Testing the link between Jurassic-Paleocene mantle dynamics and the western Irish offshore sedimentary record

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1. Project Motivation

A dynamic mantle control on the spatial pattern of uplift and exhumation observed across the British Isles has been proposed for both the Late Jurassic (e.g., *Jones et al., 2012, J. Geol. Soc. Lon.*) and Paleocene (e.g., *Cogné et al., 2016, EPSL*).

Transient, dynamically-supported uplift should result in increased exhumation and drainage divide reorganisation. Is this recorded in the offshore detrital provenance record?

In the regional context, this project will also link onshore exhumation, recorded by low-temperature thermochronometry, to major paleo-sediment transport networks and the offshore sedimentary record.

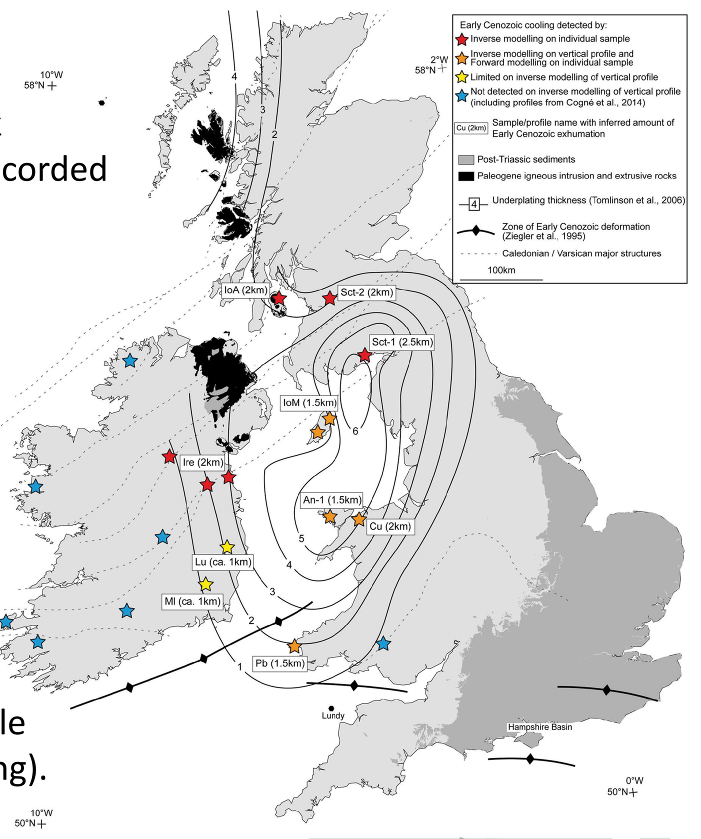


Fig. 1: The spatial pattern of Paleocene exhumation attributed by *Cogné et al. (2016, EPSL)* to mantle upwelling (± underplating).

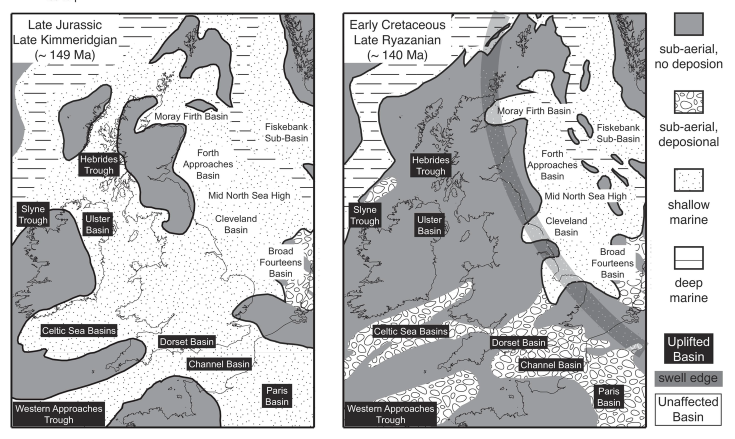


Fig. 2: The spatial pattern of Late Jurassic exhumation attributed by *Jones et al. (2012, J. Geol. Soc. Lon.)* to mantle upwelling (± underplating)

2. Methods

Project will utilise the apatite and rutile U-Pb thermochronometers (temperature sensitivity ca. 375-550 °C and ca. 490-640 °C, respectively; *Cochrane et al., 2014, GCA; Kooijman et al., 2010, EPSL*).

Detrital sedimentary rock samples from the Atlantic offshore, deposited in the Jurassic to Cenozoic, will be targeted for provenance analysis.

In addition to routine single-grain dating, phases sensitive to different temperature ranges hosted in single clasts will also be targeted. This will utilise thin-section phase mapping by SEM-EDX.

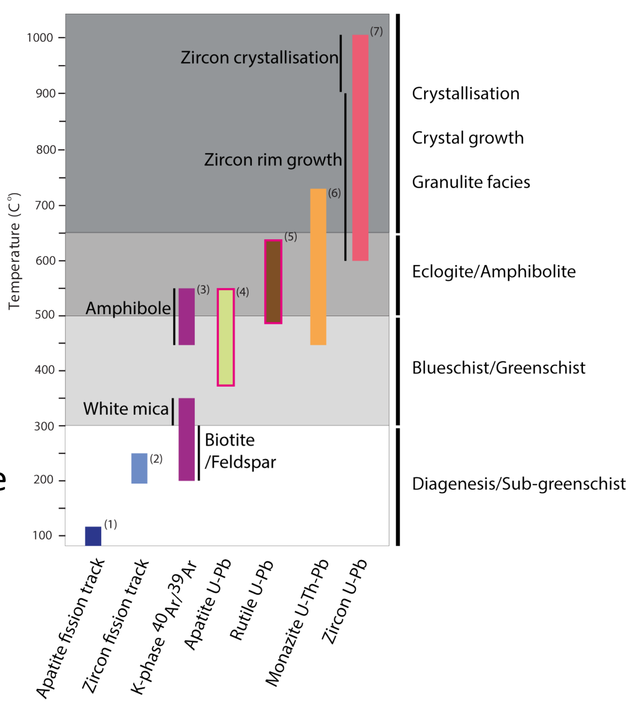


Fig. 3: Approximate temperature sensitivity of commonly used thermochronometers.

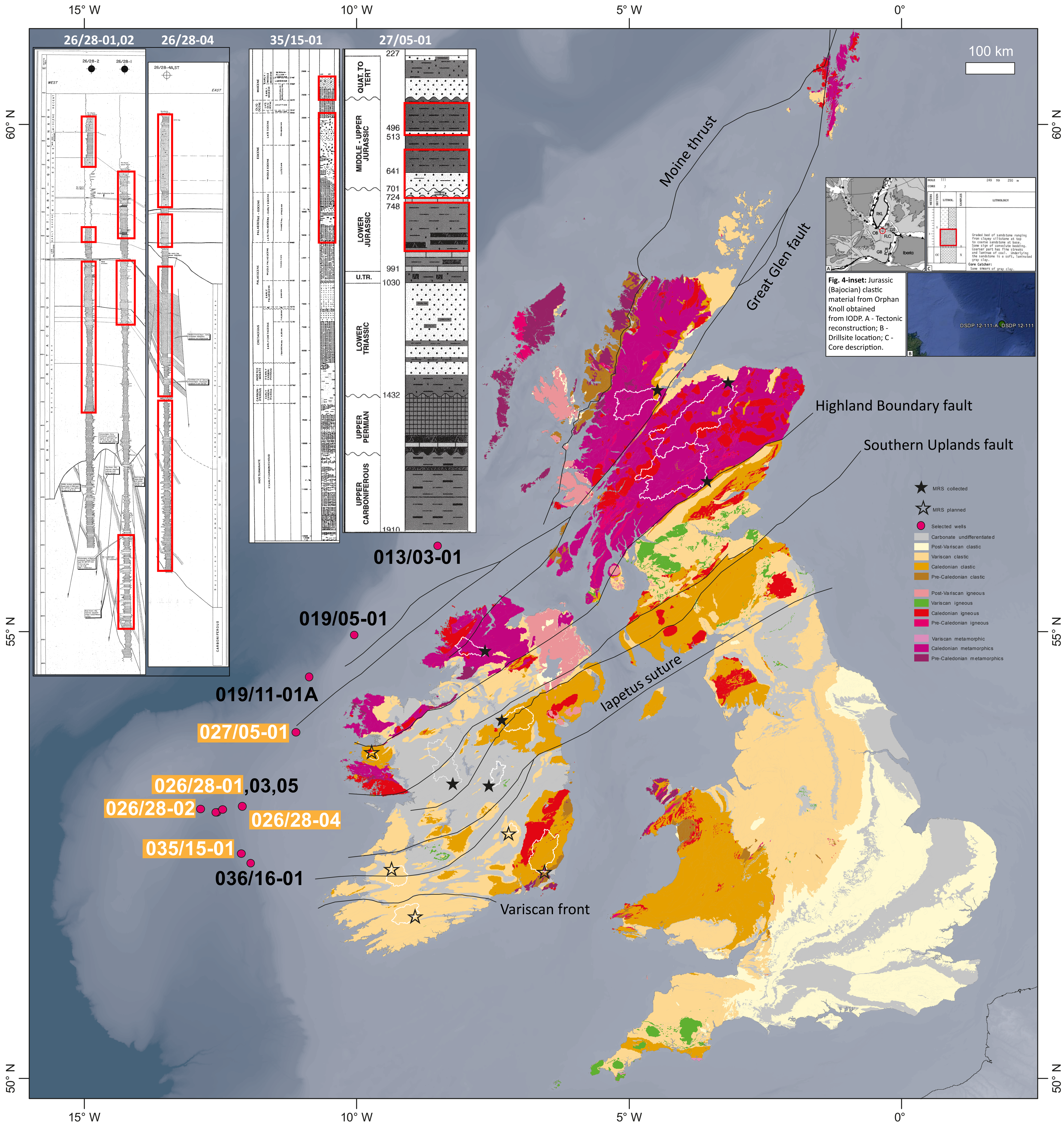


Fig. 4: Major geological units of the British Isles (highly simplified), showing onshore modern river sediment (MRS) sample locations and offshore boreholes (white - this study; black - 4.2-PhD6, offshore exhumation by means of AFT and AHe analysis).

3. Work Program

Source area characterisation is essential for detrital apatite and rutile U-Pb, as these techniques have not previously been employed either onshore or offshore in the British Isles.

MRS (modern river sediment) samples will be collected from rivers draining all major/key clastic units in Ireland and Scotland (also a possible sediment source to the Atlantic offshore); sediment from England and Wales is assumed to have been intercepted by the Irish Sea - Celtic Sea basin system since at least the Permian. **See Fig. 4.**

Core and cuttings will be collected from offshore borehole material held by Petroleum Affairs Division (PAD), for detrial apatite and rutile U-Pb, and multi-phase single-clast U-Pb analysis.

Provenance analysis will be carried out in close collaboration with:

1) iCrag project 4.2-PD6 (Dr. Claire Ansberque): analysis of onshore exhumation timing and magnitude by means of apatite fission track (AFT) and apatite (U-Th-Sm)/He (AHe) analysis.

2) iCrag project 4.2-PhD6 (Mr. Remi Rateau): analysis of offshore basin inversion and exhumation by means of AFT, AHe, and interpretation of legacy seismic data.

3) Linked offshore detrital provenance and sediment mass-balance studies ongoing at University College Cork (Mr. Odhran McCarthy and Prof. Pat Meere), University College Dublin (Dr. Sebastian Zimmermann), and NUI Galway (Ms. Jess Franklin, Mr. Martin Nauton-Fourteu, and Dr. Shane Tyrrell).

4. Initial Results: Modern River Sediment

For all samples:

Apatite U-Pb Rutile U-Pb

Irish MRS samples: apatite and rutile U-Pb data

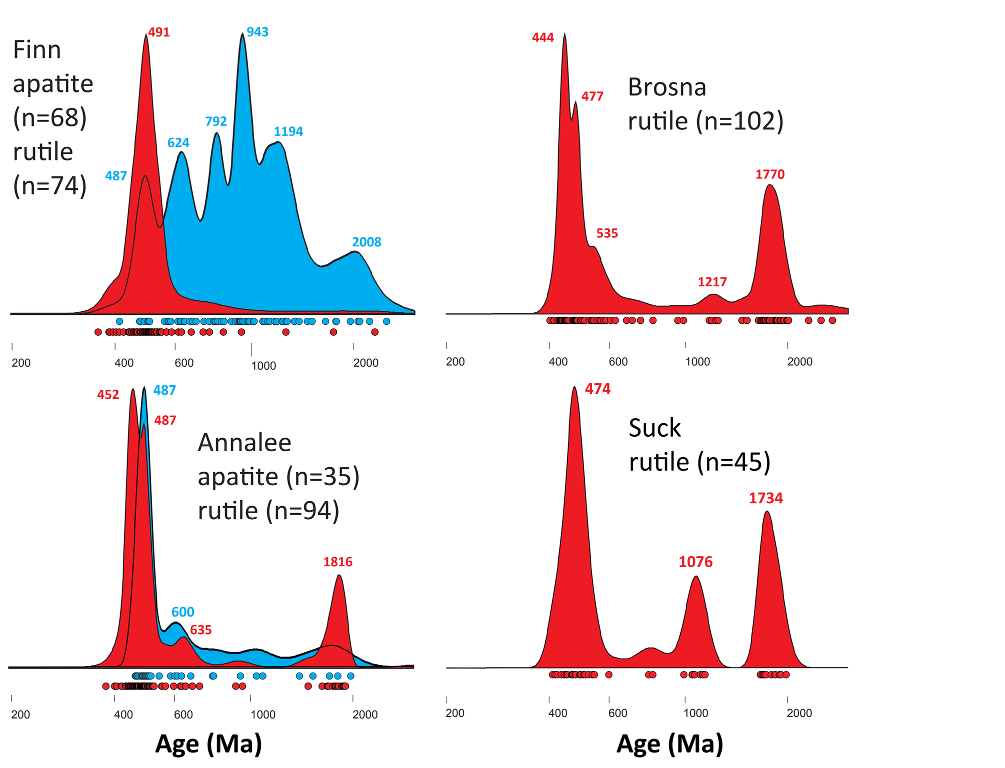
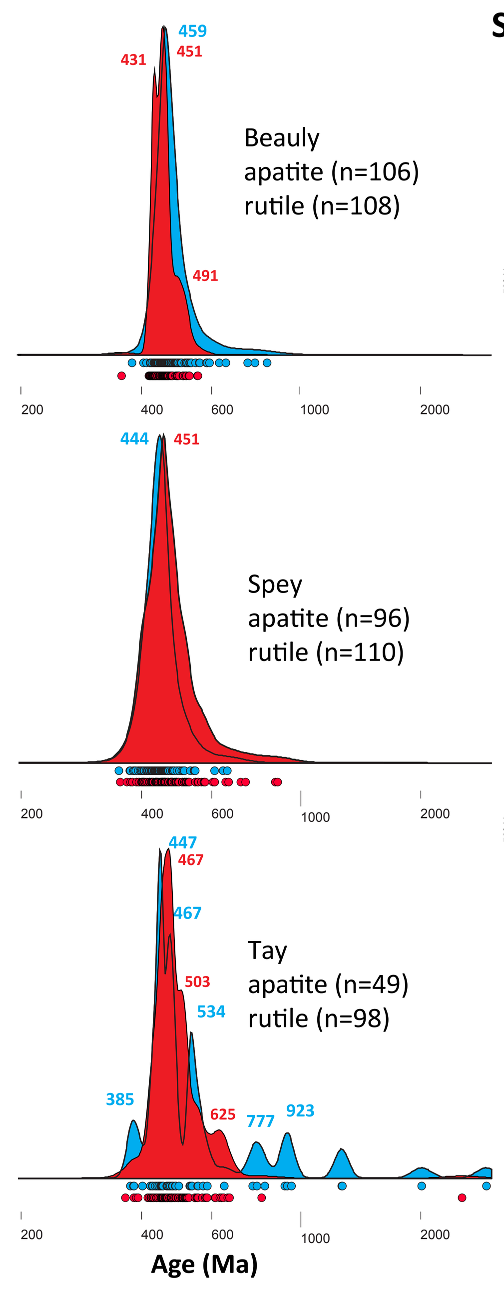


Fig. 5: Initial detrital U-Pb analyses for MRS sampled from rivers draining the Irish Caledonides (Finn), Irish Southern Uplands (Annalee), and Irish Early Carboniferous carbonates (Brosna and Suck).
Apatite U-Pb data preserve pre-Caledonian in-situ metamorphic and detrital ages; the dominant Caledonian age peak in rutile and apatite U-Pb is older than in Scotland (ca. 491-487 Ma).
Early Caboniferous carbonate units do not yield significant apatite, but do host detrital rutile, possibly sourced from the Scottish Caledonides.

Scottish MRS samples: apatite and rutile U-Pb data



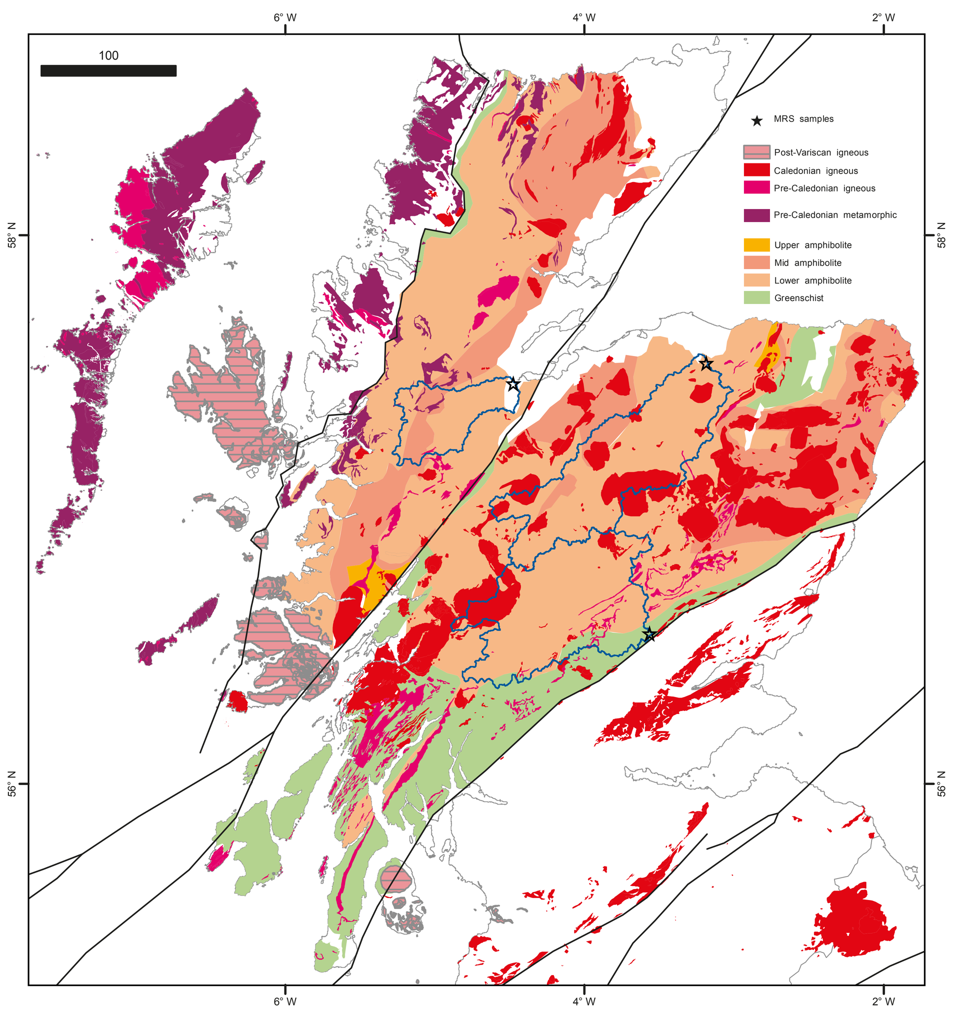


Fig. 7: Distribution of metamorphic grade attained during the Caledonian. After *Fettes et al. (1985, GSL Memoir 9)* and *Johnstone and Mykura (1989, HMSO)*.

Fig. 6: Initial detrital U-Pb analyses for MRS sampled from rivers draining the Scottish Caledonides. Apatite and rutile ages reset wherever Caledonian metamorphism > greenschist -facies grade. Apatite U-Pb age peaks are intermediate between Grampian (ca. 475-465 Ma) and Scandian (ca. 435-425 Ma): either mixed ages, or record post-Grampian cooling.

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