Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Research Programme
- Short Calls, Final Report -

Lead Applicant Name	Nancy Riggs
Email	nancy.riggs@nau.edu
Host Organisation name	TCD
Project Title	Detrital zircon geochronology in the west of Ireland in support of Tellus geophysics interpretations
Contract Number	2017-sc-024

Date: 20th November 2018

This report covers the period November 1st 2017 to October 31st 2018

2. (a) Project information:

Final project report (*max **2500**words, excluding figures and headings*):

(i) Progress of objectives beyond state of the art. We stated three objectives in the proposal; these are reviewed here with a statement of progress for each

1) *Investigation of the obduction suture between the Deer Park ophiolite complex and North Mayo Dalradian: use Tellus data to identify individual melange blocks within the ophiolite complex and U-Pb dating of zircons to date these blocks.* We were testing conflicting hypotheses concerning the age or ages of obduction and structural juxtaposition. Williams et al. (1984) inferred a Silurian age for some mélange blocks, based on microfauna found in shale chips within sandstone. We therefore focused our work on finding appropriate outcrops, and were eventually successful on Clare Island in the Ballytoohy Formation. Zircon grains were extracted from the sandstone, and the resulting age spectrum does not include Phanerozoic zircon ages, but the Dalradian signature very closely matches that obtained by Chew et al. (2010) for the Kilidangan succession on the south shore of Clew Bay. We can thus support the assumed correlation of the two units, although we could not provide a useful test for the proposed question.

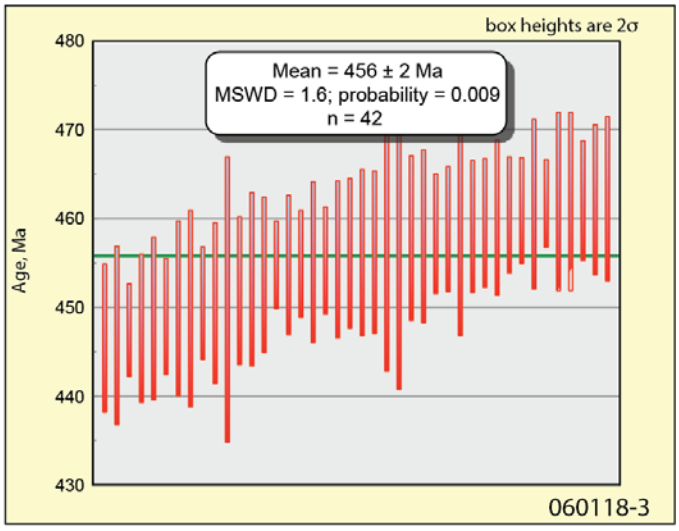
The application of Tellus geophysical data was unsuccessful for this part of the project. Electromagnetical data, which had the best chance for providing information about distinguishing melange elements, were impeded in this area yielding gaps in coverage.

2) *Place of the South Connemara Group (SCG) in the geological history of South Mayo: use Tellus data to identify the suture zone between the SCG and Connemara Dalradian rocks to the north; use detrital zircon data to understand the age and tectonic significance of the SCG, neither of which is firmly established.* Williams et al. (1988) considered the SCG to be a part of the Northern Belt of the Southern Uplands terrane, and thus an accretionary-prism complex. These authors also provided an Early Ordovician age based on fossil data. Ryan and Dewey (2004) refined the accretionary-prism interpretation to suggest that the SCG was deposited as a trench-accretion complex related to collision of oceanic plateaus or seamounts. All previous studies have agreed that the SCG is in fault contact with Proterozoic Dalradian Supergroup meta-sedimentary rocks to the north representing the western continuation of the Southern Uplands fault across Scotland and Ireland.

We made one trip to the SCG in early January, 2018, and collected five samples of metasandstone and one metabasalt that represent the majority of the SCG succession. Detrital zircon from these samples were analysed using the LA-ICPMS at TCD during Spring 2018. Our results (Fig. 1) were the topic of a poster presented at the annual meeting of the Geological Society of America (Riggs et al., 2018); we are discussing how best to begin work on a manuscript for publication. Our detrital data suggest that previous age interpretations are too old – although some of our data are anomalously young, overall we suggest that deposition of the strata occurred at c. 460 – 450 Ma. A pre-volcanic

suite of zircon crystals, ranging in age from c. 500 Ma – c. 2600 Ma (Fig. 2) is interesting for the provenance of the grains, which may indicate expected Laurentian sources, but peri-Gondwanan sources as well. This would suggest that volcanism, deposition and accretion occurred during later stages of closing of the Iapetus Ocean, when peri-Gondwanan micro-continental landmasses would have been approaching the Laurentian continent.

The Tellus geophysical study provided interesting but non-conclusive insights. The Southern Uplands fault is obscured by the Galway granitic suite, but lineaments within the granite may reflect the interaction of the intrusions with the fault zone. Magnetic data patterns do suggest that more SCG strata are present offshore of the main outcrop body.



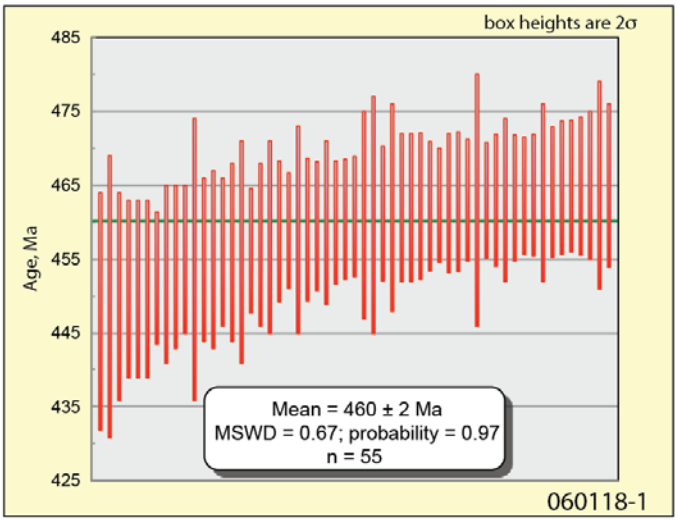


Fig. 1. Detrital zircon weighted-mean average plots from two metasandstone samples from the South Connemara Group. These data indicate a maximum depositional age of c. 455 Ma. Other spectra provide less definitive ages and are the subject of further consideration.

3) *Silurian cover rocks as a record of terrane amalgamation: use Tellus data to map terrane boundaries beneath dominantly Carboniferous cover and detrital zircon data to understand the relative contributions of different terranes.* Our goal in this objective was to determine if detrital-zircon signatures in the overlap successions would reflect the terranes on either side of their fault

contact. In addition, we hoped to see signatures of the three subbasins proposed for Silurian overlap successions (e.g., Graham et al., 1989). From north to south, these are the Louisburgh, Croagh Patrick, and Joyce Country subbasins.

Together with TCD emeritus professor John Graham, we had one field trip to Mayo to collect samples of the Silurian overlap succession, and additionally collected a tuff bed from within Silurian rocks on Clare Island. Analysis of detrital zircon from these successions was delayed by lack of specific equipment needed to separate very small zircon grains, as well as the temporary malfunction of the LA-ICPMS at TCD. The final data will be available in January 2019, but at this point preliminary interpretations can be made. Age spectra (Fig. 3) largely demonstrate the strong influence of the Laurentian continent on which they were deposited, but one sample from the Louisburgh subbasin yielded Silurian zircon that suggest a depositional age of 434 ± 4 Ma (Fig. 4).

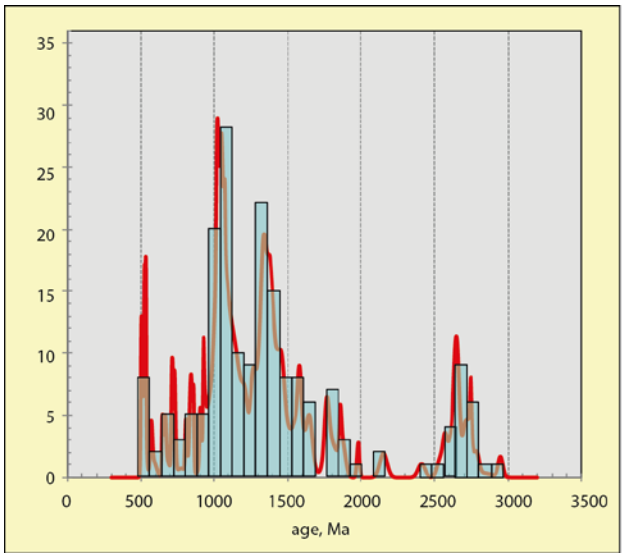


Fig. 2. Probability density plot of detrital zircon grains older than 500 Ma. Although the signature dominantly reflects Laurentian provenance, the sparse, but present c. 500 – 700 Ma grains may represent a peri-Gondwanan source.

We had planned to use Tellus magnetic data to interpret locations of terrane-bounding faults, but this part of the project was not successful; we infer that the thick Silurian section obscures the signature of these faults.

References cited:

Chew, DM, Daly, JS, Magna, T, Page, LM, Kirkland, CL, Whitehouse, MJ, Lam, R, 2010, Timing of ophiolite obduction in the Grampian orogen, Bulletin of the Geological Society of America, Vol. 122, (11-12), p. 1787-1799.

Graham, JR, Leake, BF, & Ryan, PD, 1989, The Geology of South Mayo, western Ireland. Publication of the Department of Geology and Applied Geology, University of Glasgow.

Riggs, N, Crowley, Q, and McConnell, B., 2018, U-Pb zircon dating of the South Connemara Group, Ireland, and implications for late stages of the Iapetus Ocean basin: Geological Society of America Abstracts with Programs. Vol. 50, No. 6, ISSN 0016-7592; doi: 10.1130/abs/2018AM-324312

Ryan, PD and Dewey, JF, 2004, The South Connemara Group reinterpreted: a subduction-accretion complex in the Caledonides of Galway Bay, western Ireland. Journal of Geodynamics, Vol.

37, p. 513-529.

Williams, D.M., Armstrong, H.A., and Harper, D.A.T., 1988, The age of the South Connemara Group, Ireland, and its relationship to the Southern Uplands Zone of Scotland and Ireland: Scottish Journal of Geology, Vol. 24, p. 279-287.

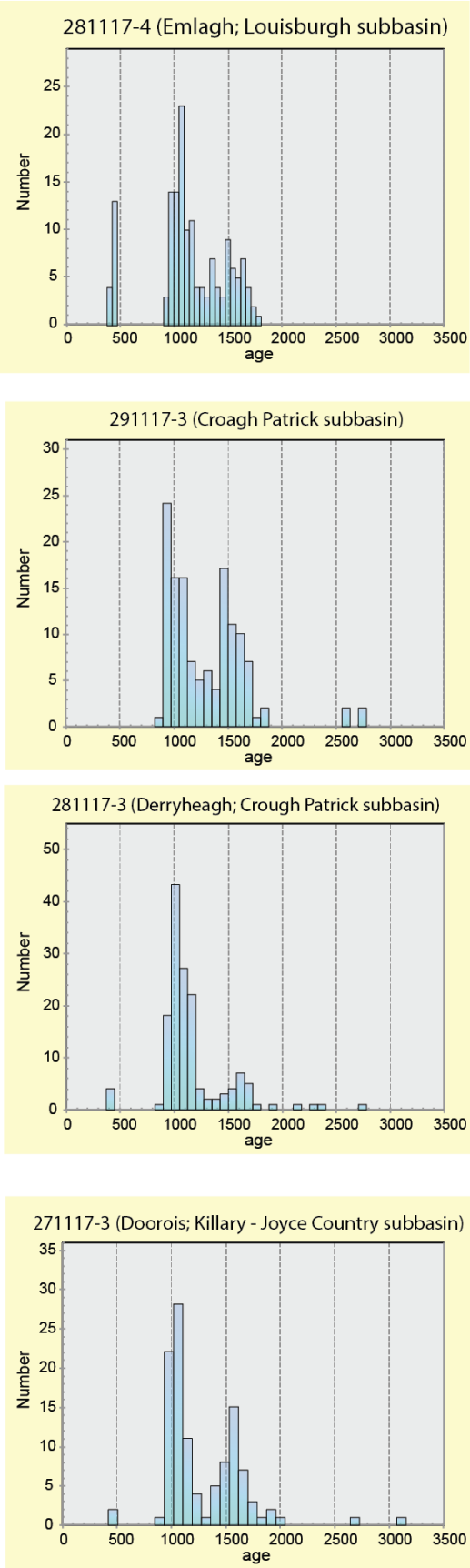


Fig. 3. Probability density plots for Silurian overlap successions. Note overall similarity between the basins in detrital zircon populations.

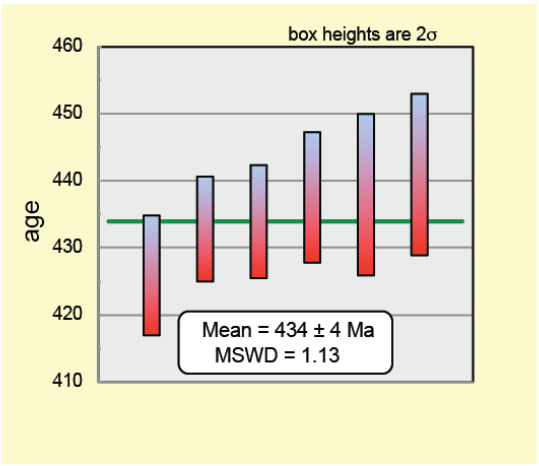


Fig. 4. Weighted average plot for Silurian grains from sample 28117-4 (Louisburgh subbasin)

(ii) Implementation.
We were able to leverage the short-call grant to complete work on a project at Navan. This project was a useful demonstration of applying methods that are part of the grant in an industry setting.
We presented a paired-subduction zone model related to the closure of the Iapetus Ocean basin (McConnell et al., in review; see below), but our work was partially funded by Tara-Boliden mines and is of strong interest to them
Three other factors were important in the project having different outcomes to what the original proposal suggested.
A. Tellus geophysics. Geophysical data, although readily available, were not always able to provide the information we had hoped for.
B. Zircon-separation equipment. Many of the samples collected were fine siltstone, and owing to a density contrast density, zircon grains are commonly smaller than the average grain size in a clastic sample. This was compounded by the fact that zircon was common in some samples and less so in others. Ultimately, we decided that separates needed to be sieved to remove larger "junk" grains or aggregates from the small zircon grains. Unfortunately this could not be done in TCD, and thus had to wait for the PI's return to her university in Arizona.
C. Mass spectrometer availability. The mass spec in TCD is used by many workers and time was simply not available for the PI to complete all analytical work before her departure in late July. Analyses will be completed early in 2019.

(iii) Outputs.
The mid-award report to Fulbright Ireland was completed in June 2018.
Three abstracts were submitted and presented – one to IGRM in Feb 2018, and two to Geological Society of America in November 2018-11-22
One paper is in review at Journal of the Geological Society

Task No.	Deliverable description	Planned delivery (as per proposal)	Date of delivery
1	Mid-award report by Riggs to Fulbright commission	Month 3	June 2018
2	Abtract to and presentation at IGRM	Month 3	February 2018
3	Peer-reviewed manuscript(s)	Month 5-7	McConnell, Riggs, and Sevastopulo, in review; submitted 6 September 2018
4	Presentation at Geological Society of America 2018 Annual Meeting	Post-award period	Two posters presented 6 November 2018

Publications to date: *Please use format below and provide a copy of the presentation*
Riggs, N.; McConnell, B.; Sevastopulo, G.; Williams, M.; Siveter, D.; and Meidla, T. (2018) Insight

into late-Iapetus tectonics from new U-Pb and biostratigraphic age data from the Navan area, E Ireland *Irish Geological Research Meeting* Poster 33, University College Cork, 24-FEB-2018

McConnell, B., Riggs, N., and Sevastopulo, G, in review, Insight into late-Iapetus tectonics from new U-Pb zircon and micropalaeontological data from the Navan area, eastern Ireland: Journal of the Geological Society, 10 ms pages, 5 figures.

McConnell, B., Riggs, N., and Sevastopulo, G, 2018, Insight into late-Iapetus tectonics from new U-Pb and biostratigraphic age data from the Navan area, eastern Ireland: Geological Society of America Abstracts with Programs. Vol. 50, No. 6, ISSN 0016-7592; doi: 10.1130/abs/2018AM-319812

Riggs, N, Crowley, Q, and McConnell, B., 2018, U-Pb zircon dating of the South Connemara Group, Ireland, and implications for late stages of the Iapetus Ocean basin: Geological Society of America Abstracts with Programs. Vol. 50, No. 6, ISSN 0016-7592; doi: 10.1130/abs/2018AM-324312

4. Data/outputs submitted with final report *(please list the documents, presentations, datasets etc. submitted with this report)*

a. copies of published abstracts

SUPPLEMENTARY MATERIAL

(This section will be included in your published report unless otherwise instructed. If you have a published report, publication, etc. you may include it here).

Copy of McConnell et al., submitted