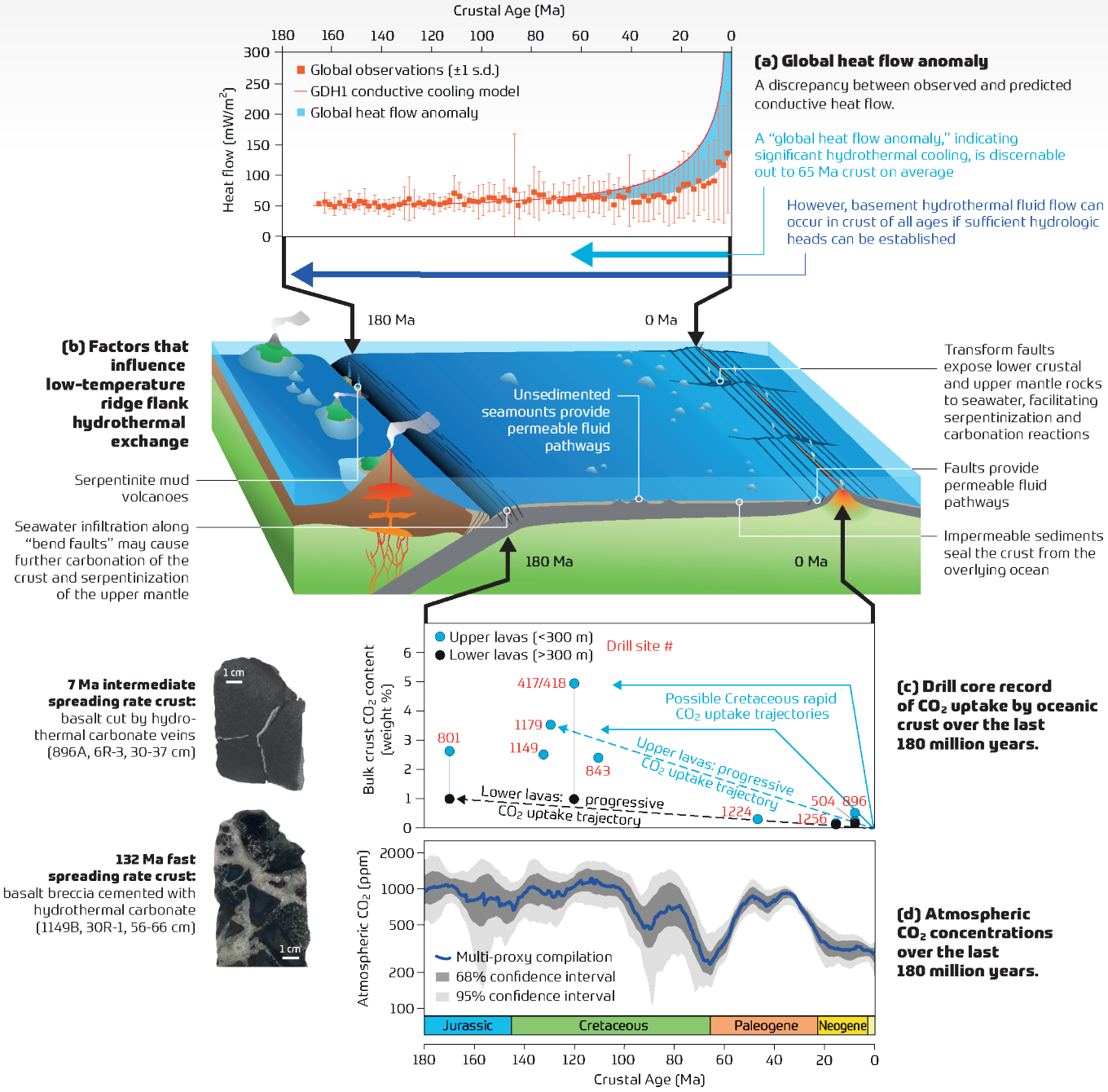
Quantifying the role of mid-ocean ridge spreading in controlling atmospheric CO_2



Scientific ocean drilling is required to quantify the role of natural CO_2 sequestration in oceanic crust as a result of hydrothermal exchange between the crust and overlying ocean in the long-term global carbon cycle. The role mid-ocean ridge spreading plays in controlling past atmospheric CO_2, and hence climate, remains controversial because of uncertainties regarding the rate, extent, and duration of hydrothermal carbonate precipitation. (a) A global heat flow anomaly indicates that hydrothermal circulation persists across the ridge flanks for ~65 million years on average[1], but fluid circulation can occur at all crustal ages given sufficient hydrologic head and permeability, which are influenced by factors such as local basement cover, topography, stratigraphy, and structure (b)[2]. (c) The higher bulk CO_2 contents of cored Cretaceous and Jurassic lavas compared to younger lavas is consistent with either progressive CO_2 uptake by the crust (dashed arrows) or with the majority of uptake within 10–40 million years of crustal formation (solid arrows)[3]. (d) Global conditions during the Jurassic and Cretaceous, including higher atmospheric CO_2[4] and global temperature, may have enhanced hydrothermal carbonate precipitation. The lithospheric flux of carbon into subduction zones likely depends on the age of the plate, its pathway across Earth's surface, its sedimentation and hydrological history, and the physical and chemical conditions of the overlying ocean. To quantify the role of hydrothermal circulation in the long-term global carbon cycle requires acquiring intermediate age oceanic crust.

Original figure compiled by Rosalind Coggon. [1]Modified from Stein and Stein (1994), https://doi.org/10.1029/93JB02222. [2]Illustration by Rosalind Coggon and Geo Prose. [3]Modified from Alt and Teagle (1999), https://doi.org/10.1016/S0016-7037(99)00123-4; core photographs from Alt et al. (1993), https://doi.org/10.2973/odp.proc.ir.148.1993, and Plank et al. (2000), https://doi.org/10.2973/odp.proc.ir.185.2000). [4]Modified from Foster et al., 2017, https://doi.org/10.1038/ncomms14845).