

# **Committee on Geologically Defining Continents (COGDC 2021)**

## **working definitions (Final Version: April 1, 2022)**

### **Abstract**

*The word “continent” can mean different things to different people. Herein, it will be defined strictly for geologic purposes and most disciplines therein. The definition will only apply to Earth since it has a unique style of losing internal heat via global plate tectonics. Even within geology, the word’s usage has varied slightly depending on who is using it and in what context. In order to solidify the definition of a continent for geologic purposes, it is important to define other terms as well. The two most important words to define are “continent” and “craton”. Other words will need to be defined so we can use them in the context of this publication but are not necessarily carried on outside of geological purposes. Every reasonable effort was made to define terms in the general context of which they have been traditionally used, but tradition doesn’t take priority over a functional definition. It is also important to not only define things as they exist in the present, but to at least acknowledge things that existed deep in the geologic past. We realize that the results of COGDC 2021 will not appease everyone just as the 2006 “International Astronomical Union” made a lot of Pluto lovers angry. But a concise definition of continent is needed, and we can only do the best we can.*

### **Introduction**

The focus of this report is to lock down the definition of what a continent is and what a craton is, for geologic purposes. One of the primary goals was to be able to have the term understandable into both the past and future. One of the side effects of the primary definition was the need to define other terms.

These other terms are relevant directly to the definition of continent and craton, but they are not the primary focus of this report. One of the results is that some of the terms defined outside of continent may be applicable to the same landmass being defined. For example, it is possible for something to be both a paleocontinent and a continent or even megacontinent. The user’s intent will have to be defined in context. However, the definition of continent and craton should be rigid and well defined herein.

The term “continental fragment” essentially has the exact same definition as a “continent”, except for the surface area requirement. The term “craton” is also closely tied to the definition of “continent”.

The rest of this report is dedicated to the description and definition of continents as well as the physical delineation of the North American Continent.

## **Potential terms being defined herein for geological purposes**

### **CONTINENT**

A physically continuous solid land mass more than 1,000,000 km<sup>2</sup> in surface area, where the majority of the surface is above sea level. Its outer boundaries are formed by continuous continental shelf and continental slope directly connecting to ocean crust and it has to be at least 80 % surrounded by ocean crust, and a continent must mostly be composed of felsic rock with at least one Archean craton as part of it. Small sections of peninsulas, emergent island chains, or isthmus of landmasses do not have to be dominantly intermediate to felsic as long as the land and continental shelves are connected to larger continental masses by more than 5% of the connecting continental shelves. Emergent island chains are ones where most of the island's surface is above sea level.

Two or more separate continents can be physically connected to one another as long as no more than 20 % of the continental shelves and dry land connect. An emergent island chain can also be part of a continent as long as its continental shelf is connected to a continent by more than 20 %. Free standing islands and landmasses, not attached to continents as defined herein, are not part of continents.

In this case of connecting continents, the boundary between the continents should be a line drawn (but not necessarily straight) through a prominent geomorphic feature or a well-established unmovable boundary, such as a line of latitude or longitude, mountain ridge, adjoining ocean trench, or prominent geologic structures. If the longitude/latitude method is employed, and it bisects any islands above sea level on the continental shelf, the islands should be assigned to one continent or another at a set distance from the shore. The edge boundaries of continents continue from where the continental shelf meets the ocean crust, down vertically in the direction of the center of the earth, terminating at the base of the lithosphere or the physical Mohorovičić discontinuity (a.k.a. Moho), depending on the in context usage.

Continent borders are independent of socioeconomics, geopolitical, historical, and cultural constraints.

A continent includes the land above sea level and the submerged continental shelf. A continent includes all the lakes, glaciers, rivers, streams, and geomorphic features that sit upon them. From a geologic standpoint, things like "disconnected (non-emergent) island chains" and "non-craton bearing crust far below sea level" are not part of continents, nor are they continental fragments. The concept of a continent can be extrapolated into the past as far as reasonably possible as long as Earth's oceans were around. – *This definition is tied to definition 1 of "continental fragment".*

Main criteria of the delineation of continent.

- 1) Physically continuous landmass with a surface mostly above sea level and including the continental shelf.
- 2) Must be >1,000,000 km<sup>2</sup> in surface area.
- 3) Outer natural boundaries are formed by where the continental crust meets the ocean crust.
- 4) It is surrounded by >80% ocean crust.
- 5) Composed of dominantly felsic and intermediate rocks.
- 6) It must contain at least one complete Archean aged craton or fragment.
- 7) A continent can share up to 20% of its continental shelf with another continent. Artificial boundaries may have to be established.
- 8) Continent boundaries are vertically drawn towards the center of the earth from their defined surface delineations, until the physical Mohorovičić discontinuity is reached or the base of the lithosphere, depending on in context usage.

- 9) Continent boundaries are independent of socioeconomics, geopolitical, historical, and cultural constraints.
- 10) It includes all of the rivers, lakes, mountains, geomorphic features, and glaciers, sits upon the continental crust.
- 11) Emergent island chains with a continental shelf that physically connect to a continent are part of that continent as long as they share at least 5% of their shelf with the continent.

### CONTINENTAL CRUST

Part of a continent that is above the physical Mohorovičić discontinuity (a.k.a. Moho) or the part of a continental fragment that is above the physical Moho. Continental crust, unlike continents themselves, cannot go below the physical Moho.

### CONTINENTAL FRAGMENT

A piece of felsic to intermediate crust that would in essence be considered a continent if its area were larger than 1,000,000km<sup>2</sup>. – *This definition is tied to definition 1 of “continent”.*

### CRATON

A landmass that is a stable piece of dominantly felsic to intermediate lithosphere and is composed of Precambrian rock basement (older than the breakup of Rodinia) that serves as a platform for the dominantly lateral accretion of younger crust. They are rooted by ultra-high pressure (UHP) metamorphosed crust that does not get subducted. They also serve as the bedding for Phanerozoic platform deposits. The terms archon, proton, and tecton are acknowledged herein as in Janse 1998, except that there are no tectons younger than the onset of the breakup of Rodinia.

Cratons serve as the nucleus or core of a continent. The term “protocontinent” can be used as a synonym for craton, as long as it is clearly defined.

### MEGACONTINENT – NEW TERM

A megacontinent is when at least 40% of all Earth’s continental masses are joined together. At present, Earth has no megacontinents, although Eurasia is close.

### PALEOCONTINENT

A generic term used to refer to an ancient continent or assemblage of ancient continents that no longer exist but were stable for long periods before being broken-up or assembled into other continents. The usage of the term can be used with a bit of flexibility as long as it is defined and/or consistently used in context.

### PSEUDOCONTINENT

A terrane that does not fit the definition of a continent or continental fragment but contains some defined properties of being continental crust. It consists mostly of felsic to intermediate crust that either broke away from a continent or is made up of felsic ocean crust and contains no Archean cratons. It also does not have to be mostly above sea level. Nor does it need to have a continental shelf surrounding it.

### SHIELD

A continental shield is essentially the same thing as a craton, except it only refers to the part exposed at the surface or just under Quaternary deposits.

## **SUBCONTINENT**

An area of a continent that has a distinct geologic history separate from the continent that it is now part of. They were independent continental landmasses at some point when Pangea broke up to recent times but are presently a part of some other continent. They are usually bounded to their present continents by connecting continental shelves or mountain ranges. Subcontinents existed post Pangea breakup until they collided with another continent. Pre-Pangea “subcontinent type” landmasses would better be described as a “protocontinent” or “paleocontinent”. India is an example of a subcontinent. As where Laurentia is a protocontinent or paleocontinent. Gondwana and Laurasia can be referred to as either a paleocontinents or megacontinents.

## **SUPERCONTINENT**

A supercontinent is when at least 75 % of all Earth’s continental masses are joined together into one continent.

## **Conclusions**

The definitions herein have been standardized for “continent” and related terms. These definitions provide a well defined concept and framework for future works involving the usage of the words defined herein. We understand that extrapolating of the definitions into the deep past maybe a bit cumbersome, but we do not feel that it is necessarily impossible to do so.

## **Key Notes and changes brought about by COGDC 2021**

There are some important things to keep in mind.

Some independent continents may connect to some degree. We have addressed this in the definitions. However, some boundaries will need to be selected to separate some continents. Like North America from Greenland, South America, and Eurasia.

Minor sediment infill or slumps on top of a dominantly mafic oceanic lithosphere does not count as “continental shelf”. Hopefully, this will avoid square pegs into round holes.

This process may also, add continents. One such continent is Greenland. It will also get rid of others. Like the separation of Europe and Asia. Zealandia will also fall away as a continent but falls within the definition of pseudocontinent.

In order to justify some of the changes, we will need to “standardize” some publications for purposes herein. See References/Standards. We realize that as new information and technology come around, that these standards may need revising in the future.

It is important to note that the continents as defined herein will not coincide with tectonic plate boundaries. That was not the intent of this report. Plate boundaries are different from continental ones. Plate boundaries can serve as borders for continents, but it is not a requirement.

## **References/Standards**

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<sup>2</sup>Rockwell, T., Gath, E., Gonzalez T., Madden, C., Verdugo, D., Lippincott, C., Dawson, T., Owen, L.A., Fuchs, M., Cadena, A., Williams, P., Weldon, E., and Franceschi, P., 2010. Neotectonics and paleoseismology of the Limon and Pedro Miguel Faults in Panama: earthquake hazard to the Panama Canal. *Bulletin of the Seismological Society of America*, vol.100, doi:10.1785/0120090342

## **Glossary of terms used herein**

Here are some definitions that COGDC 2021 has deemed necessary for a greater understanding of terms. However, to avoid rabbit holes, we have only included what we thought was absolutely necessary for clarity in the context of the goals of COGDC 2021.

### **CONTINENTAL SHELF**

Area of felsic to intermediate dominated seabed connected to a large landmass where the sea is relatively shallow compared with the open ocean floor and abyssal plain. This also includes the drop off or slope from the shallow area to the deeper ocean crust. The continental shelf is part of a continent.

### **EMERGENT ISLAND**

An island or an island chain where the majority of the surface is above mean sea level.

### **FELSIC ROCK/CRUST**

Rock composed of dominantly quartz, plagioclase, and potassium feldspars (such as granitoids), as well as the clastic rocks derived from them (such as sandstone and shale). As applied herein, it is not used to discriminate between igneous or sedimentary clastic rocks.

### **GEOLOGICAL PURPOSES**

Referring to uses by geologists and disciplines within geology. At present the disciplines considered geological herein are “applied geology, economic geology, engineering geology, geochemistry, geochronology, geologic mapping, geomorphology, geophysics, geotechnical engineering, hydrology, mineralogy, mining geology, paleogeology, petrology, sedimentology, seismology, stratigraphy, structural geology, and tectonics”. COGDC 2021 recognizes other people may have a different list, but herein, this is what we are using. We also acknowledge that new disciplines may arise in the future, and that will be for future committees. Some, like planetary geology, were left out intentionally as the focus of this committee is to define things as they pertain to Earth.

### **GEOMORPHIC FEATURE**

Bathymetric and topographic landforms.

### **GRANITOID**

Any rock that plots within of the phaneritic (a.k.a. plutonic) streckeisen ternary plot/diagram.

### **LAND**

The solid surface of the Earth, to exclude ice caps.

### **LITHOSPHERE**

The rigid part of the Earth closest to the surface involved in plate tectonics. The lithosphere includes not only the upper most mantle but all overlying ocean and continental crust.

### **MAFIC ROCK/CRUST**

Rock composed dominantly of iron and magnesium rich minerals relatively low in quartz and feldspar. The dominant feldspars that are present are plagioclase.

## OCEAN CRUST

The mostly ultramafic and mafic crust of the Earth that was created by seafloor spreading and is recycled into the mantle via subduction, although small slivers may be preserved on the continents as ophiolite. It may or may not include the underlying oceanic lithosphere based on its usage and context.

## SEABED

Land that lies beneath present mean sea level.

## STABLE LAND

For the most part, land that has been mostly tectonically quiet for a period of at least 100 million years and devoid of volcanic activity and are located away from a subduction, rift, or a transform boundary. Earthquakes may occur but are rare and of low magnitude (<4.5 on the Richter Scale).

## TERRANE

A mostly fault bounded area of felsic to intermediate crust, with a distinct geologic history.

# **Defining the boundaries of North America**

## **Abstract**

*North America is bounded to several continents by its continental shelf. It physically connects to Eurasia, South America, and Greenland. All of which are continents in their own right. We will not be defining the boundaries of other continents herein. The official boundaries of North America between Eurasia are based off lines of latitude and longitude. The boundaries between North America and Greenland are a combination of latitude/longitude and midpoints between shorelines. The borders between North and South America are based off geological structures coupled with cardinal directions and island curves at a distance of five kilometers from the shorelines. A side effect of the way we defined continents created Greenland as one.*

## **Introduction**

Although tradition and common usage was taken into account; we had no intent to ever fit square pegs into round holes, just for the sake of tradition and common usage. The next section shows the maths on Greenland. No matter how we cut it, following the continental shelf between North America and Greenland, never reached the required 20% to keep it as part of North America. It fits all the other criteria for a continent. Greenland is a continent. Along with Antarctica, North America, South America, Eurasia, Africa, and Australia.

## **The Greenland Problem**

The computations run on trying to discern if Greenland connects to the North American continental shelf by >20% the perimeter. Greenland has significant oceanic crust surrounding it (Figure 1).

Greenland continental shelf border:  $100 (720.99 / 4126.90 \text{ miles}) = 17.470498 \%$  (Google Earth)

Greenland continental shelf border:  $100 (1151.72 / 7226.53\text{km}) = 15.937386 \%$  (Gregersen et al., 2019)

Greenland continental shelf border:  $100 (1.75 / 12.55\text{in}) = 13.944223 \%$  (Muller et al., 2008)

Mean average =  $15.7840357 \%$   $\sim 15.784 + 1.840 \%$

Based off the definition, Greenland is a continent.

The separation of North America from South America and Eurasia is far less problematic than the Greenland problem.

**These are just the defined separation lines and other computations that are aiding in the definition.**

## **Separating North America from Eurasia**

North America is separated from Eurasia by its physical definition except between Alaska and Siberia where it is separated by starting at the north most point of the continental shelf at  $76.0^\circ\text{N} \times 168.5^\circ\text{W}$ .

From there it heads south along the longitude of  $168.5^\circ\text{W}$  until it meets the latitude line of  $55.5^\circ\text{N}$ .

From here it follows  $55.5^\circ\text{N}$  heading west a short distance until the edge of the continental shelf is reached. This puts the following islands where above mean sea level entirely in North America: King Island Shoal and Nunivak

Island. This puts the following islands where above mean sea level entirely in Eurasia: Diomed Islands, St. George Island, St. Lawrence Island, St. Matthew Island, and St. Paul Island (Figure 2).

#### Separating North America from South America

The dividing line between North and South America is in Panama and is as follows. In three segments The Pedro Miguel Fault's southern end (at about 9.0°N, 79.6°W) , extended south to the edge of the continental shelf (at about 7.20°N and 79.6°W) is the southernmost segment. Bypassing Isla Otoque and Bona to the east at mean sea level for a distance of 5km. Bona and Otogue both stay with North America.

From the Pedro Miguel Fault to the Limon Fault extended to where it meets the Rio Gatun Fault is the middle segment.

From where the Limon Fault meets the Rio Gatun Fault at an azimuth of N60W (a.k.a. 300°) until the continental shelf is reached, is the north and final segment (Figure 3).

(Bennett et al., 2014: <sup>1</sup>Rockwell et al., 2010: <sup>2</sup>Rockwell et al., 2010) .

#### Separating North America from Greenland

Greenland is separated from North America starting at GPS at 82.3°N x 59.4°W. From that spot the line breaks due north until reaching the edge of the continental shelf at ~84.1°N.

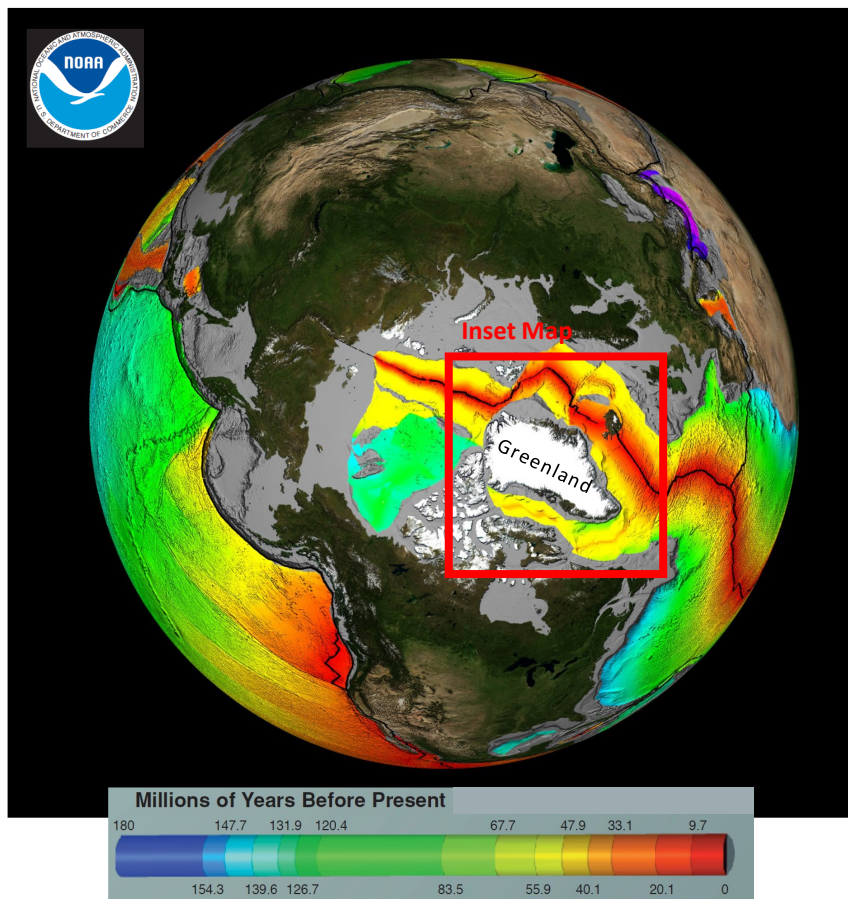
Going back to 82.3°N x 59.4°W, the division follows in a southerly direction at the midway point between the shore of Greenland and Ellesmere Island and then Devon Island (based off mean sea level) until reaching the edge of the continental shelf at roughly 74.8°N x 71.5°W (Figure 4).

(Gregersen, et al., 2019 and Muller, et. al., 2008)

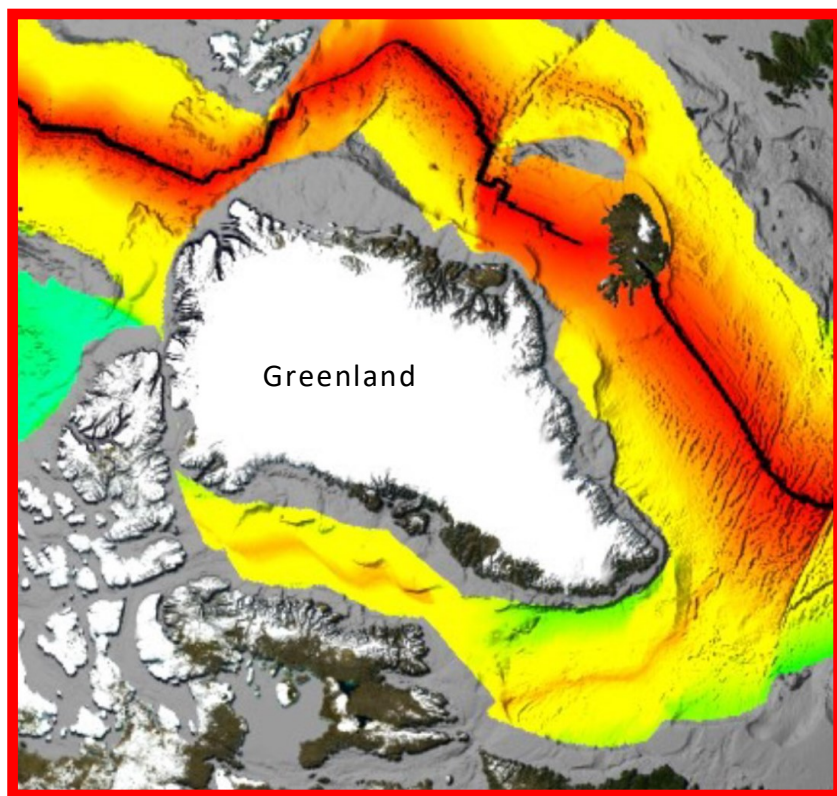
Note on using the above for Greenland. That gives a distance separating North America from Greenland to be 1161.00km.  $100(1161.00 / 7226.53\text{km}) = 16.0658 \%$ . Still well within the margin of error.

**FIGURE 1: Age of the ocean floor from the North Pole**

North polar view of the ocean crust with a bar for the color coded ages. The map below is the inset map outlined to the right.



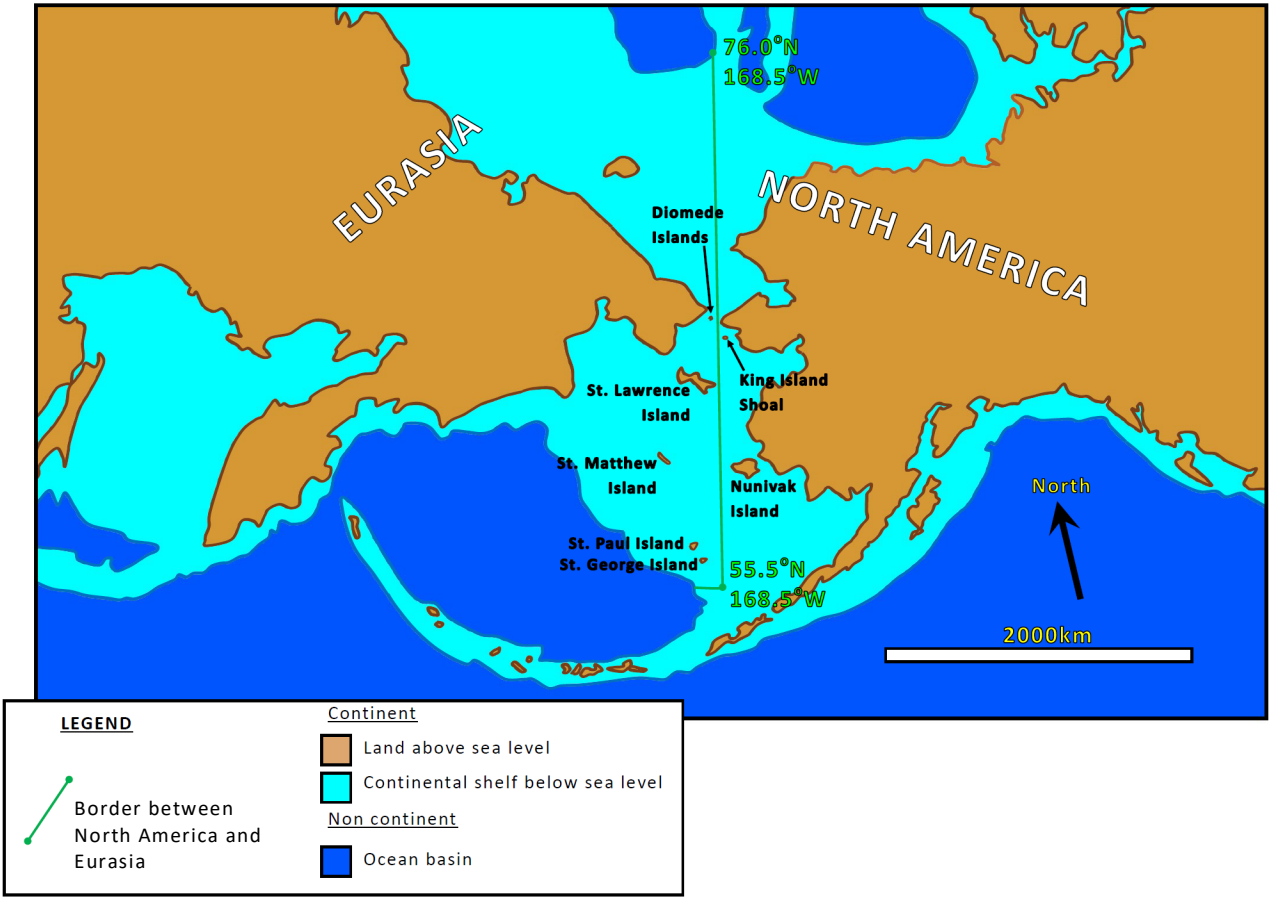
**Inset Map**



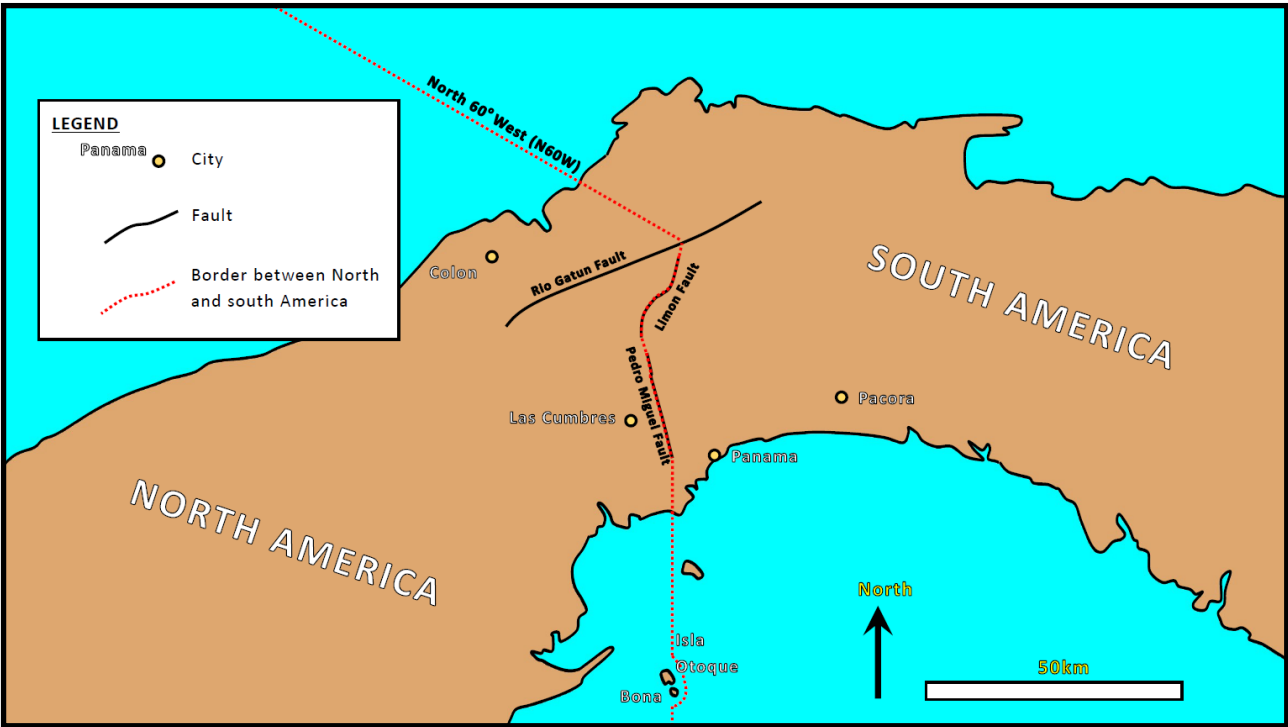
Inset map showing the approximate ocean floor extent (red-green color) compared with the continent (gray, white, and deep brown).

Adapted from: *Muller et al., 2008*

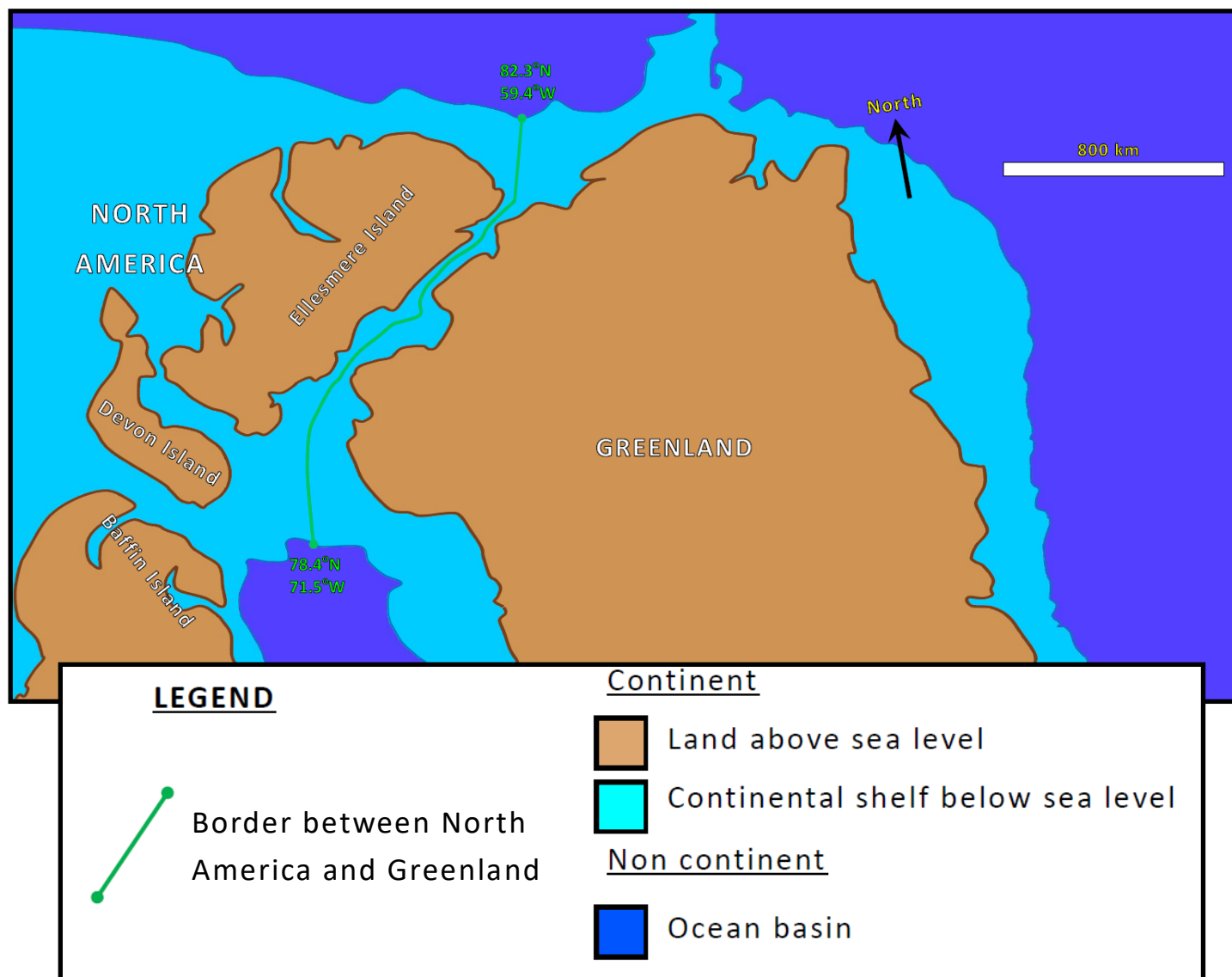
**FIGURE 2:** Border between Eurasia and North America



**FIGURE 3:** Border between South America and North America



**FIGURE 4: Border between Greenland and North America**



# **Direct contributors and timeline of COGDC 2021**

## **Acknowledgments**

*The following people directly contributed to the efforts herein and all their input, edits, and patience are greatly appreciated.*

### **Chairpersons**

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## **Actual timeline of COGDC 2021 milestones**

*The following is a timeline of milestones reached by the committee. As often with these things, things didn't go exactly to plan. So below is what actually occurred. All correspondence was conducted electronically.*

<u>Milestone</u>	<u>Date reached</u>
Committee founded	March 15, 2021
Applications sent out to potential committee members	April 9, 2021
Video "Committee on Geologically Defining a Continent" uploaded to YouTube	April 13, 2021
First draft of report	April 15, 2021
Edits received	April 17, 2021
Second draft	May 4, 2021
Committee members finalized	May 31, 2021
Committee plan uploaded to <a href="http://mige-web.org">mige-web.org</a>	June 10, 2021
Third draft	August 16, 2021
Discussion, suggestions, and input initiated	October 7, 2021
Discussion, suggestions, and input finalized	February 28, 2022
Final version submitted for review	March 16, 2022
Final version authorized	April 1, 2022