Assessing the process and timescale of megagravel emplacement in a coastal boulder deposit, Annagh Head, western Ireland

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We measure in-situ produced ^{10}Be from a wave-emplaced coastal boulder deposit (CBD) located on Annagh Head in County Mayo, on the west coast of Ireland. CBD often contain megagravel weighing 10s to 100s of tonnes and are an indicator of high energy wave events. They are generally found along coastlines exposed to the open ocean where deep water is close to shore, facilitating the efficient onshore transfer of wave energy. Recent work has demonstrated that these deposits are dynamic, with documented displacement of megagravel by storm waves at other sites in western Ireland. The Annagh Head CBD forms a ridge that is 8 m high (14 m a.s.l.), ~180 metres wide (from the seaward edge to the farthest inland boulders), and ~160 m in shore-parallel length. It is comprised of gneissic boulders which can be in excess of 50 t mass. Repeat photographs have documented the movement of boulders up to ~5 t mass, attributed to wave action during winter storms, but little is known about the long-term history of the deposit. To date, geochronologic studies of CBD emplacement have had limited success. Radiocarbon dating of attached organisms provides maximum limiting chronologic constraints on megagravel emplacement, but this approach is limited to boulders eroded from the inter-tidal or sub-tidal zones, which represents a relatively small fraction of the clasts in supra-tidal CBD, as most are sourced from subaerial coastal platforms. In situ produced cosmogenic isotopes present a promising avenue for assessing the timing of CBD emplacement. Here we make the first attempt to quantify CBD emplacement history using in-situ produced cosmogenic ^{10}Be from 20 quartz-bearing boulders. Our sampling focused on the largest boulders in the deposit, ranging from just over 1 to ~59 t mass, with samples collected along a shore-normal transect across the full width of the deposit. Initial results yield a range of ages encompassing much of the Holocene, with a cluster of ages falling within the mid-Holocene. Our interpretation is ongoing, but we hypothesize that the apparent cosmogenic exposure ages reflect a combination of pre-erosion bedrock inheritance, in addition to a protracted history of deposition and re-mobilization in response to wave action and rising post-glacial sea level. In total, this dataset provides a quantitative view on a dynamic feature of coastal landscapes, allowing for investigation into the geomorphic processes at work, as well as exploration of possible linkages to climate and landscape evolution.

Tidal rhythmite deposits provide support for a Late Carboniferous mid-Euramerican seaway

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Support for the presence of a mid-Euramerican seaway during the Late Carboniferous is minimal. Current research performed on a sedimentary succession endorses the notion of a seaway linking with the Paleo-Tethys Ocean. In the Cumberland Basin of Nova Scotia, the Joggins Formation preserves an unrivalled record of terrestrial life in their environmental framework throughout the Late Carboniferous 'Coal Age'. Regardless of the research conducted over the past two centuries, questions persist concerning the paleoenvironment, including the extent and form of marine impact. The analysis of tidal rhythmite deposits allows for paleomarine conditions, including tidal regimes, to be inferred. This rhythmicity is primarily associated with tides in marine environments. In the Joggins Formation, we find spring-neap-spring cycles within parallel, thinly laminated, vertically accreted tidal rhythmites. The examples include: 1) sand and mud couplets deposited during flow and slack water phases, respectively, which correlate to ebb and flood tidal sequences; 2) variation in sand and mud lamination thickness from variations in sand and mud availability during neap-spring tidal cycles; 3) spring couplet thickness variations indicating lunar cycles of low and high spring tides; and 4) rhythmite thickness variations suggesting tidal variations with longer cycles or sediment concentration fluctuations. Here, we employ quantitative and visual frequency analysis procedures to investigate and interpret the laminae-scale cyclicity of tidal rhythmite intervals. Visual core assessment identified three ideal intervals for tidal rhythmite thickness data collection. Visual cyclicity analysis uncovered the cycles in the intervals. Fast Fourier transform and continuous wavelet transform analyses revealed the primary periods and substantiated the visually uncovered tidal regime with that established geomathematically. Our findings suggest tidal rhythmite deposition followed the semi-diurnal tidal pattern with a lunar monthly tidal cycle. This research offers support for the existence of a mid-Euramerican seaway, which may help with clarifying the irregularity in paleoecological trends between the northern and southern Paleo-Tethys Ocean.

Do Archean grey gneiss domains represent mid-crustal-scale crystal mush complexes?

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Exposures of Archean middle crust are dominated by grey gneiss domains and although various metaigneous and metasedimentary components may be present, grey gneiss is commonly composed mainly of tonalite-trondhjemite-granodiorite (TTG) suites. The trace element compositions of TTGs have been conventionally used to infer the geodynamic settings of their sources. Whole-rock Sr/Y and La/Yb ratios in particular have been linked to the depth of source melting, which in turn may indicate a subducted slab (high-pressure) versus crustal (low-pressure) origin for TTGs. However, this approach assumes that TTGs represent primary magmas with source-controlled compositions. This contrasts with recent work showing that fractional crystallization may have strongly influenced TTG geochemical compositions. Here, we present a petrological–geochemical model for the evolution of coexisting TTGs with high- and low-pressure geochemical signatures in a mid-crustal grey gneiss domain in the southern Superior Province. We propose that this domain represents a former crystal mush complex of TTG magma. Field relationships, petrographic observations, and phase equilibrium modelling indicate that TTGs in this region may represent variable accumulation of plagioclase crystals and fractionated melt derived from a common parental magma. The models show that plagioclase-rich TTGs exhibit "high-pressure" geochemical signatures whereas fractionated melt-rich TTGs have "low-pressure" signatures. Results of zircon U–Pb geochronology and Hf isotopic analysis from several TTG samples support our interpretation that TTGs with different chemical compositions share a single origin. This work demonstrates the importance of plagioclase fractionation in the chemical evolution of TTG magmas, as this mineral can influence not only Sr/Y but also fractionation of light rare earth elements from heavy rare earth elements. In addition, the existence of a mid-crustal crystal mush has implications for the rheology of Archean continents. Finally, our results indicate that interpreting source characteristics based on TTG compositions should be done with caution.