

New constraints on the age, geochemistry, and environmental impact of High Arctic Large Igneous Province magmatism: Tracing the extension of the Alpha Ridge onto Ellesmere Island, Canada

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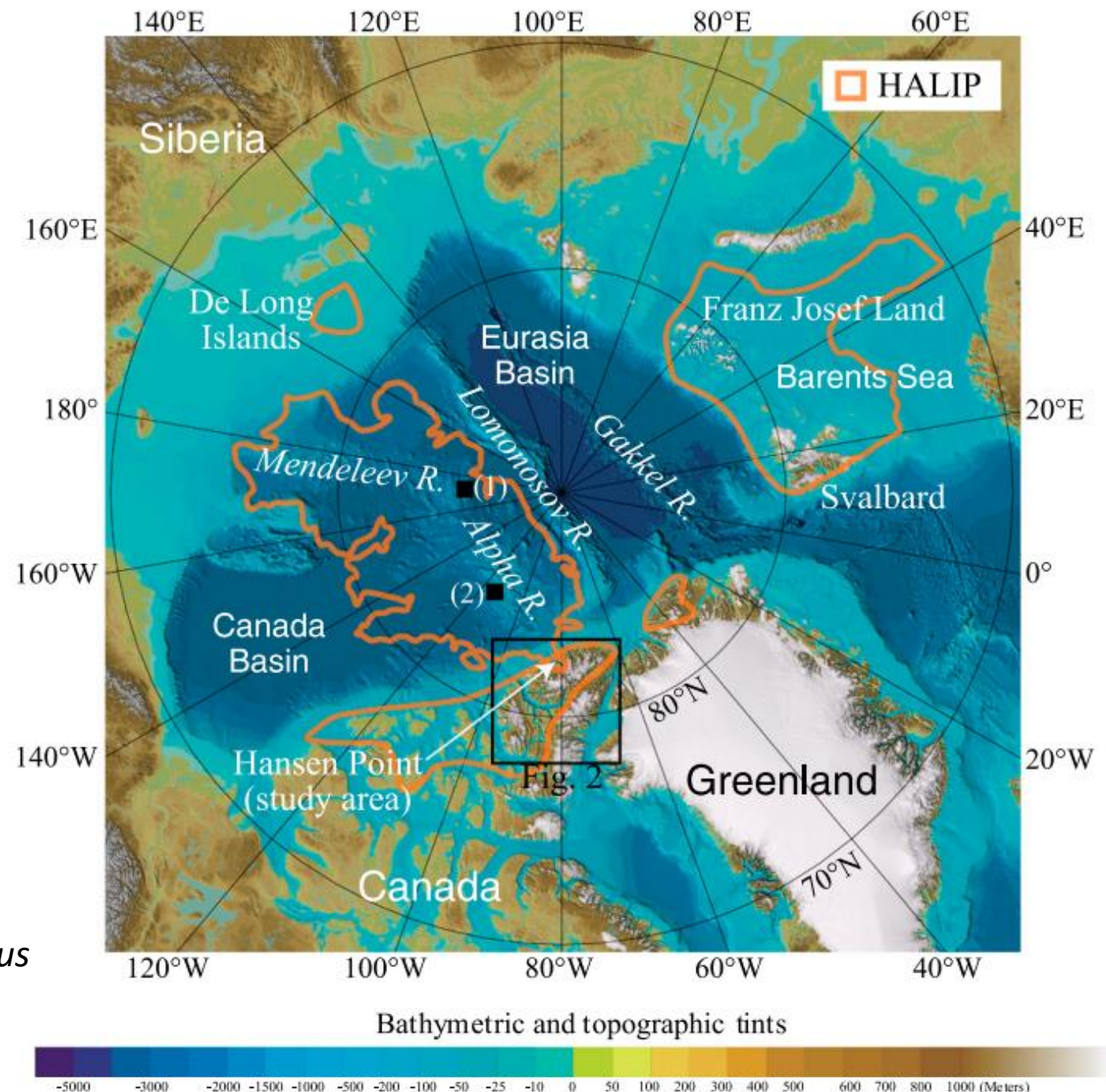
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Based on Naber et al. (2020). GSA Bulletin. Published online; <https://doi.org/10.1130/B35792.1> (open access).

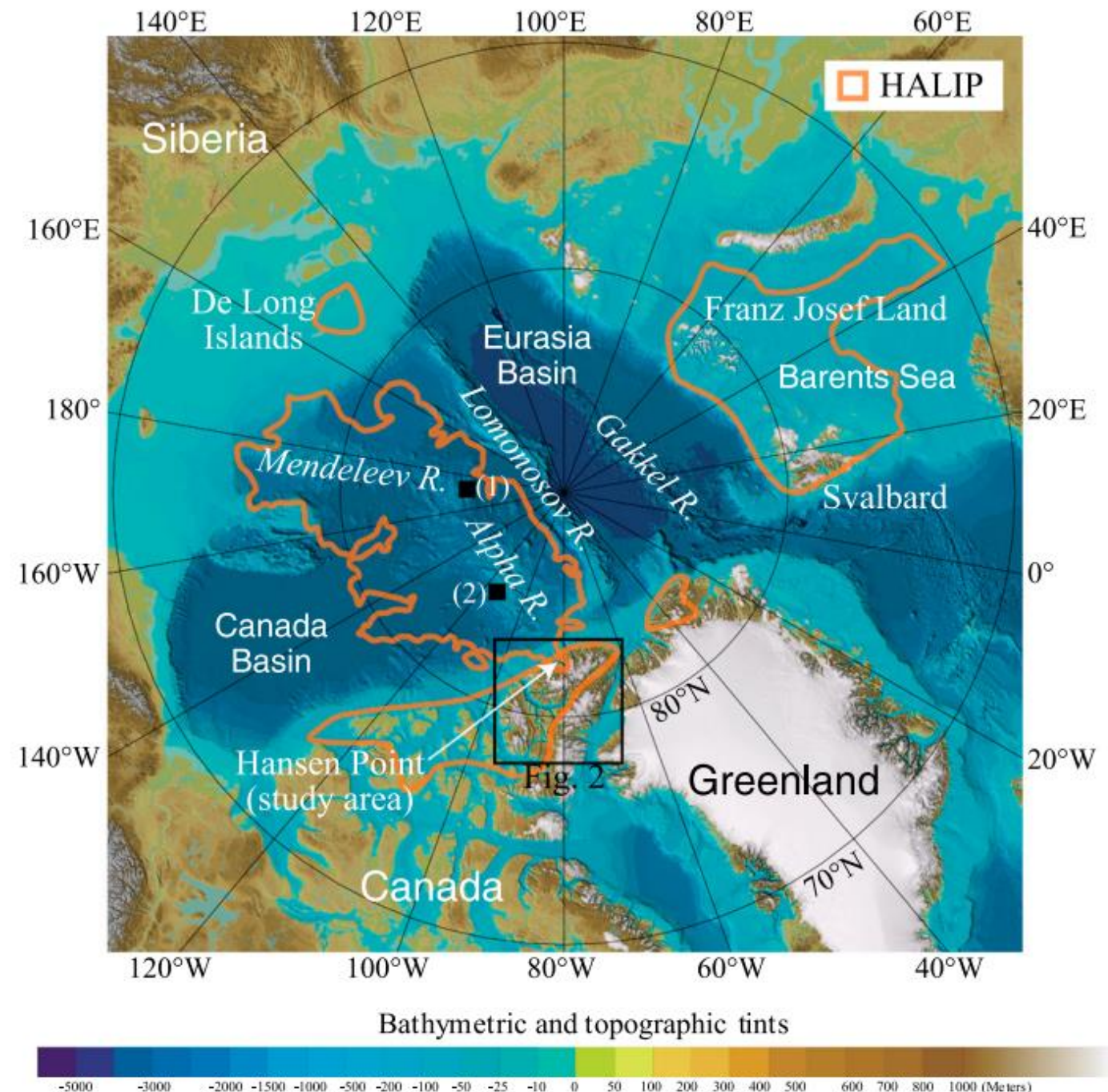
Area of study

- The High Arctic Large Igneous Province (HALIP) represents extensive Cretaceous magmatism throughout the circum-Arctic borderlands and within the Arctic Ocean (e.g., the Alpha-Mendeleev Ridge).

Figure 1. Bathymetric map of the High Arctic region showing the extend of on-land and offshore areas with magmatic rocks ascribed to the High Arctic Large Igneous Province (HALIP), and the location of the study area at Hansen Point, northern coast of Ellesmere Island, Canada.



- Recent aeromagnetic data shows anomalies that extend from the Alpha Ridge onto the northern coast of Ellesmere Island, Nunavut, Canada.
- To test this linkage, we present (in the manuscript) new bulk rock major and trace element geochemistry, and mineral compositions for clinopyroxene, plagioclase, and olivine of basaltic dykes and sheets and rhyolitic lavas for the stratotype section at Hansen Point, which coincides geographically with the magnetic anomaly at northern Ellesmere Island. New U-Pb chronology is also presented.



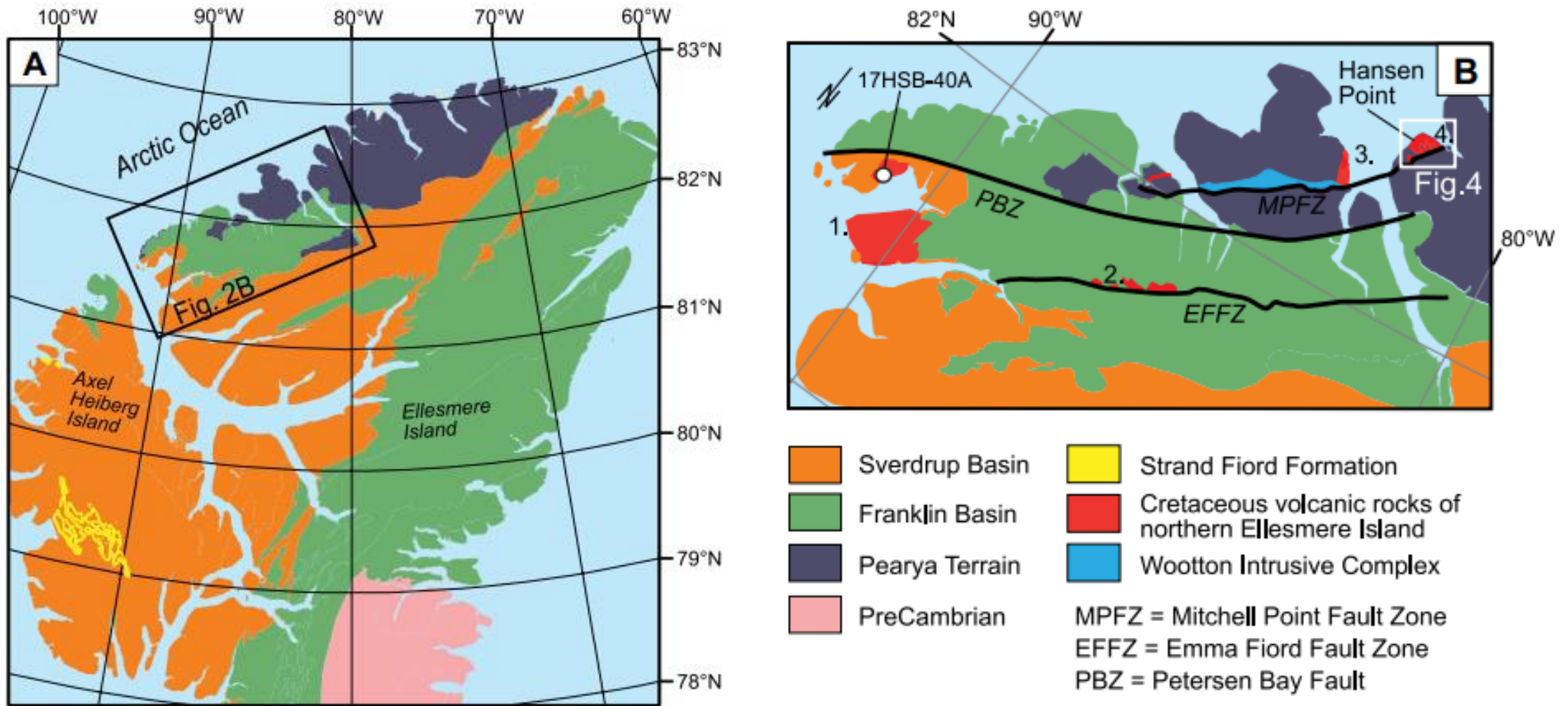
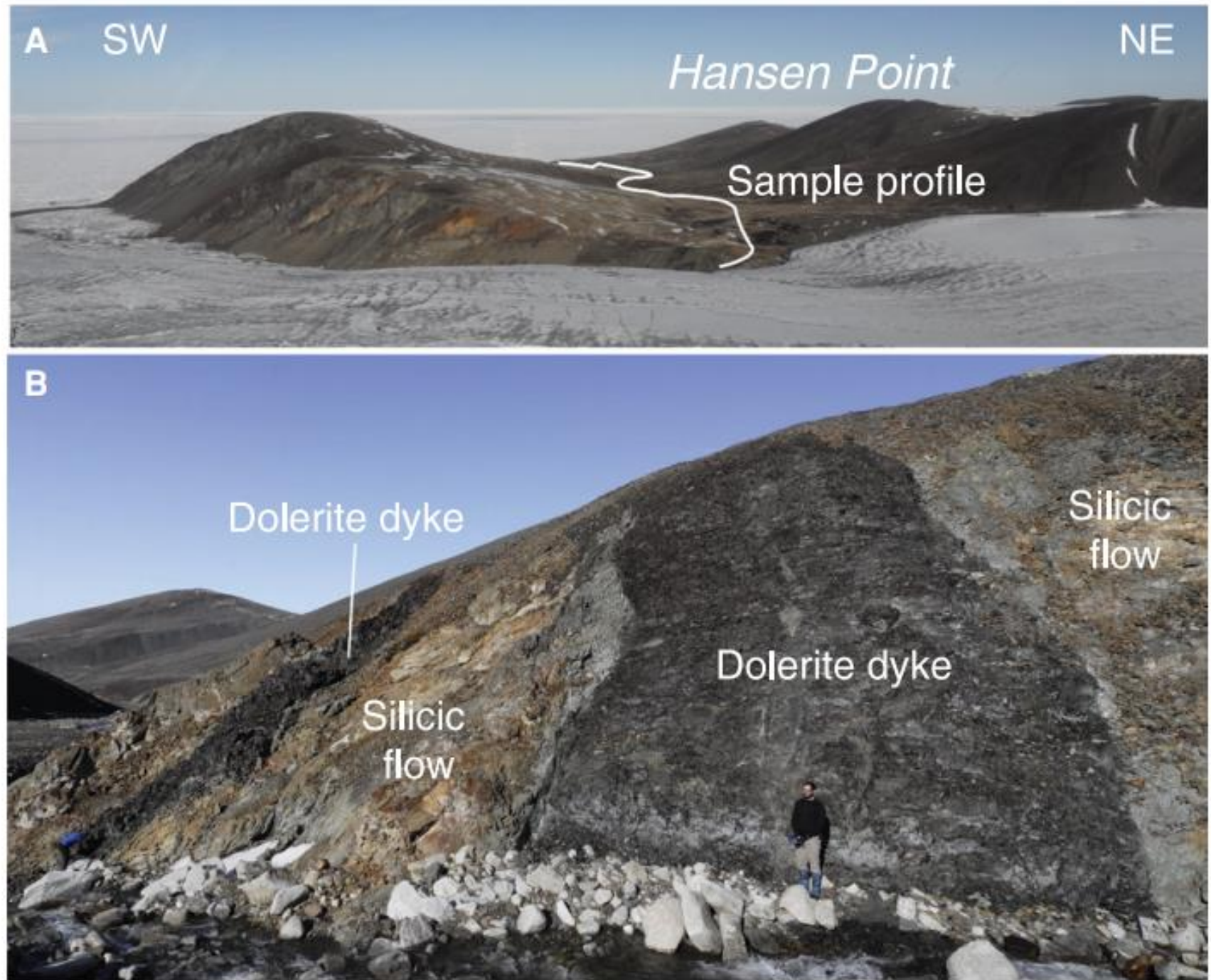


Figure 2. (A) Regional map of the northern portion of the Canadian Arctic Archipelago, showing main sedimentary basins as well as regional exposures of the Strand Fiord Formation volcanic units. (B) Close up of northern Ellesmere Island showing location of the Hansen Point stratotype study area along with mapped occurrences of volcanic units and major fault zones (after Harrison et al., 2015). The main occurrences of Cretaceous volcanic rocks of northern Ellesmere Island are labeled: (1) Audhild Bay, (2) Philips Inlet, (3) Yelverton Bay West, and (4) Yelverton Bay East that includes Hansen Point itself.

Hansen Point stratotype section

- The sample profile and biomodal volcanics at the Hansen Point stratotype section.



Hansen Point geochemistry

- The Hansen Point rocks are tholeiitic and compositionally akin to (i) dykes cutting Pearya basement in the vicinity of Hansen Point and to (ii) lavas and intrusions of the Strand Fiord Formation (SFF) on Axel Heiberg Island.

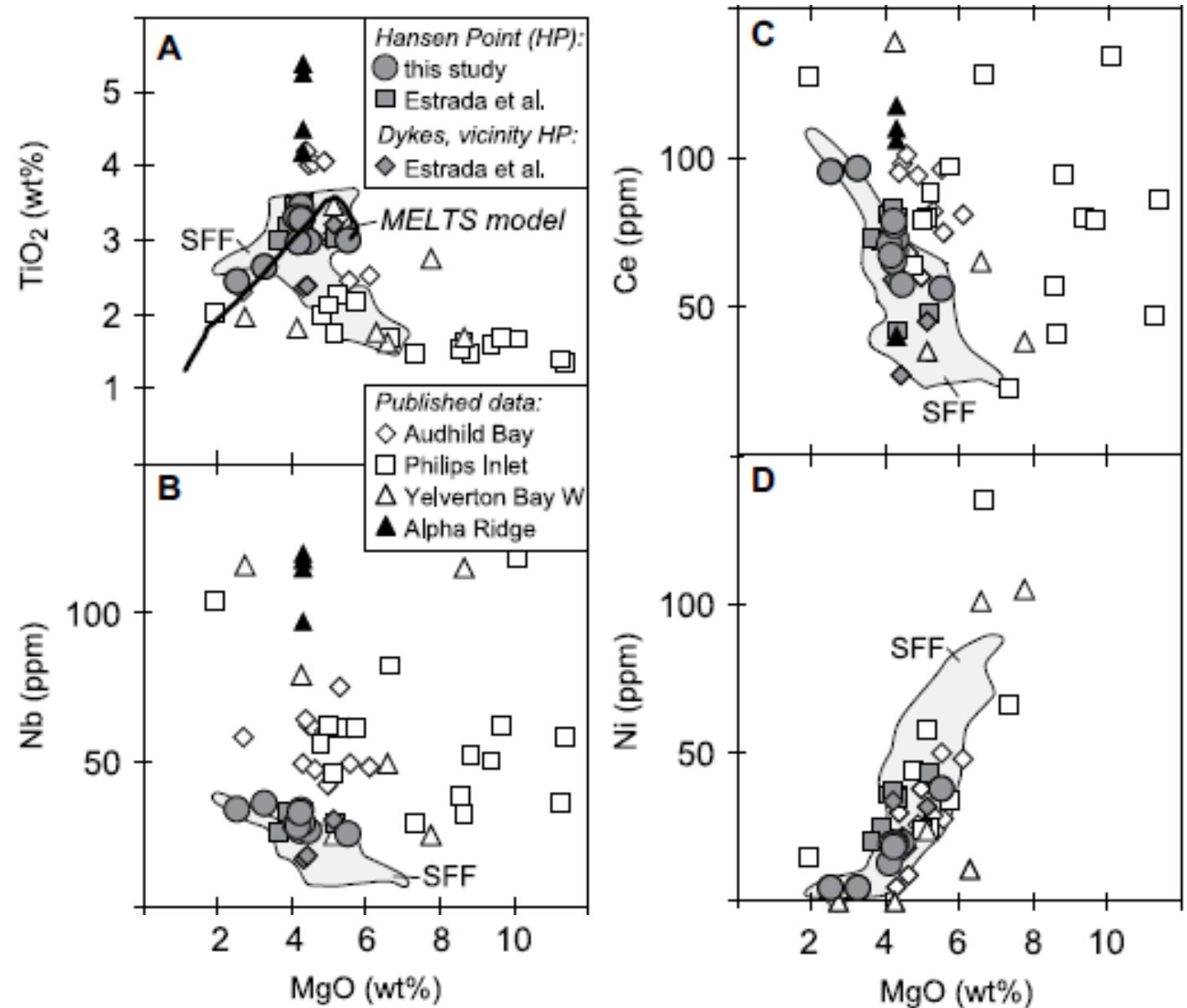


Figure 3. The bulk rock compositions of immobile elements TiO₂, Nb, Ce, and Ni vs. MgO for basaltic samples of Hansen Point of this study, Ellesmere Island, Canada.

Hansen Point geochemistry

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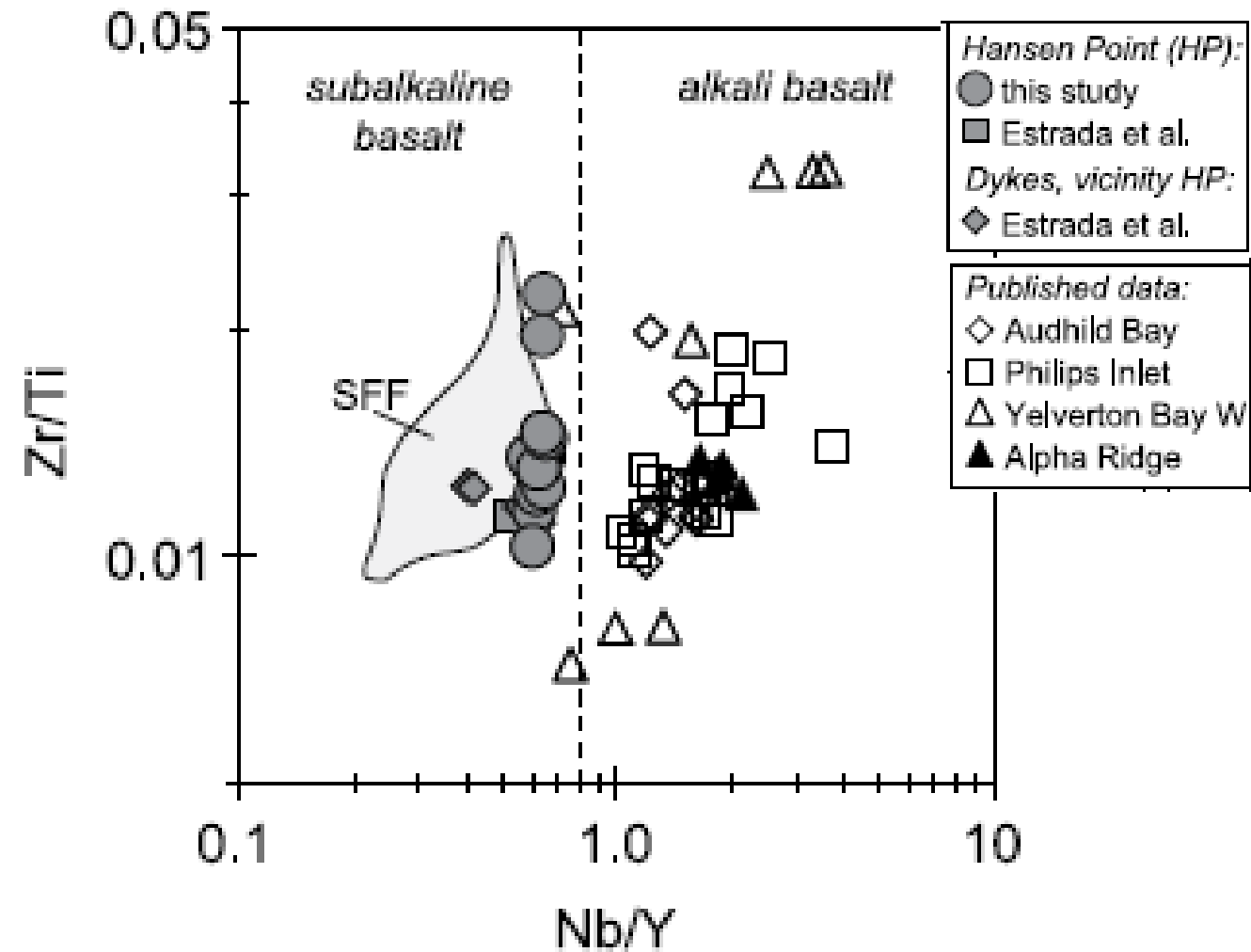


Figure 4. Zr/Ti versus Nb/Y discrimination diagram (Pearce, 1996) showing the bulk rock compositions of basaltic samples of this study from Hansen Point (Ellesmere Island, Canada), together with published data for basalt and basaltic andesite from Audhild Bay, Philips Inlet, Yelverton Bay West, Alpha Ridge, and the Strand Fjord Formation (SFF).

Pyroxene chemistry

- The compositions of the Hansen Point rocks are distinct from the alkaline compositions of basaltic dykes and lavas of northern Ellesmere Island, and to the alkaline basalts dredged from the Alpha Ridge. This is confirmed by distinct clinopyroxene compositions for Hansen Point and the Alpha Ridge.

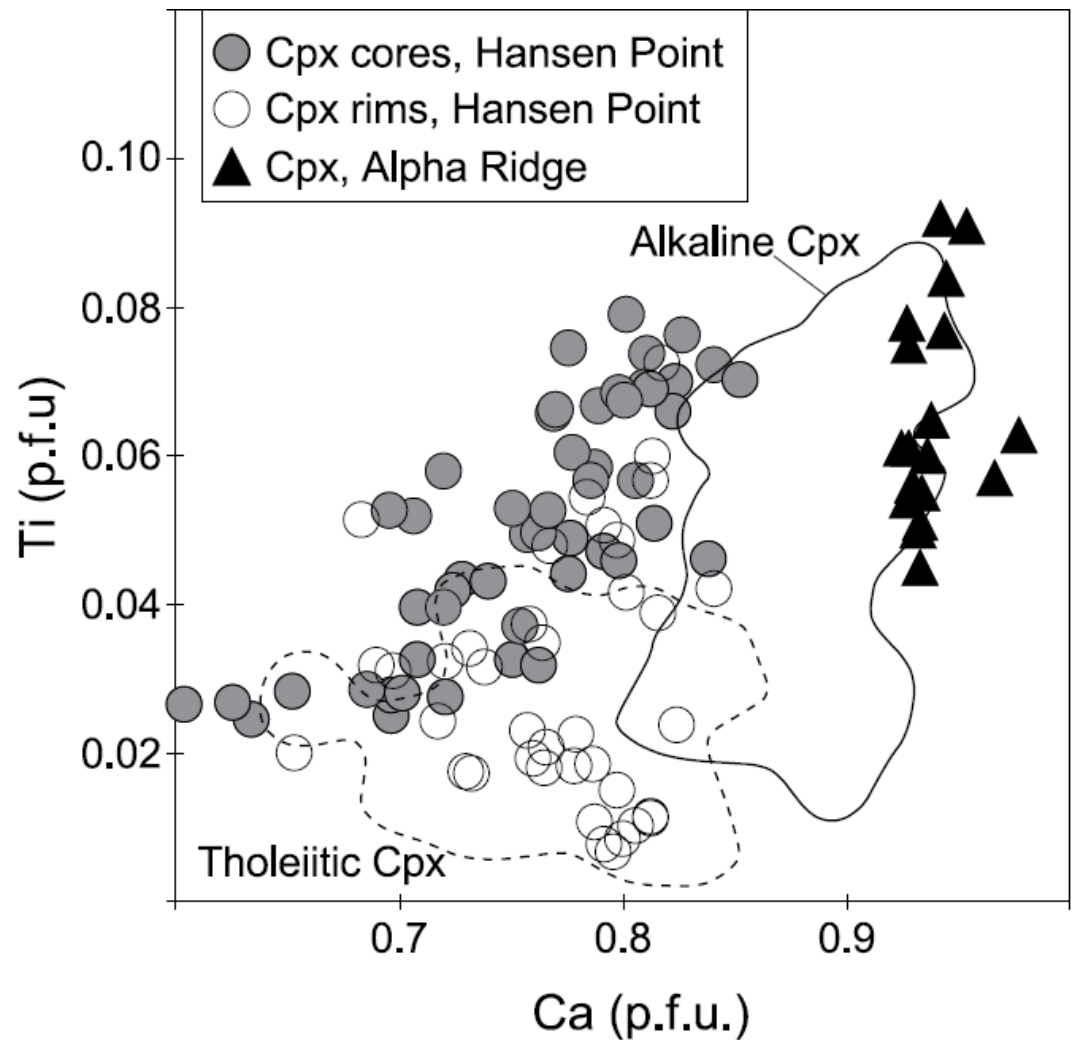


Figure 5. Clinopyroxene (Cpx) compositions from basaltic dykes and sheets of Hansen Point (Ellesmere Island, Canada) plotted in the Ti vs. Ca per formula unit (p.f.u.) discrimination diagram of Leterrier et al. (1982). Also shown are the clinopyroxene compositions from the dredge samples of the Alpha Ridge (Van Wagoner et al., 1986).

Geochemical trends

- The volcanics at Hansen Point show coherent geochemical trends that are best explained by fractional crystallization coupled with ubiquitous assimilation of upper continental crust.

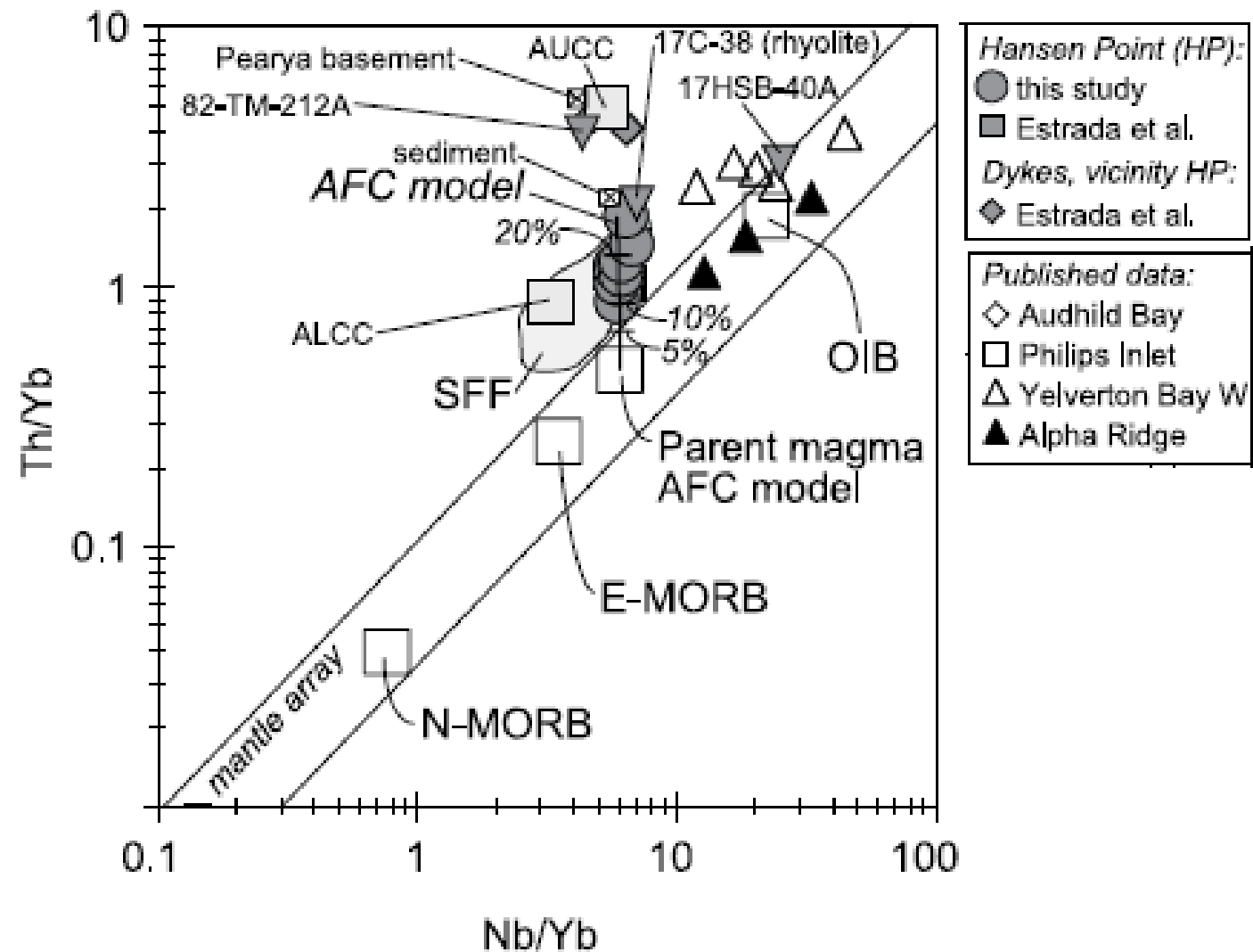


Figure 6. Th/Yb vs. Nb/Yb showing the Hansen Point basalts, basaltic andesites, and silicic rocks of this study, other basaltic rocks of northern Ellesmere Island, Canada, and the Strand Fiord Formation (SFF), the oceanic mantle array of Pearce (2008), the average composition of upper and lower continental crust (AUCC and ALCC, respectively, Willbold and Stracke, 2006), the average composition of Pearya basement gneisses in the Hansen Point area (Succession I, Estrada et al., 2018) and a Cretaceous sediment (sandstone) from Axel Heiberg Island (Evenchick et al., 2015).

Geochemical trends

- The trace element composition of the parental magma in these models is best explained as intermediate between E-MORB and OIB. This suggests the tectonic setting was one of continental intraplate, rift-related volcanism.

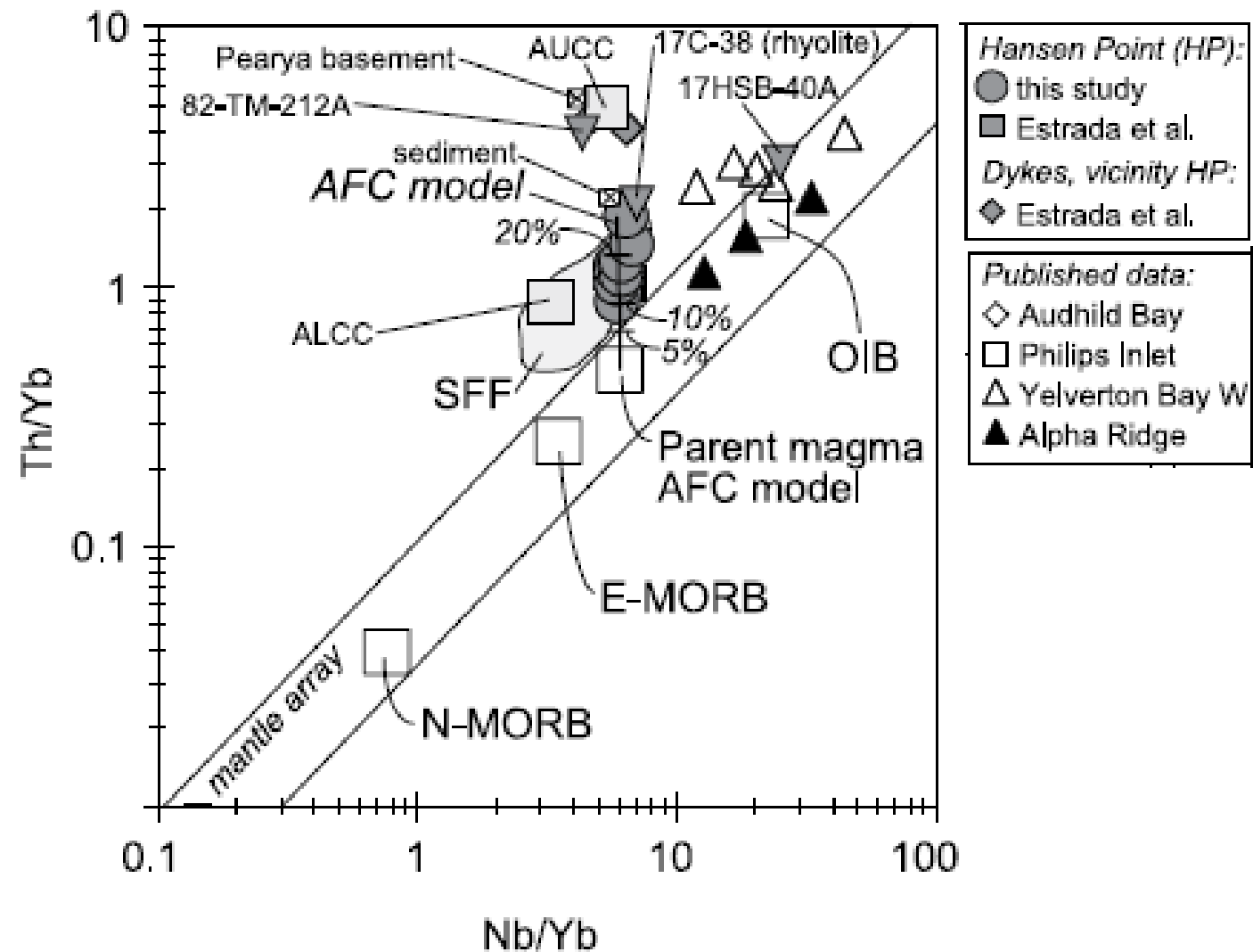
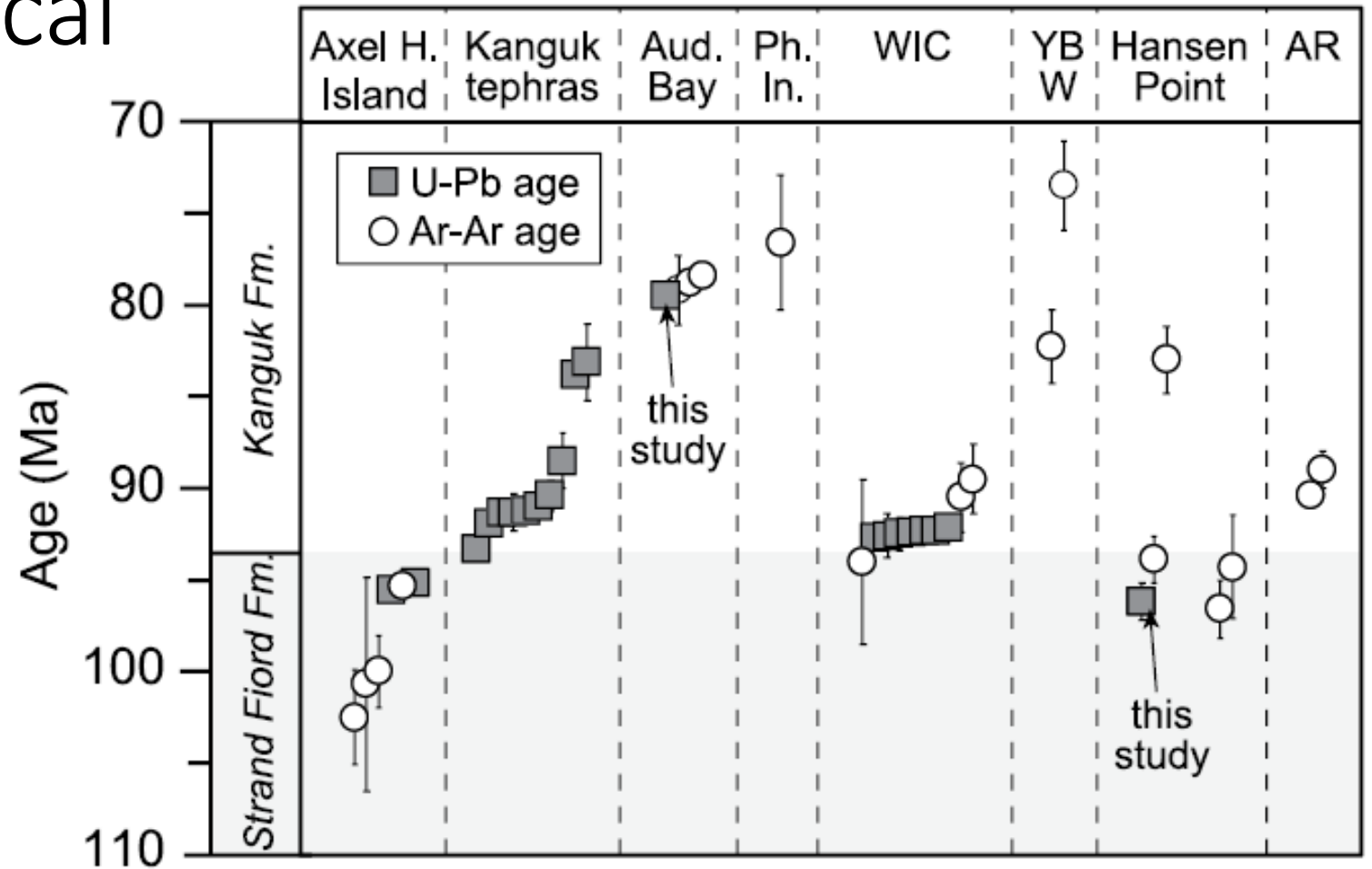


Figure 7. Th/Yb vs. Nb/Yb showing the Hansen Point basalts, basaltic andesites, and silicic rocks of this study, other basaltic rocks of northern Ellesmere Island, Canada, and the Strand Fiord Formation (SFF) (see caption to Fig. 8), the oceanic mantle array of Pearce (2008), the average composition of upper and lower continental crust (AUCC and ALCC, respectively, Willbold and Stracke, 2006), the average composition of Pearya basement gneisses in the Hansen Point area (Succession I, Estrada et al., 2018) and a Cretaceous sediment (sandstone) from Axel Heiberg Island (Evenchick et al., 2015).

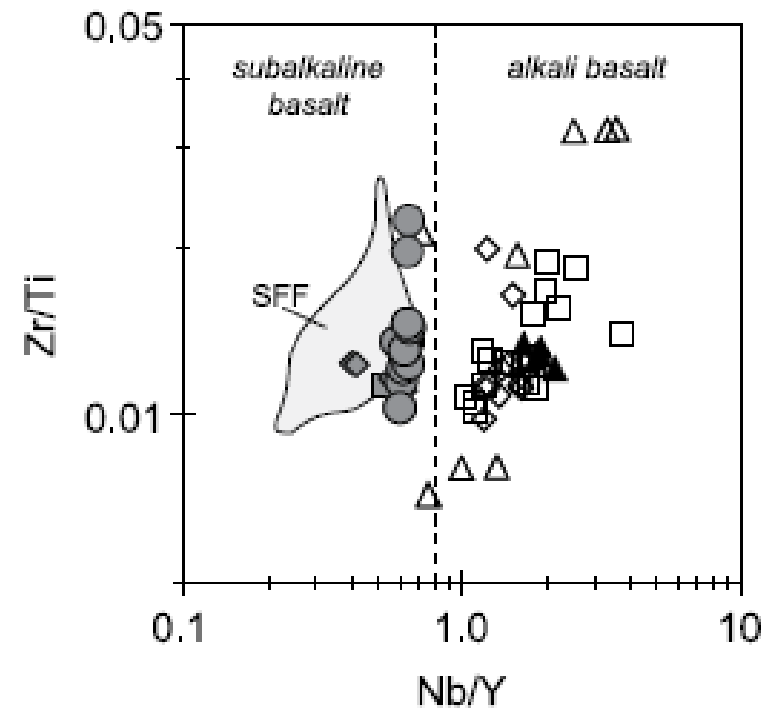
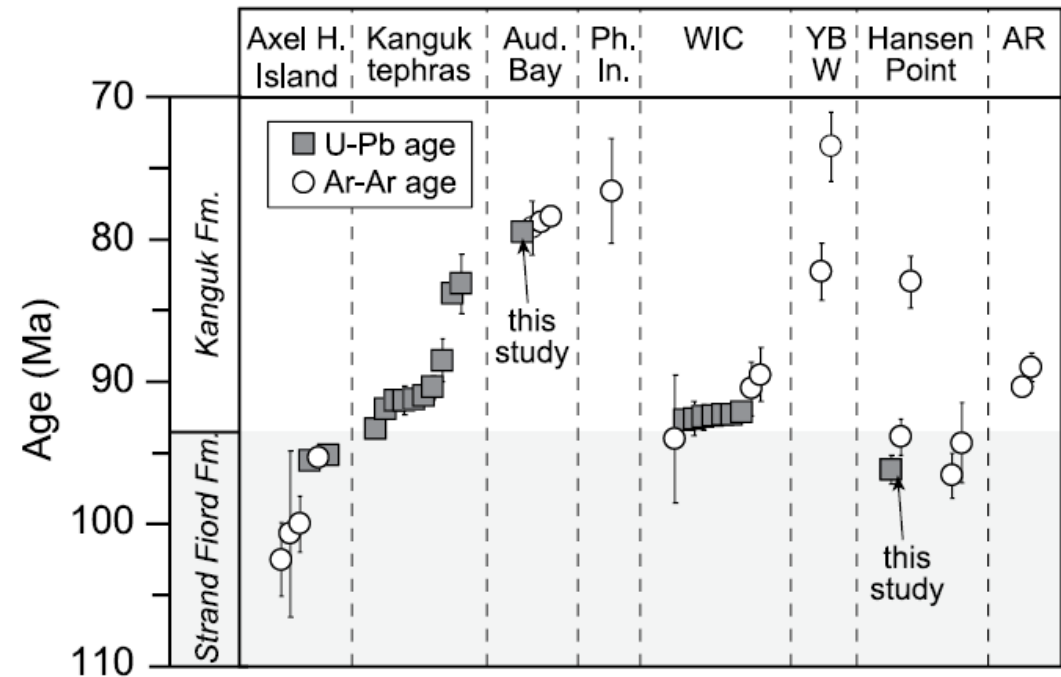
Age and geochemical distinctions

- Our study reveals that the volcanics of Hansen Point are distinct both in terms of age and composition from other occurrences of magmatism of northern Ellesmere Island, that hitherto all have been denoted the Hansen Point Volcanic Complex.



Revision of the nomenclature

- Because of these age and compositional differences, we propose revise the nomenclature of the volcanic rocks of northern Ellesmere Island and divide them into two suites:
 - the Hansen Point tholeiitic suite (HPTS) that were emplaced at 97–93 Ma and mainly is represented at the Hansen Point stratotype section; and
 - the Audhild Bay alkaline suite (ABAS) that is considerably younger (83–73 Ma) and includes volcanic and intrusive rocks at Audhild Bay, Philips Inlet, and Yelverton Bay West.



Conclusions and implications

- Our study supports the view that rocks of Audhild Bay alkaline suite are related to those of the Alpha Ridge. We emphasize that the lack of direct geochemical correlation of the volcanic rocks at Hansen Point and the few available samples from the Alpha Ridge does not preclude a relationship. The deeper parts of the Alpha Ridge could easily include Hansen Point Type Section and Strand Fiord Formation equivalents, as suggested by the on-land extension of the Alpha Ridge geophysical signatures on the Canadian Arctic islands.
- The Hansen Point Type Section demonstrates a large subaerial HALIP eruption event (97–93 Ma) that overlaps with the Cretaceous Ocean Anoxic Event 2 and may be the hypothesized driver of this anoxic event.
- Understanding the onland-offshore connections can also help resolve total eruptive volumes during HALIP events and the potential global environmental change they may have driven.

Thank you!

We would like to acknowledge that this work is an outcome of the joint Geological Survey of Canada and German Federal Institute for Geosciences and Natural Resources (BGR) Pearya Project: Circum-Arctic Structural Events expedition n. 19 (CASE 19) in 2017.

