



SFI Research Frontiers Programme  
Final Report

<b>SFI Programme Code: 05/RFP/GEO029</b>		<b>Date Report Submitted to SFI:</b>				
<b>Summary Information</b>						
<b>1a</b>	<b>Principal Investigator Name &amp; Title</b>	Dr. Peter D.W. Haughton				
<b>1b</b>	<b>Email Address</b>	peter.haughton@ucd.ie				
<b>1c</b>	<b>Gender</b>	Male				
<b>1d</b>	<b>Year of PhD</b>	1986 (University of Glasgow)				
<b>2a</b>	<b>Host Institute</b>	University College Dublin				
<b>2b</b>	<b>School</b>	School of Geological Sciences				
<b>3</b>	<b>Project Title</b>	Controls on sediment dispersal in the Triassic of northwest Europe: an investigation of provenance and palaeodrainage using the Pb isotopic composition of detrital K-feldspar grains				
<b>4</b>	<b>Duration of Award (Years)</b>	<b>2</b>				
<b>5a</b>	<b>Staff associated with Award</b>					
	<b>Type*</b>	<b>Name</b>	<b>Gender<sup>1</sup></b>	<b>New Affiliation</b>	<b>Nationality<sup>1</sup></b>	<b>Degree Awarded</b>
	<i>Postdoctoral</i>	Shane Tyrrell	Male		Irish	

\* Please select 'Type' from the following categories: Postdoctoral / Postgraduate (PhD) / Postgraduate (MS) / Undergraduate / Visiting Researcher / Technician / Administrative / Other

<sup>1</sup> Information collected on gender and nationality is for data analysis only. SFI is required to report this data to the Department of Enterprise, Trade and Employment, the Productive Sector Monitoring Committee, FORFAS and other government bodies.

5b	Students graduated during Award					
	Type*	Name	Gender <sup>1</sup>	New Affiliation	Nationality <sup>1</sup>	Degree Awarded

\* Please select 'Type' from the following categories: PhD / MS / BS / BA / Other

Scientific Information	
6	<p><b>Outline of research work carried out during award (bullet point format appreciated)</b></p> <p>The project set out to characterise and constrain the distribution of proven and potential Triassic hydrocarbon reservoir sandstones in basins offshore Ireland and UK. These sedimentary rocks represent the deposits of ancient large-scale river systems, the orientations and geometries of which are poorly understood. It was the aim of this research to better reconstruct these ancient drainage routes and pathways by using a new provenance technique - the Pb isotopic composition of detrital K-feldspar. The main research work carried out is summarised below...</p> <ul style="list-style-type: none"> <li>• Triassic sandstones were sampled from both drilled core outcrop and from basins from the NW European margin (Slyne, Rockall, Færoe – Shetland basins and Viking Graben) and from onshore - offshore UK (East Irish Sea Basin and onshore south UK). Sampled cores were logged in detail in order to assess the environments of deposition.</li> <li>• Sampled sandstones were characterised using standard optical microscopy on prepared thin sections and K-feldspar grains were selected for further analysis. Target grains were imaged using backscatter electron microscopy and cathodoluminescence.</li> <li>• Previously uncharacterized basement samples were analysed in order to improve the comparative Pb source database. Newly analysed material included crystalline rocks from offshore basement highs (the Porcupine High and Stanton Banks) and Precambrian meta-sedimentary rocks from onshore Scotland (the Torridonian Supergroup) which are potentially a source for second cycle K-feldspar</li> <li>• The bulk and trace element composition of target K-feldspar grains was constrained using electron microprobe analysis (EMPA).</li> <li>• A new analytical technique for analyzing Pb in K-feldspar was implemented in collaboration with colleagues in Memorial University Newfoundland. The new methodology involved measuring the Pb, U and Th concentration in target grains (using ELEMENT LA-ICPMS) prior to isotopic analysis (carried out on a NEPTUNE LA-MC-ICPMS). This technique allowed the measurement of Pb isotopes in sub-300µm sized grains for the first time.</li> </ul>

7	Details of deviation from approved work plan, if any (bullet point format appreciated)
	<ul style="list-style-type: none"> <li>• Imaging of target grains was originally intended to be carried out at UCD, with Electron Microprobe Analysis (EMPA) carried out at a UK based facility. However, it became more feasible (and less expensive) to carry out both the imaging (backscatter electron and cathodoluminescence) and EMPA at Geowissenschaftliches Zentrum, Göttingen, Germany, in collaboration with Dr. Andreas Kronz.</li> <li>• Originally, the Pb isotopic analysis of K-feldspar grains was to be carried out at the Geological Institute, Copenhagen. However, this facility became inaccessible to external users during the early part of the project. Arrangements were made to carry out the analysis in Memorial University Newfoundland instead, a collaboration which turned out to be highly productive and led to a vast improvement in the methodology (see research accomplishments below).</li> <li>• It was planned to carry out a programme of grain leaching in order to improve the accuracy of individual analyses. However, with the resolution (i.e. small spot size for analysis) allowed by the new technique, this became unnecessary.</li> <li>• It was originally proposed that Ar-Ar analysis be carried out on selected K-feldspar grains in order to constrain the thermal history of the detrital grains. However, it was decided that, given the likelihood of argon loss during the transport and diagenesis process, the data obtained would be of little overall value. It was instead decided to directly measure Pb, U and Th concentrations in detrital grains to allow improved isotopic analysis and to better constrain potential radiogenic lead growth.</li> </ul>

8	Research accomplishments (bullet point format appreciated)
	<ul style="list-style-type: none"> <li>• Establishment of new technique and protocols for the measurement of Pb isotopes in K-feldspar sand grains using in-situ laser ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICPMS). The new methodology allows very small (~100 µm long axis) grains to be analysed and thus the probability of significant detrital populations remaining uncharacterized is significantly reduced.</li> <li>• Pb analysis of detrital K-feldspar grains from the Triassic of East Irish Sea Basin and onshore south UK shows the same populations in the two areas, confirming that a south to north oriented large-scale (&gt; 500km) drainage system “the Budleighensis River” operated at this time.</li> <li>• Recycling of K-feldspar from Carboniferous sandstones onshore UK into the Triassic East Irish Sea Basin, previously mooted as a potential source by earlier workers, can be ruled out based on the Pb isotopic composition of the detrital K-feldspar sand grains.</li> <li>• The Pb analysis of K-feldspar grains from the Slyne Basin (well 27/5-1) highlight two populations, likely derived from the same sources as the Corrib sandstones in quadrant 18 (still within the Slyne Basin), i.e. from Archaean and Proterozoic rocks to the north and west.</li> <li>• Triassic sandstones from the margins of the Rockall Basin were studied and directly sampled for the first time (well 12/2-1z). The Pb analysis of K-feldspar grains from this well show a bimodal distribution, with derivation from the Archaean and Proterozoic basement, possibly from local sources to the north and east (the Stanton Banks) or from the Rockall Banks.</li> <li>• The Pb analysis of K-feldspar grains from Triassic sandstones in the Færoe – Shetland Basin show derivation from a single source, most likely from Archaean rocks in eastern Greenland, which is in agreement with previous provenance work based on U-Pb zircon geochronology.</li> <li>• Triassic sandstones from the Viking Graben reveal a complex provenance, with K-feldspar from pre-rift sandstones derived from Archaean basement. However, coarse, syn-rift sandstones show a very different provenance, likely sourced from local radiogenic crystalline rocks on the flanks of the rift, part of the Norwegian Shelf.</li> <li>• Overall, Pb analysis of detrital K-feldspar grains from Triassic sandstones from NW margin basins (Slyne, Rockall, Færoe – Shetland basins) demonstrate that drainage in these areas was dominantly controlled by uplifted Archaean – Proterozoic basement blocks. There is no evidence to support derivation from southern sources with little or no sand grains from the Irish Mainland or from the Variscan Uplands. In addition, Archaean sources are completely dominant in the far north (Færoe – Shetland Basin), but the influx of material from Proterozoic basement increases toward the south, with Proterozoic basement dominant in the Slyne Basin.</li> <li>• The Pb data highlights the contrast in drainage style between Triassic basins on the NE Atlantic Margin basins and those closer to the European continent. This indicates the presence of a drainage divide or sink for sand grains operated, oriented NE-SW, spanning what is currently the Irish Mainland and Northern UK.</li> </ul>

Strategic Information	
9	<p><b>Outline the value to Ireland produced by the research (bullet point format appreciated)</b></p> <ul style="list-style-type: none"> <li>• This research allowed for improved characterisation of economically important sandstone and demonstrated the likely distribution of this sedimentary rock in basins offshore Ireland. For the first time, Triassic sandstones in the Rockall Basin were studied directly, and the research concludes that these are likely to have a widespread occurrence at depth within this basin, where they potentially form an, as yet, untapped but significant reservoir for hydrocarbons.</li> <li>• The techniques used in this research help in the development of in-house technology, especially since the establishment of the National Centre for Radiogenic Isotope Geochemistry, which is being supported by SFI.</li> <li>• This research also led to the establishment of a new research group, the UCD Sand Provenance Centre, which hopes to become an internationally recognised centre for excellence and training in provenance research through active programmes of post-graduate and postdoctoral research.</li> </ul>

Academic and Other Interactions		
<b>10</b>	<b>Details of active collaborations with other organisations <u>directly related to this award</u></b>	
<b>Organisation type*</b>	<b>Name of institution or organisation</b>	<b>Name and title of collaborator</b>
<i>Academic, International</i>	University of Aberdeen, UK	Dr Sophie Leleu
<i>Academic, International</i>	Memorial University, Newfoundland, Canada	Prof. Paul Sylvester
<i>Academic, International</i>	Geowissenschaftliches Zentrum, Göttingen, Germany	Dr. Andreas Kronz
<b>Description of work undertaken (bullet point format appreciated)</b> <ul style="list-style-type: none"> <li>Collaborated with Dr Sophie Leleu (University of Aberdeen) on the study of the Triassic sandstones from the Færoe–Shetland Basin and Viking Graben. Dr Leleu is a post-doctoral fellow, researching the broad-scale tectono-stratigraphic development of Triassic basins.</li> <li>Worked extensively with Prof. Paul Sylvester (MUN) and his group (especially PhD student, Kate Sounders) on developing and applying a new methodology for the Pb isotopic analysis of K-feldspar using the NEPTUNE MC-ICPMS at their institute. Prof. Sylvester and his group have a wide knowledge of micro-analysis, especially using laser sampling.</li> <li>Collaborated with Dr Andreas Kronz (Geowissenschaftliches Zentrum, Göttingen) on the imaging and electron microprobe analysis of target K-feldspar grains.</li> </ul>		

\* Please select 'Organisation type' from the following categories: Academic, national / Academic, international / Multinational company, Irish based / Multinational company, foreign based / SME, Irish based / SME, foreign based / Start-Up / Hospital / Other

Knowledge Dissemination						
<b>11</b>	<b>Refereed publications <u>directly related to this award</u></b>					
<b>Total number of publications</b>	1	<b>URL of publications website</b>				
<b>Author list (as published)</b>	<b>Publication Title</b>		<b>Journal</b>	<b>Volume</b>	<b>Issue</b>	<b>Page No.s</b>
S. Tyrrell, P.D.W. Haughton and J.S. Daly	Drainage re-organization during break-up of Pangea revealed by <i>in-situ</i> Pb isotopic analysis of detrital K-feldspar.		<b>Geology</b>	<b>35</b>	<b>Nov. '07</b>	971 - 974

12	International presentations <u>directly related to this award</u>				
Total number of presentations made: 10					
Title of event	Event type*	Presentation type**	Title of presentation	Date of presentation	Website (if applicable)
Goldschmidt 2008, Vancouver, Canada	Conference	Invited Speaker	Paleodrainage reconstruction using Pb isotopes in K-feldspar sand grains: examples from the NW European Triassic	July, '08	<a href="http://www.goldschmidt2008.org/">http://www.goldschmidt2008.org/</a>
European Geosciences Union General Assembly 2008, Vienna, Austria	Conference	Poster	Sand provenance in Triassic basins along the NE Atlantic margin – implications for Pangaeon drainage evolution and reservoir sandstone distribution.	April, '08	<a href="http://meetings.copernicus.org/egu2007/">http://meetings.copernicus.org/egu2007/</a>
Irish Geological Research Meeting 2008, Dublin, Ireland	Conference	Paper	Pb isotopes, provenance and Pangaeon palaeodrainage: new insights into Triassic sediment dispersal on the NW European margin.	February, '08	
“Team Triassic” Annual Meeting with Shell E&P, Dublin	Invited Seminar	Invited Speaker	Mesozoic palaeodrainage on the NE Atlantic Margin: insights from Pb isotopic analysis of detrital K-feldspar grains.	February, '08	
British Sedimentological Research Group, Annual General Meeting, 2007, Birmingham, UK	Conference	Paper	Sediment dispersal patterns in northern Pangea – new evidence from basins on the NW European margin.	December, '07	
American Association of Petroleum Geologists, Annual Meeting 2007 Longbeach, California, US	Conference	Paper	Pb isotopic constraints on Mesozoic paleodrainage from the northwest European Margin - implications for reservoir distribution.	April, '07	<a href="http://www.aapg.org/longbeach/">http://www.aapg.org/longbeach/</a>
Irish Geological Research Meeting 2007, Coleraine, Northern Ireland	Conference	Paper	Sediment dispersal across the Pangean Supercontinent: insights from provenance analysis of Mesozoic sandstones, offshore western Ireland.	February, '07	
“Team Triassic” Annual Meeting with Shell E&P, Stavanger, Norway	Workshop	Invited Speaker	Triassic palaeodrainage on the NE Atlantic Margin: insights from Pb isotopic analysis of detrital K-feldspar grains	January, '07	

British Sedimentological Research Group, Annual General Meeting, 2006, Aberdeen, UK	<i>Conference</i>	<i>Paper</i>	Mesozoic palaeodrainage on the NE Atlantic Margin: insights from Pb isotopic analysis of detrital K-feldspar grains.	December, '06	<a href="http://www.bsr.org.uk/agm2006.htm">http://www.bsr.org.uk/agm2006.htm</a>
Seminar Series, British Antarctic Survey, Cambridge, UK	<i>Invited Seminar</i>	<i>Invited Speaker</i>	Pangean drainage evolution on the NE Atlantic Margin: insights from rapid, <i>in situ</i> Pb isotopic analysis of detrital K-feldspar	September '06	

\* Please select 'Event type' from the following categories: Conference / Workshop / Invited Seminar / Seminar

\*\* Please select 'Presentation type' from the following categories: Keynote talk / Plenary talk / Invited speaker / Paper / Poster



<b>13</b>	<b>Patents and copyrights <u>directly related to this award</u></b>	
<b>Number of patent applications</b>		0
<b>Number of patent applications granted</b>		0
<b>Number of copyrights awarded</b>		0
<b>Patent Title</b>	<b>Type*</b>	<b>Status**</b>
<b>Copyrights</b>	<b>Status**</b>	

\*Please select 'Type' from the following categories: Irish / EU / International

\*\* Please select 'Status' from the following categories: Applied / Pending / Awarded

14	Scientific awards received during term of this award		
Honour/Prize bestowed		Awarding Body	Date
2006 Outstanding Paper in Journal of Sedimentary Research for “S. Tyrrell, P.D.W. Haughton, J.S. Daly, T.F. Kokfelt and D. Gagnevin, <i>The Use of the Common Pb Isotope Composition of Detrital K-Feldspar Grains as a Provenance Tool and Its Application to Upper Carboniferous Paleodrainage, Northern England</i> , JSR, Vol 76 Iss 2, pgs. 324-345.”		SEPM – Society for Sedimentary Geology	April, 2008
15	Details of Education and Outreach initiatives undertaken		

<b>Details of Other Current Financial Support</b>	
<b>16</b>	<b>Other grants and funded research projects (title, amount, start date and end date) received during term of this award</b>