The Middle Miocene climate transition: biomarker constraints on temperature, CO_2 paleo-ecology and climate sensitivity.

Dr James Bendle, Dr Appy Sluijs (Biomarine Sciences, Institute of Environmental Biology; Utrecht University, Netherlands), Dr Robert McKay (Antarctic Research Centre, Victoria University of Wellington, New Zealand).

- **International laboratory visits and fieldwork.**
- **Study of a crucial period in Cenozoic climate evolution.**
- **Training in organic geochemistry.**

Background to the project:

The Mid-Miocene Climatic Optimum (MMCO ~17-15 Million years ago, MA) and subsequent cooling during the Middle Miocene Climate Transition (MMCT ~15-13.7 Ma) represent critical case studies for climate and carbon cycle dynamics in response to global warmth. Major warmth during the MMCO has, amongst others, been shown using fossils of subtropical plants at high latitudes. Subsequent cooling is evidenced by major decreases in sea-surface temperatures (SST), falls in eustatic sea-level and a rapid expansion of the East Antarctic Ice Sheet (at ~13.9 – 13.7 Ma). The forcing mechanisms during this period are controversial. Many of major Cenozoic climate transitions suggest atmospheric concentrations of CO_2 as a controlling factor. However, proxy evidence of CO_2 is not unambiguous and leaves significant room for the warmth and subsequent cooling to have been triggered by alternative forcing and feedback mechanisms (see Figure 1). Moreover, a general lack of well-calibrated absolute surface temperature reconstructions hampers quantification of global change and sensitivity of climate to CO_2 during these critical time periods. Finally, temporal resolution of the available data is insufficient to resolve millennial-scale climate variability. High-resolution, high-quality latitudinal proxy information from this period is now necessary to quantify global and regional changes and thus constrain forcing and feedback mechanisms during this period.

The student will lead work to produce multiple biomarker records of temperature, palaeoecology (and, where relevant, additional alkenone pCO_2) from a series of Middle Miocene marine sequences already collected and stored in repositories: from IODP Expeditions 318, 320 and 321 and terrestrial exposures in Italy, Malta and the Antarctic. The age-models for the sequences vary in resolution, but in some cases are orbitally tuned (thus facilitating high-resolution work). The student's biomarker data-sets will develop in parallel with palynological work lead by Utrecht University. If advantageous to the project the student may also have the opportunity to train and generate palynological data-sets at UU. The student must be willing and capable of spending extended periods of the PhD away from Glasgow, working with collaborators, either at UU or with project partners in NZ, the US or elsewhere. Additional fieldwork at the terrestrial exposures may also be required and the must be willing and capable of undertaking fieldwork in remote regions (a clean drivers license is essential). Successful candidates will have access to world-class preparative and analytical facilities in the School of Geographical and Earth Sciences (GES) (http://www.ges.gla.ac.uk:443/research/facilities/gmol) and opportunities to gain experience in collaborative laboratories.

Applicants should have a 1st class bachelors degree in geology, geography, chemistry or a related discipline or a 2.1 class degree plus a masters degree. Overall priority will be given to candidates with a masters degree in palaeoclimatology, organic geochemistry/analytical chemistry or related discipline.

Application procedure and deadlines

To be considered for PhD studentships to be held in the School of Geographical and Earth Sciences (GES), suitably qualified candidates should apply via the website of the College of Science and Engineering (http://www.gla.ac.uk/colleges/scienceengineering/graduateschool/prospectivestudents/essentialinformation/). Closing dates for University and research council funded studentships

will be in early in the new year, as stated on the GES studentships page: http://www.gla.ac.uk/schools/ges/research/postgraduate/.

Non- English speakers must meet the University's English language requirements. Candidates for NERC studentships should also meet the NERC's requirements for both academic qualifications and residential eligibility. For more information go to http://www.nerc.ac.uk/funding/application/studentships and please note that *non-UK European Union citizens will be awarded fees only by NERC.*

For informal enquiries about the research projects please contact the relevant supervisors. Information on the GES graduate school and the application process can be obtained from Mrs Jean McPartland, the assistant to head of the School (Jean.McPartland@glasgow.ac.uk).

Figure F1. Updated Cenozoic pCO_2 and stacked deep-sea benthic foraminifer oxygen isotope curve for 0 to 65 Ma. Updated from Zachos et al. (2008) and converted to the Gradstein timescale (Gradstein et al., 2004). ETM2 = Eocene Thermal Maximum 2, PETM = Paleocene/Eocene Thermal Maximum, ETM1 = Eocene Thermal Maximum 1.