UNIVERSITY OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE

PROBING SUBDUCTION ZONE BEHAVIOR WITHIN PLATE TECTONICS RECONSTRUCTIONS

Jazmin Garza[1] , Adam Holt[1]

[1]Rosenstiel School of Marine and Atmospheric Science, University of Miami, FL

jxg1608@miami.edu

Introduction

Subduction zones govern fundamental Earth processes such as earthquakes, mountain-building events, and the accretion sediments from tectonic erosion. The distribution of subduction zones throughout Earth's surface has been concluded based on multiple sub-disciplines in geology, including but not limited to structural, petrological, paleomagnetism, and seismic tomography. Subduction zone locations, convergence rates, and dip direction can be assimilated into plate reconstruction models, which are defined as models that integrate the movement of tectonic plates via relative plate motions, an absolute reference frame, designated timescale, and the construction of continuously closing plate polygons. Such plate reconstruction models are accessed through online open sources where pre-made scripts can be used to conduct further calculations to predict movement in exterior and interior Earth processes. With the programming language, Python, we were able to extract data pertaining to the properties of tectonic plates such as subduction zone locations and topological plate boundaries. Through variable manipulation in the Python script, we aimed to answer the question of how subduction zone behaviors have significantly changed throughout the geologic record.

Materials and Methods

Analysis of subduction zone and plate tectonic properties were done within PyGplates, a Python library belonging to GPlates, a desktop software for interactive visualization of plate tectonic behavior through geological history. PyGplates provided the functions necessary to export the constructed data provided by the plate reconstruction model (Müller 2016). To efficiently write the Python scripts, modules were imported at the beginning of each script (e.g., numpy, cartopy, matplotlib, netCDF4).

The first step was to calculate the subduction length proportion. Each subduction length proportion value is equal to the division of the subduction zone length by the boundary polygon length. By using the same PyGplates function, we were able to exhibit convergence rates (cm/year) associated with each subduction zone location. Both trends were plotted against time (220 Ma) which produced Figure 1. The maximum and minimum rates were observed at 124 Ma and 219 Ma, respectively. By following similar steps in using built in PyGplates functions, we were able to exhibit convergence rates (cm/year) associated with each subduction zone location. A scatter plot in Figure 2 displays their global distributions in a map centered around the Pacific utilizing the Plate Carree projection style. Although Figure 2 focuses on the modern time (0 Ma), Figures 3 and 4 focus on subduction zone distributions specific to the times of the maximum and minimum convergence rates. Across the maps, the plate boundaries are outlined in grey to highlight spreading ridges, creating new seafloor and oceanic crust. Using a netCDF grid that contained data pertaining to coordinates and ages of the seafloor, the seafloor ages were interpolated and exhibited across Figures 2, 3, and 4.

Results

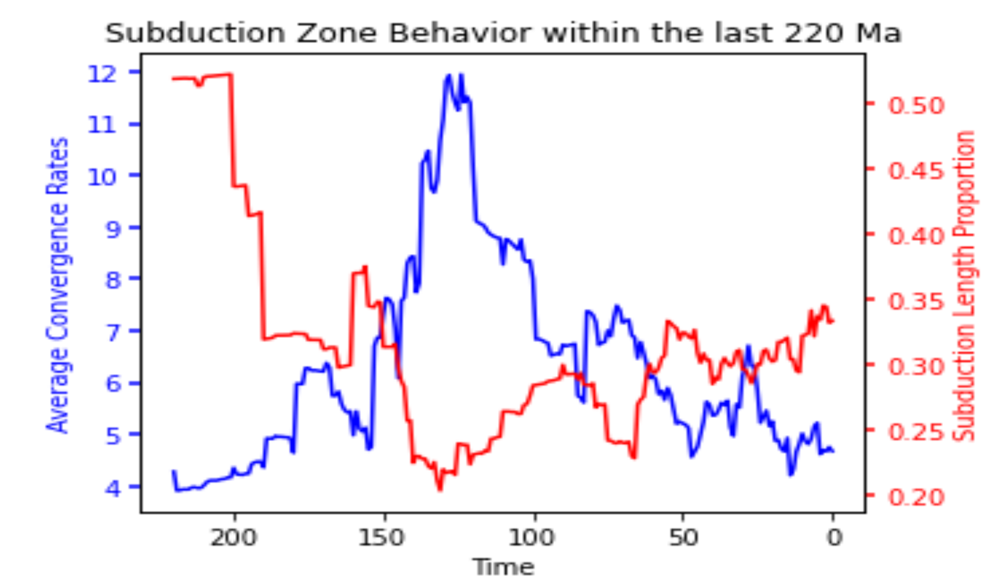

Figure 1 – Plot exhibiting fluctuations in average convergence rates and subduction length proportions in the last 220 million years.

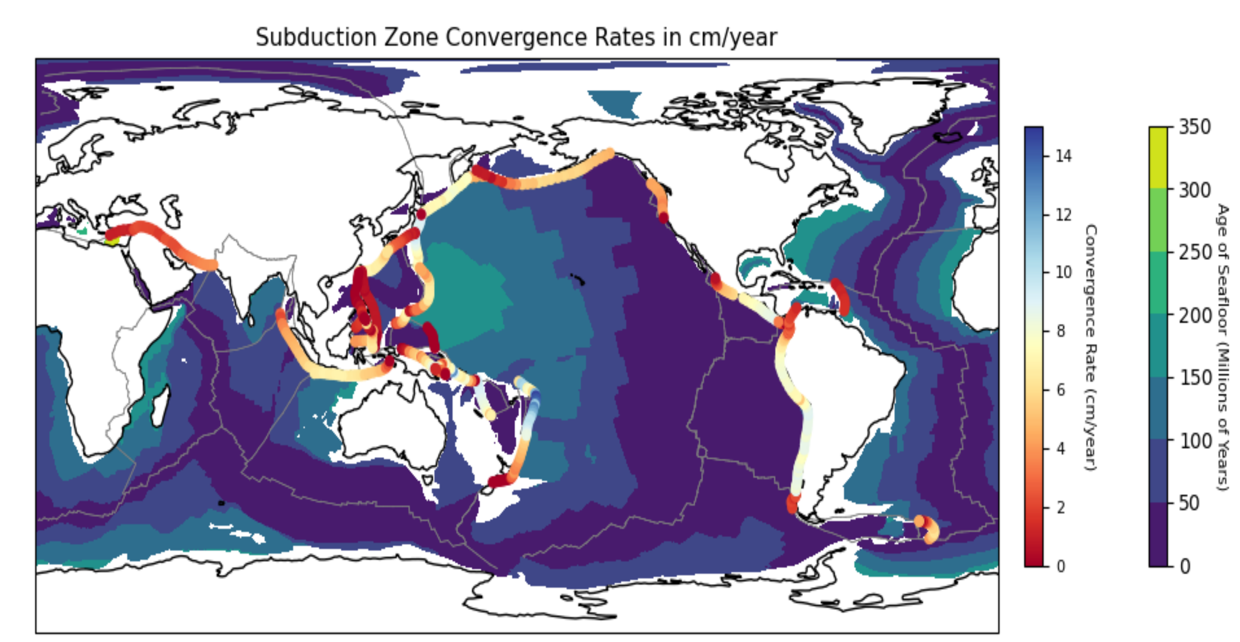

Figure 2 - Global map exhibiting the distribution of subduction zone locations with their associated convergence rate. Also included are interpolated seafloor ages measured in millions of years.

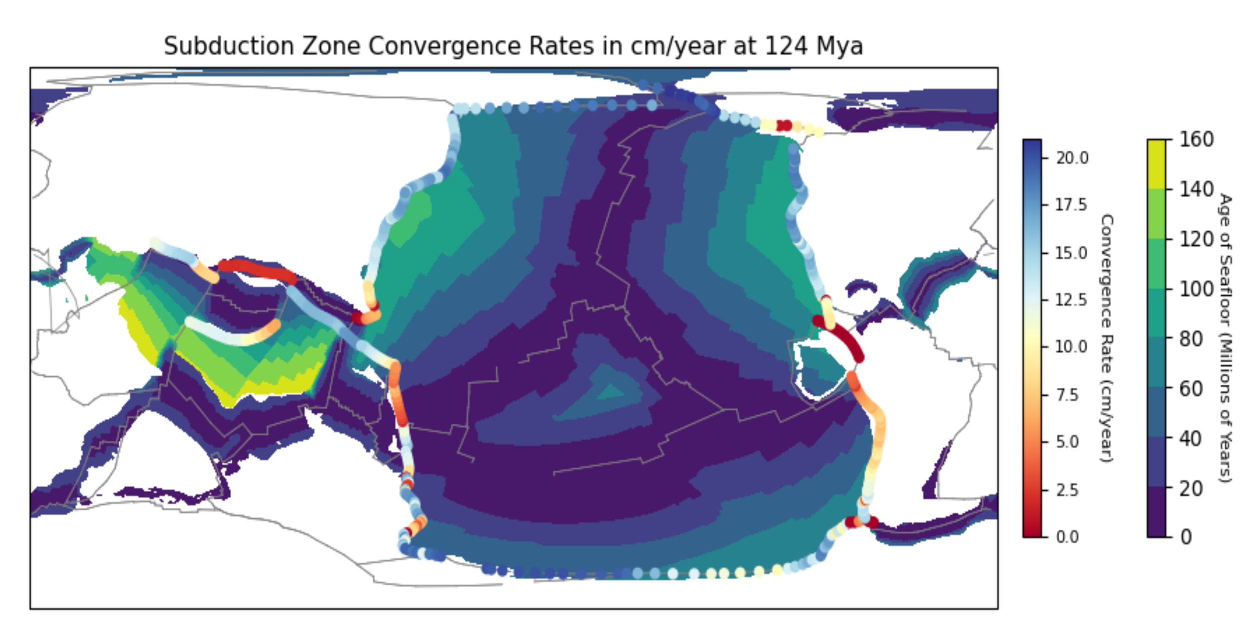

Figure 3 - Global map exhibiting the distribution of the subduction zones and their associated rates at 124 Ma, where the average convergence rate was the maximum in the last 220 Mya.

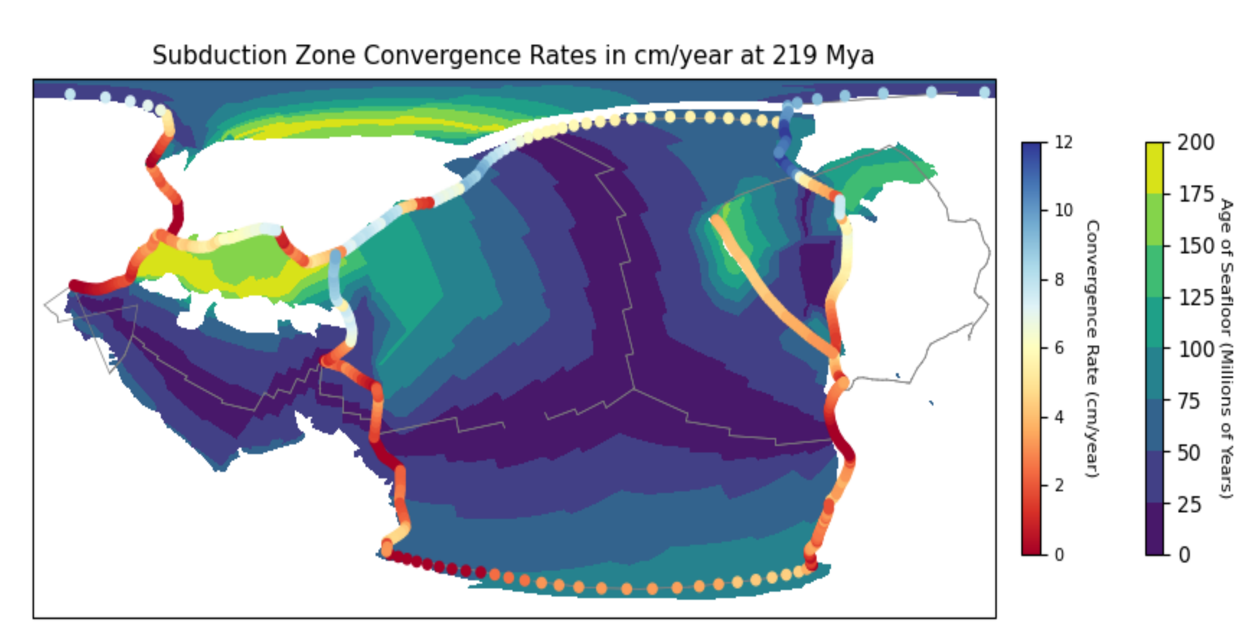

Figure 4 - Global map exhibiting the distribution of the subduction zones and their associated rates at 219 Ma, where the average convergence rate was the minimum in the last 220 Mya.

Conclusion

- Based on Figure 1, it is observed that the average convergence rates and the subduction length proportion are inversely related.
- Within the last 220 Ma, the average maximum convergence rate was 11.94 cm/year at 124 Mya. The average minimum convergence rate was 3.91 cm/year at 219 Mya.
- Peak convergence rates are related to the mid-Cretaceous seafloor spreading pulse, estimated to have started 120 Mya.
- Minimum convergence rates can be associated with supercontinent formation as it occurs during the time of the maximum amalgamation of Pangea.

Summary

Recent published research regarding plate reconstructions is widely available through online open sources. With the available data, we were able to observe the relationship between the convergence rates of subduction zones and their calculated length proportions. In addition, we were able to reconstruct the current distribution of subduction zones and during times when the average convergence rates were at a maximum and minimum value. Both times are associated with significant geological events. Although these correlations could be concluded, implications include rise of uncertainties as the time from the present increases due to the continuous subduction of the tectonic plates' record.

Acknowledgements & References

Thank you to Dr. Adam Holt for the advisement and mentorship into completing this project. I would also like to thank my committee members, Dr. James Klaus and Dr. Guoqing Lin, and Ph.D. student, Valeria Turino for their support.

1 Karlsen, K. S., Conrad, C. P. & Magni, V. Deep Water Cycling and Sea Level Change Since the Breakup of Pangea. *Geochemistry, Geophysics, Geosystems* **20**, 2919-2935, doi:10.1029/2019gc008232 (2019).
2 Hier-Majumder, S. & Hirschmann, M. M. The origin of volatiles in the Earth's mantle. *Geochemistry, Geophysics, Geosystems* **18**, 3078-3092, doi:10.1002/2017gc006937 (2017).
3 Müller, R. D. *et al.* Ocean Basin Evolution and Global-Scale Plate Reorganization Events Since Pangea Breakup. *Annual Review of Earth and Planetary Sciences* **44**, 107-138, doi:10.1146/annurev-earth-060115-012211 (2016).
4 Seton, M. *et al.* A Global Data Set of Present-Day Oceanic Crustal Age and Seafloor Spreading Parameters. *Geochemistry, Geophysics, Geosystems* **21**, doi:10.1029/2020gc009214 (2020).
5 Müller, R. D. *et al.* A Global Plate Model Including Lithospheric Deformation Along Major Rifts and Orogens Since the Triassic. *Tectonics* **38**, 1884-1907, doi:10.1029/2018tc005462 (2019).
6 Müller, R. D. & Seton, M. in *Encyclopedia of Marine Geosciences* Ch. Chapter 84-1, 1-15 (2015).
7 Keppie, F. How subduction broke up Pangaea with implications for the supercontinent cycle. *Geological Society, London, Special Publications* **424**, 265-288, doi:10.1144/sp424.8 (2016).