic and Raman spectroscopic characterization of coal from Himalayan fold-thrust belts of Sikkim, India. *International Journal of Coal Geology*, 196, 246-259.



Giallorenzo, M. A., Wells, M. L., Yonkee, W. A., Stockli, D. F. & Wernicke, B. P., 2018. Timing of exhumation, Wheeler Pass thrust sheet, southern Nevada and California: Late Jurassic to middle Cretaceous evolution of the southern Sevier fold-and-thrust belt. *GSA Bulletin*, 130, 3-4, 558-579.

Harrison, C., 2018. Intersecting fold belts in the Bathurst Island region, Nunavut. *Journal of Geodynamics*, 118, 82-105.

Lee, H., Jang, Y., Kwon, S., Park, M-H. & Mitra, G., 2018. The role of mechanical stratigraphy in the lateral variations of thrust development along the central Alberta Foothills, Canada. *Geoscience Frontiers*, 9, 1451-1464.

Parui, C. & Bhattacharyya, K., 2018. Duplex and along-strike structural variation: A case study from Sikkim Himalayan fold thrust belt. *Journal of Structural Geology*, 113, 62-75.

Pei, Y., Paton, D. A., Knipe, R. J., Lickorish, W. H., Li, A. & Wu, K., 2018. Unraveling the influence of throw and stratigraphy in controlling subseismic fault architecture of fold-thrust belts: An example from the Qaidam Basin, northeast Tibetan Plateau. *AAPG Bulletin*, 102, 6, 1091-1117.

Srivastava, V., Mukul, M., Barnes, J. B. & Mukul, M., 2018. Geometry and kinematics of Main Frontal thrust-related fault propagation folding in the Mohand Range, northwest Himalaya. *Journal of Structural Geology*, 115, 1-18.

Tsukahara, K. & Takada, Y., 2018. Aseismic fold growth in southwestern Taiwan detected by InSAR and GNSS. *Earth, Planets and Space*, 70, 1, 52.

Yang, H., Yang, X., Zhang, H., Huang, X., Huang, W. & Zhang, N., 2018. Active fold deformation and crustal shortening rates of the Qilian Shan Foreland Thrust Belt, NE Tibet, since the Late Pleistocene. *Tectonophysics*, 742-743, 84-100.

Yuan, N., Huiwen, X., Hongwei, Y., Yong, L. & Wei, W., 2018. Effect of basement structure and salt tectonics on deformation styles along strike: An example from the Kuqa fold–thrust belt, West China. *Tectonophysics*, 730, 114-131.

Useful links

F-TRG website: www.abdn.ac.uk/research/foldthrust

F-TRG knowledge exchange site: this is a sponsor page and is password protected. Please get in touch with your company contact for the login details.

<https://365abdn.sharepoint.com/sites/cops/research/foldthrust/SitePages/Home.aspx>

e-Rock: ‘an open source repository of virtual outcrops and samples’: <https://www.e-rock.co.uk/>

AusGeol: ‘Virtual Library of Australia’s Geology’: <http://www.ausgeol.org/>

Virtual seismic atlas: ‘a "free-at-the-point-of-access" resource that captures and shares the geological interpretation of seismic reflection data’: <https://www.seismicatlas.org/>