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**SUPPLEMENTAL TEXT CAPTIONS**

Table S1: New and published U-Pb zircon, ZHe, 40Ar/39Ar, AFT, and AHe sample and data details.

**SUPPLEMENTAL TEXT CAPTIONS**

Text S1. Detailed 40Ar/39Ar methods.

Text S2. Detailed apatite fission track methods.

Text S3. Detailed apatite (U-Th)/He methods.

Text S4. Detailed HeFTy modeling methods.

**SUPPLEMENTAL FIGURE CAPTIONS**

Figure S1. Weighted average plot of U-Pb single grain zircon ages for sample 01Pyramid.

Figure S2. Weighted average plot of U-Pb single grain zircon ages for sample 20RAP.

Figure S3. Digital elevation model of the high peak region of the eastern Alaska Range (USGS SRTM 30 m). A) Sample locations for glacial outwash single grain U-Pb detrital zircon populations. Divisions are based on known periods of high magmatic flux in the Hayes Range (Regan et al., 2021). Nenana Glacier sample is from this study. Westfork, Susitna, Blackrapids, and Augastana from Regan et al. (2021). Blue star is location of Mount Hayes. B) Sample locations for glacial outwash single grain 40Ar/39Ar biotite detrital populations. Divisions are based on the timing of Eocene-Oligocene magmatism in the Hayes Range. Blue star is location of Mount Hayes. DR—Delta River, NR—Nenana River.

Figure S4. 40Ar/39Ar hornblende age spectra, Ca/K, and Cl/K ratios for the new bedrock samples. Steps filled in grey were used for plateau and weighted average age determinations. Steps filled in red were used for isochron age determinations.

Figure S5. 40Ar/39Ar biotite age spectra, Ca/K, and Cl/K ratios for the new bedrock samples. Steps filled in grey were used for plateau and weighted average age determinations. Steps filled in red were used for isochron age determinations.

Figure S6. 40Ar/39Ar potassium feldspar age spectra, Ca/K, and Cl/K ratios for the new bedrock samples. Steps filled in grey were used for plateau and weighted average age determinations. Steps filled in red were used for isochron age determinations.

Figure S7. HeFTy modeling of AFT and AHe data.