Detrital zircon U-Pb ages: evidence for Variscan sediment provenance in the Grand Banks, offshore Newfoundland

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Summary

Following a one year analytical programme of core and cuttings samples, the single largest heavy mineral and detrital zircon database for the Mesozoic and Paleogene sedimentary successions of the basins of the Grand Banks area, offshore Newfoundland has been acquired. Primarily, this non-proprietary study provides provenance data, coupled with an intensive geochemical analytical programme, for the Orphan, Flemish Pass, Carson and Jeanne D'Arc basins as well as the Outer Ridge Complex. During this analytical campaign, it was recognised that some Grand Banks sedimentary successions, predominantly in the southern Flemish Pass Basin and the Outer Ridge Complex, contain a significant late Carboniferous to Permian detrital zircon component. This component is interpreted to be ultimately sourced from Iberia, where potential zircon sources of this age were abundantly developed during Variscan orogenesis. The rarity of Silurian to Devonian zircon components in those successions with high proportions of late Carboniferous to Permian zircons is further suggestive of an Iberian source because voluminous felsic igneous rocks of Silurian and Devonian age are rare in Iberia. Furthermore, felsic igneous rocks of Silurian and Devonian age crop out extensively in Nova Scotia and Newfoundland and sediment derived from those areas would be expected to contain zircon grains which reflect this abundance.

Introduction

During Mesozoic development of the basins of the Grand Banks area, the geology of the hinterlands predominantly consisted of rocks of peri-Gondwanan affinity, namely the rocks of Ganderia, Avalonia, Megumia and Iberia. These rocks characteristically provide an abundance of late Neoproterozoic zircon grains and this is reflected in the aforementioned database. Given the ubiquity of late Neoproterozoic zircon grains in the Grand Banks, it is essential to identify other zircon age components which could aid in discriminating between peri-Gondwanan domains. Palaeozoic age components are useful for such discrimination, at least for distinguishing between Iberia and those domains with 'type terranes' in Newfoundland and Nova Scotia (i.e. Ganderia, Avalonia and Megumia). Sediment derived from Iberia is expected to contain an abundance of detrital zircon grains of late Carboniferous to Permian age, representative of granitoid genesis during the Variscan Orogeny (see, for example, Dinis et al., 2017). Granitoids of this age are rare in Newfoundland, Nova Scotia and in Ireland. In contrast, the rocks of Ganderia, Avalonia and Megumia in Newfoundland and Nova Scotia contain numerous Silurian to Devonian granitoids and felsic volcanic rocks and the Trans Suture Zone Suite (Brown et al., 2008) in Britain and Ireland presents a source of zircons of late Silurian to early Devonian age. Felsic igneous rocks of this age are comparitively rare in Iberia.

Methods

Cuttings and core samples of sedimentary rocks were disaggregated and sieved to isolate the 40 to 250 µm grain-size fraction. After cleaning the samples in 10 % acetic acid, dense grains were extracted using a lithium metatungstate solution (density 2.89 g/cm^3) by way of the funnel separation technique described by

Mange and Maurer (1992). The dense mineral fraction was split using a micro splitter. One split fraction was mounted on a glass slide and each slide was analyzed with a Horiba LabRam Raman Microscope, using a 532nm green laser. The second fraction was used for zircon U-Pb age determinations.

A Frantz magnetic separator was employed to further concentrate zircon grains. U-Pb ages for each zircon was determined by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). The Plesovice zircon standard (Sláma et al., 2008) was used to correct for downhole U-Pb fractionation, mass bias and instrument drift. Any age that was more than ± 10 % discordant was not used for provenance interpretations. $^{207}Pb/^{206}Pb$ ages were utilised for grains older than 1.0 Ga and $^{206}Pb/^{238}U$ ages were used for grains younger than 1.0 Ga.

Our current provenance database for the Grand Banks includes more than 250 samples analyzed by Raman spectroscopy. Detrital zircon U-Pb ages were determined for more than 300 sedimentary samples, representing over 30 000 single-grain analyses. Additional samples are still being processed.

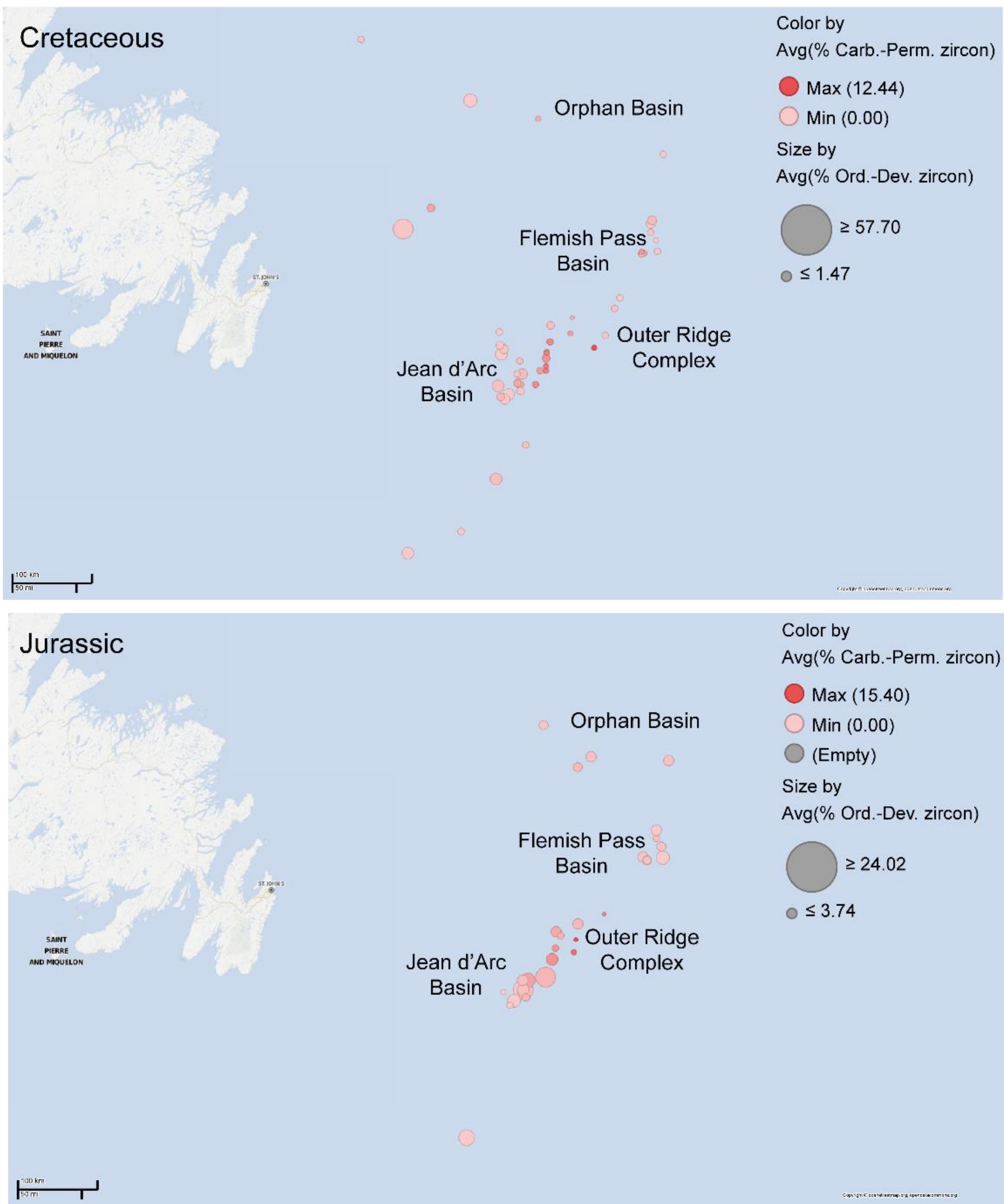

Figure 1. Average distribution of Carboniferous to Permian and Upper Ordovician to Devonian age zircons across Jurassic (bottom) and Cretaceous (top) successions of the Grand Banks.

Results and Discussion

Samples that show the highest proportion of Carboniferous-Permian zircons are predominantly from wells in the Outer Ridge Complex and southern Flemish Pass Basin, namely Golconda C-64, Lancaster G-70, Panther P-52 and Aster C-93A. The majority of samples from these wells have high proportions (> 30 %) of late Neoproterozoic (750-540 Ma) zircons.

The wells Golconda C-64, Lancaster G-70 and Panther P-52 intersect Jurassic successions in the Outer Ridge Complex whereas Aster C-93A intersects both Jurassic and Cretaceous sequences in the southern part of Flemish Pass Basin. In well Aster C-93A, samples from either side of the Jurassic-Cretaceous transition contain up to c. 20 % zircon grains with ages between 325 Ma and 275 Ma and less than c. 6 % of grains with ages between 450 Ma and 375 Ma. Samples from Jurassic sedimentary rocks in well Golconda C-64 contain up to 24 % zircon grains in the 325-275 Ma age range and generally have less than 7 % of grains within the 450-375 Ma age range. Similarly, the lowermost samples in well Lancaster G-70, taken from Jurassic sandstones, contain 17-20 % of grains with ages between 325 Ma and 275 Ma and less than 3 % with ages between 450 Ma and 375 Ma. Jurassic sandstones intersected by well Panther P-52 contain up to 18 % zircon grains with 325-275 Ma ages and 0-9 % of grains with 450-375 Ma ages.

The proportion of 325-275 Ma zircons tends to decrease away from the Outer Ridge Complex while the proportion of 450-375 Ma zircons increases in samples from wells that are in the western parts of the Grand Banks. Sediment derived from an ultimate Variscan (Iberian) source was therefore predominantly deposited into the Outer Ridge Complex and Flemish Pass Basin during the Late Jurassic and Early Cretaceous. This suggests an eastern or southeastern source area. The western increase in the proportion of 450-375 Ma zircons suggests greater influence from Avalonian, Megumian and Ganderian sediment sources.

Although the ultimate source of sediment for the successions intersected by the wells mentioned above appears to be Iberia, it is difficult to determine with a high level of certainty whether the zircons were sourced directly from Iberia (i.e. first cycle) or were recycled from upper Permian to Triassic strata adjacent to the Iberian margin.

Conclusions

Carboniferous-Permian zircons from Upper Jurassic and Lower Cretaceous successions in the Outer Ridge Complex and southern Flemish Pass Basin indicate a significant Iberian sediment source where Variscan granitoids are abundant. Such zircons are not present in significant quantities in other Mesozoic basins of the Grand Banks area. It is difficult to determine the manner in which the zircons were delivered to the Outer Ridge Complex and Flemish Pass Basin successions. Two plausible hypotheses exist: the first is that the zircons were derived directly from weathering and erosion of the Variscan granitoids; the second is that the zircons were recycled from pre-existing Permian and Triassic strata. Testing these hypotheses may prove crucial in understanding sandstone maturity and reservoir quality in the Outer Ridge Complex and Flemish Pass Basin.

References

Brown, P. E., Ryan, P. D., Soper, N. J. and Woodcock, N.H., 2008. The Newer Granite problem revisited: a transtensional origin for the Early Devonian Trans-Suture Suite. Geological Magazine, v. 145, p. 235 - 256.

Dinis, P. A., Dinis, J., Tassinari, C., Carter, A., Callapez, P. and Morais, M., 2015. Detrital zircon geochronology of the Cretaceous succession from the Iberian Atlantic Margin: palaeogeographic implications. International Journal of Earth Science, v. 105, p. 727 - 725.

Mange, M. A. and Maurer, H. F. W., 1992. Heavy Minerals in Colour. Chapman and Hall, London, 147pp.

Sláma, J., Kosler, J., Condon, D. J., Crowley, J. L., Gerdes, A., Hanchar, J. M., Horstwood, M. S. A., Morris, G. A., Nasdala, L., Norberg, N., Schaltegger, U., Schoene, B., Tubrett, M. N. and Whitehouse, M. J., 2008. Plešovice zircon - A new natural reference material for U–Pb and Hf isotopic microanalysis. Chemical Geology, v. 249, p. 1 - 35.