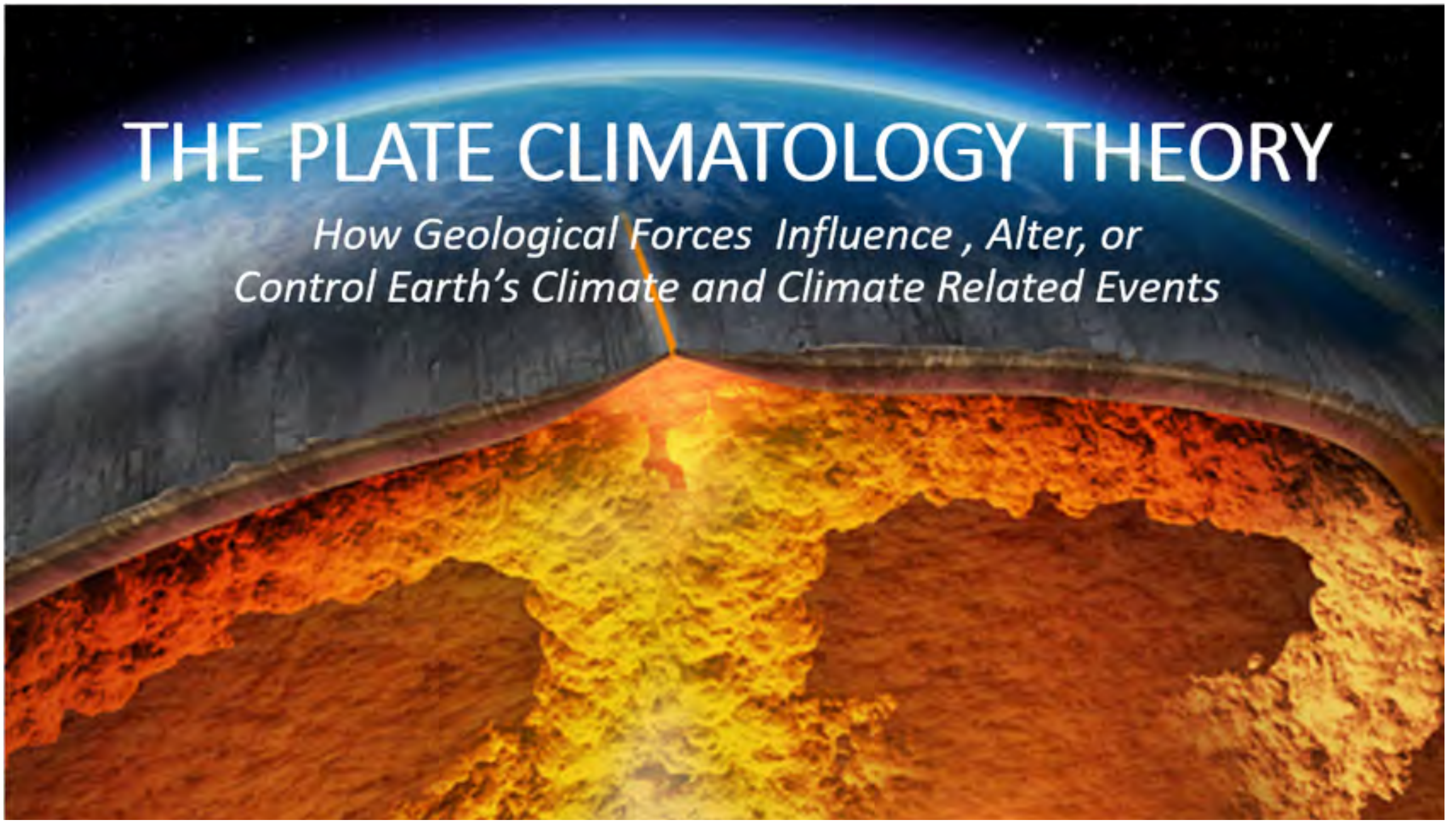

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ACKNOWLEDGEMENTS

Theory technical consultation provided by; meteorologist and computer programmer Paul E. Kamis, geophysicist James Ligon, geologist Steven Parks, and geologist David Entzminger. Thanks to Steve Parks and James Ligon for final editing and years of lively discussion concerning many aspects of the theory. Thanks to Laura Wilson for building and maintenance of the theory website. Thanks to Thomas Richard of the Climate Change Dispatch Website and John O'Sullivan of the Principia Scientific website for posting my many Plate Climatology articles. Special thanks to my wife Nadine Ellen Schoenbeck Kamis for moral support and encouragement during the lengthy process of developing this theory.

ABSTRACT

Increased tectonic and volcanic activity, either locally or globally, equates to more geologically induced heat transfer and chemically charged temperature altered fluid (HCF) release from active geological features into oceans, polar areas, and atmosphere. Releases, that have in past and still to this day act to significantly alter or completely control earth's climate and climate related events. To describe this new theory, the term Plate Climatology was designated on 7 October 2014 (Kamis 2014) and presented at the 2016 annual American Metrological Society Conference (Kamis 2016).

The significant climate effect of geological forces has been hidden from scientific investigation and understanding for several reasons. First, most of the HCF is from three extensive, remote, under explored, and under monitored regions. Specifically, the Antarctic, Arctic and deep oceans. These regions represent;

82% of earth's surface, most of earth's outer crustal plate boundaries, and numerous high HCF volcanic complexes. Virtually none of these geological features are monitored for HCF emission (see Appendix 1 at bottom manuscript) Secondly, the modern-day worldwide volume and percent of geologically induced CO2 and methane emissions from terrestrial regions has been greatly underestimated. Third, the limited amount of HCF data from remote geological features has led to the incorrect assumption that these features do not significantly contribute to changes in climate. Lastly, failure to appreciate and then incorporate into current climate theory the significant influence of ancient geologically induced extinctions, ice ages, ocean anoxia, ocean current alterations, and El Nino / La Nina events.

The Plate Climatology Theory was:

- The conception of the Plate Climatology Theory occurred in 1977 following the dive of the Alvin submarine to the ocean depths off the Galapagos Islands (see here and here) and the authors subsequent realization that ocean floor geological forces influenced ocean lifeforms (Chemosynthesis), heat and chemistry far more than current scientific theory postulated.
- Formally introduced on October 7, 2014, after 10 years of research (see the Plate Climatology website Overview Section).
- Presented as a Poster Session and subsequently published as part of the January 2016 American Meteorological Society Annual Meeting .
- Presented to the Denver Explorers Club on September 20, 2018.
- Presented to the Denver Geophysical Society on May 9, 2019

The theory website http://www.plateclimatology.com/ contains; theory developers numerous individual articles detailing specific aspects of the theory, a one hour theory summary video, and a link to a written manuscript detailing all evidence / references / building block principles of the theory.

Importantly, the Plate Climatology Theory was developed by; integration of many scientist's work, interpretation of large amounts of data, and integration of numerous research studies from many scientific disciplines all glued together by the authors own observations and hypotheses. The author does believe that those advocating the Global Warming / Climate Change Theory have gotten, shall we say, a bit ahead of process determining what force or forces influence climate and climate related trends. The Plate Climatology Theory is not intended to be a statement of the authors or others political views, nor is it meant to demean persons, universities or other entities advocating different climate theories. Instead, it is considered to be a plausible alternative explanation of many climate and climate related phenomenon.

DISCUSSION

The Plate Climatology Theory provides a powerful platform to evaluate, verify, and integrate; previous geological postulations, relevant information, and the author's observations. This process has allowed the author to achieve a more accurate realization of the significant climate impact of geological forces. In a very broad sense the main premise of the Plate Climatology Theory, that geological forces significantly influence climate, is substantiated by appreciating:

- The immense power of earth's largest geological features, upper mantle convection systems. Systems that have the energy to move entire continents 2.5 centimeters per year by emitting massive amounts of lava and associated chemicals, minerals, gases, water, and heat into earth's outer crust, oceans, and atmosphere. Knowing this it is reasonable to theorize that upper mantle convection cells have the power to significantly effect earth's climate and climate related events.

- The numerous examples of locally juxtaposed; melting to non-melting glacial ice areas, melting to non-melting ice sheets, warm to cool ocean areas, and warm to cool atmospheric areas. The boundaries between these local areas are distinct, well defined, and often of significant magnitude. It is difficult to reconcile all of these boundaries with forces associated with non-local, uniform, and worldwide atmospheric global warming. A better explanation is that many, but not all, are the result of HCF from geographically distinct geological features located in the boundary areas.
- The consistent failure of atmospheric based computer climate models to accurately predict future changes in climate trends or to reliably define the root cause of climate current trends. Failure of these climate models is likely the result of not properly including the effect of geologically induced HCF.
- That ancient extinction events, ocean anoxic events, beginnings of glacial periods, and endings of glacial periods are proven or very likely to be the result of geological forces.

The basic principles of the Plate Climatology Theory were conceived in the late nineteen seventies by considering the importance and interrelationship of two significant advances in science. First, the discovery of an entirely new environmental system located on our ocean seafloors termed the Chemosynthetic System. An environmental system that is fueled by massive geologically induced HCF emissions and unrelated light from the sun. Secondly, verification of Alfred Wegener's Continental Drift Theory which stated that inner earth geological forces had the power to move entire continents. It occurred to the author that if geological forces had the power to move continents and support a huge environmental system, they certainly had the power to influence earth's oceans, atmosphere, and climate.

The significant climate effect of geological forces has remained hidden and underappreciated by scientific investigators because their heat and fluid release are primarily found in under explored, remote, or under monitored regions:

- **Polar Ice Caps** are covered by an average ice thickness of 1,524 meters (5,000 feet), account for 11% of earth's surface, and are home to major geological features such as: divergent plate boundaries, transform plate boundaries, and high heat flow volcanic regions.
- **Oceans** which account for 71% of earth's surface, have an average depth of 4,267 meters (14,000 feet), and contain most of earth's major geological features such as divergent plate boundaries, transform plate boundaries, convergent plate boundaries, and high heat flow volcanic regions.
- **Terrestrial Volcanic Regions** are poorly understood because very few of their estimated 1,500 volcanoes are monitored for emissions of CO2, methane, sulfur, hydrogen, mercury, chloride, particulate matter, and heat. New research has shown that non-erupting volcanoes and associated volcanic features can contribute significantly to the CO2 and methane content of our atmosphere (Ilyinskaya 2018).

The power and climate influence of geological forces has also remained hidden due to misinterpretation of climate trends and climate related events. Scientists have for many years force fit many climate trends and climate related events into an atmospheric context insisting that the root cause of these phenomenon is related to atmospheric forces. This process does not follow proper scientific methodology, because it ignores the important climate influence of many other natural forces most importantly geological forces. Geological forces are the root cause of many climate trends and climate related events. In many cases accompanying side effect changes to atmospheric and ocean have been misinterpreted as root causes. They are not.

This atmospheric force fitting methodology is here termed "Atmospheric Bias".

One example of Atmospheric Bias is the designation of **So-Called Ice Ages.** During the last 450,000 years all so-called Ice ages have ended nearly instantaneously as evidenced by the very rapid melting and retreat of; glacial ice, continental ice sheets and sea ice. It is here contended that the end of so-called Ice Ages, specifically the end of Glacial Periods, is the result of massive pulses of heat and super-heated chemically charged seawater emitted from major ocean faults termed Spreading Centers / Divergent Plate Boundaries. Stated in another way, there no such things as "Ice Ages', "Glacial Periods", or "Interglacial Glacial Periods", a

Even after years of research the rate, magnitude, volume, and chemical composition of emissions from geological features are still poorly understood. These emissions include heat transfer, liquid fluid flow (primarily heated seawater, cooled seawater, CO_2, methane, sulphur, iron, phosphorous, and ~~m~~ercury), and gaseous fluid flow (primarily heated air, CO_2, and methane). To describe these geologically induced emissions the term "heat flow and chemically charged temperature altered fluid flow" (HCF) is referred to throughout this paper.

The idea that geological forces influence earth's modern and ancient climate has been postulated by numerous scientists for many years. The author has attempted to properly credit all these scientists and their ideas in the text or reference sections of this paper.

The Plate Climatology Theory is not intended to be a replacement of all aspects of current climate theory, rather a plausible alternative explanation of selective; climate events and trends, climate related events and trends, and individual aspects of current climate theory.

EVIDENCE

Polar Ice Caps

The end of Glacial Periods signified by retreat of glacial ice sheets begins suddenly and transpires in a short time frame relative to the gradual beginning and long duration of Glacial Periods represented by ice sheet advances (Steffansen 2008), Blatter 2013, Abe-Ouchi 2013, video simulation Abe-Ouchi 2013, and Van Ommen 2011). The author theorizes that these rapid Glacial Period endings are the result of worldwide pulses of increased volcanism from both ocean floor (Martínez-Botí 2105) and terrestrial volcanic (McConnell 2017) geological features.

Ocean floor geological features act to warm and chemically alter seawater. Seawater warming is the result of geothermic heat transfer and emissions of superheated water from geological features such as; ocean floor hydrothermal vents, seamounts, active faults, volcanic complexes, and spreading centers. Emissions of chemically charged fluid, primarily CO_2 and methane, from these same geological features acts to alter the chemistry of seawater. Alteration of seawater also occurs when geologically warmed oceans decrease their CO_2 concentration.

Chemical alteration of the atmosphere is the result of greenhouse gas releases from the underlying oceans and terrestrial sub-glacial volcanic features. Atmospheric warming is the result of increased CO_2 concentrations, increased methane concentrations, and heat transfer from warmed oceans.

Glacial Periods are known to begin suddenly but last for long periods of time relative to Glacial Period endings. (Abe-Ouchi 2013, Steffansen 2008). The author theorizes that the sudden cessation of a worldwide HCF pulse marks the end of Polar Ice Sheet retreats and the beginning of a so-called Glacial Period. Advance and resulting increased geographical extent of Polar Ice Sheets is not the result of anomalous forces, rather a recovery to the normal geographical extent of earth's ice sheets. As a result, the term Glacial Period does not accurately describe what is actually a very long and natural recovery process. The term Glacial Period should be replaced with the term Glacial Recovery Period.

Evidence supporting this new explanation for Glacial Period processes comes from several sources. First, the close time correlation of beginnings and endings of significant worldwide volcanic pulses with the beginnings and endings of Glacial Periods (Jagoutz 2016 and Muschitiello 2017). Secondly, geological history provides numerous analog recovery processes following significant HCF pulses for example large extinction (Jerram 2016) and ocean anoxic events (Jenkyns 2010). These HCF induced events typically occur suddenly and within a relatively short time period. In contrast, the recovery process typically takes significantly more time. Another analog is the alteration of coral reefs by El Nino ocean temperature increases and chemical alterations. El Nino a natural rapidly occurring ocean HCF event. Reef recovery is complex and longer term.

Failure of many computer models to accurately simulate or explain the beginnings and endings of glacial periods is because these models utilize input data that are side effect data of the worldwide HCF pulses. These side effect data include but are not limited to changes in wind, atmosphere temperatures, ocean currents, ocean temperatures, sedimentation sequences, etc. Researchers have in past written many papers attempting to explain the root cause of Glacial and Inter-Glacial Periods. These explanations are often complex, tedious, and unconvincing likely because they invoke data from side effects HCF pulses.

The sudden onset of rapid retreat and melting of selected portions of our polar ice caps mimics past HCF induced endings of Glacial Periods as described above. This is strong evidence supporting the idea that HCF and not anthropogenic warming is the primary cause of changes to earth's polar ice caps.

Antarctica

Portions of Antarctica's glacial ice sheet, sea ice, surrounding ocean waters, and biological regimes are currently undergoing significant change. Those advocating the theory of Global Warming / Climate Change have championed these changes as proof positive that human CO_2 emissions are at work in Antarctica. Implicit in their argument is that the underlying bedrock geology of Antarctic is of little or no consequence and merely acting as a passive support system for seawater and glacial ice. However, numerous research studies, especially those released within the last ten years, demonstrate that many of Antarctica's bedrock geological features are not passive, instead extremely active. Furthermore, the research proves that these active geological features are emitting massive amounts of HCF into Antarctic oceans and bedrock ice interfaces, thereby acting to change Antarctica's glacial ice sheet, sea ice, surrounding ocean waters, and biological regimes. A more detailed discussion of evidence supporting this contention is as follows.

The Antarctic ~~C~~ontinent which is greater in areal extent than the lower 48 US states, is formally divided into two land mass segments; West Antarctica 20% (note that the designation "West Antarctica" includes the West Antarctic Peninsula) and East Antarctica 80%. Recent NASA research, as per the Figure 1 graph, demonstrates that 100% of the Antarctica ~~C~~ontinent's ice sheet loss, here expressed as global sea level rise per year, can be attributed to the much smaller West Antarctica region. The graph also shows that East Antarctica is gaining rather than losing ice.

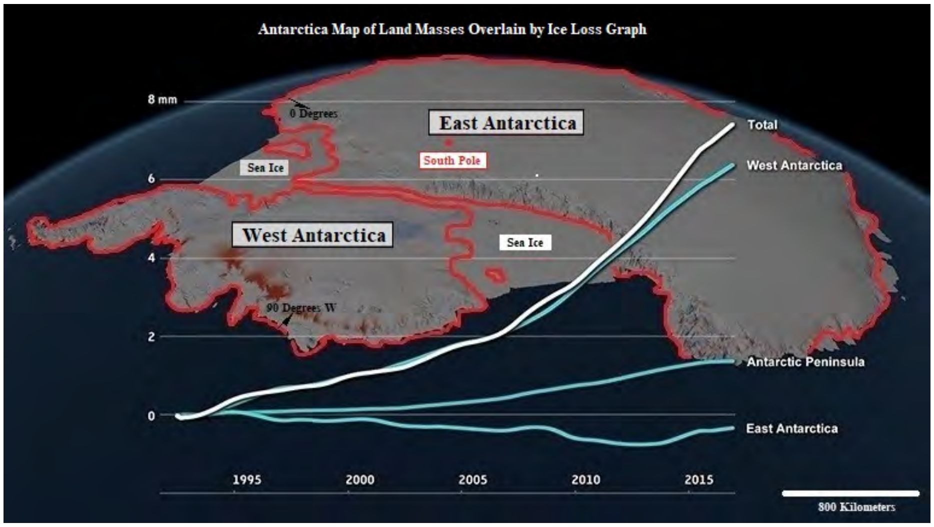

Figure 1.) Map shows red outlined West and East Antarctic land masses. Overlying graph illustrates Antarctic Ice Sheet contribution to global sea level rise by geographic region which is a proxy for ice loss (Ivins, E., 2018).

Other NASA research shows that the ice sheet gains in East Antarctica outpace ice sheet loses in West Antarctica and as a result the Antarctic ~~C~~ontinent is gaining, not losing ice (Zwally 2015). So what force or forces can explain ice gain across 80% of the Antarctic continent while at the same time the immediately adjacent 20% is losing ice?

The answer becomes evident by reviewing Figure 2 which is the University of Washington's Antarctic Fifty-Year Average Surface Temperature Map (Steig 2009, and Nicolas 2014). This map demonstrates that there are two distinct and very different near surface temperature areas. One area of anomalously high near surface temperatures associated with West Antarctica and another area of low near surface temperatures associated with East Antarctica.

The author theorizes that the high surface temperatures in West Antarctica are the result of HCF emissions from numerous geological features associated with Antarctica's largest and most active geological feature, the West Antarctic Rift System. Absence of widespread or significant HCF in the East Antarctic area accounts for near average near surface temperatures in this portion of Antarctica.

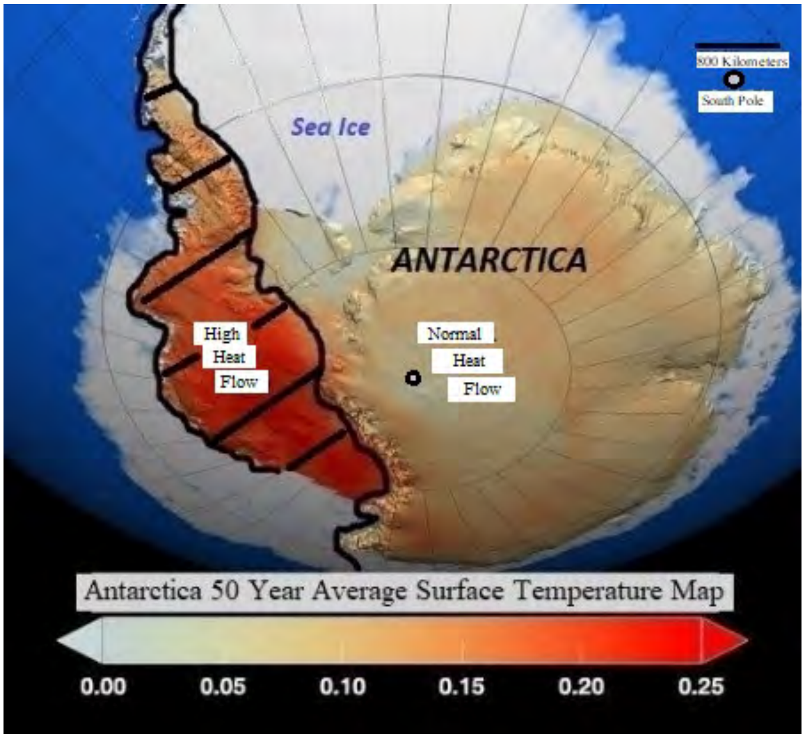

Figure 2.) Antarctic fifty-year average Surface Temperature Map. Areas of normal and high surface temperatures interpreted by author as high and low heat flow areas (research credit Steig, E., 2009, heat flow region outlines credit Kamis, J. E., 2016).

The validity of Dr. Steig's Figure 2 map was hotly debated for many years, however it has since been proven correct by two more modern research studies, NASA's Skin Temperature Map (NASA, 2006) and the British Antarctic Survey's Geothermal Heat Flux Map (Martos, Y., et. al., 2017). Dr. Steig's map was considered controversial because it did not demonstrate, as per Global Warming principles, an evenly distributed continent-wide near ground surface warming pattern. An even widespread pattern could have been interpreted as evidence uniform manmade atmospheric global warming was at work in Antarctica by melting the top surface of the ice sheet. Scientists now widely accept that loss of Antarctic Ice Sheet mass and extent is the result of basal, not top melting which can be interpreted as the result of bedrock HCF (Kamis 2018, NASA 2017, and Jordan 2018).

Other continent-wide information indicating that many modern-day changes in Antarctica are related to geologically induced HCF and not manmade atmospheric global warming are:

- The Overall East Antarctica ice gains have outpaced West Antarctica ice losses, as a result the Antarctic continent has been gaining, not losing ice mass continuously for many years (Zwally, J., 2015).
- The atmosphere above the Antarctic ~~C~~continent has been cooling, not warming for many years Sejas, S. A., 2018, Abrams, N. 2014, Turner, J., et. al., 2016, Hinkel, L., 2016).
- The ~~oc~~ean waters immediately adjacent to West Antarctica are dramatically warming while ocean waters adjacent to East Antarctica are only mildly warming or not warming at all. (NASA, April 2006).
- The existence of an extensive subglacial interconnected system of liquid freshwater lakes and streams, most significantly above sea level. (Wright, A., et. al., 2012, Fricker 2007, Siegert 2016, Goller 2014).
- The base and not the top of the West Antarctic Ice Sheet is melting (Seroussi, H., et. al., 2017)

Next, we discuss specific examples of how active geological features effect Antarctica.

West Antarctic Rift System

The West Antarctic Rift System (WARS) is a 6,437-kilometer-long (4,000 miles) and 1,127-kilometer-wide (700 mile) geological feature that has a long and complicated history of plate boundary subduction, transform movement, and rifting (Figure 3). The intent of this article segment is not to describe the geological history or complexities of this huge rift system, rather to describe the significant effect of its present day and ancient HCF. The WARS is home by latest count to; approximately 138 (De Vries 2018) land volcanoes, a 1,605,793 square kilometer (620,000 square mile) mantle plume, thousands of deep inner earth reaching faults, numerous seamounts, and a countless number of hydrothermal vents. Recent research studies by NASA (NASA 2017), the University of Texas (Schroeder 2014), and many other organizations confirm that large amounts of HCF is currently being emitted from the rift's thousands of active geological features into Antarctica's oceans and atmosphere. These emissions and other geological evidence support the idea that the WARS is a very geologically active part of the Pacific Ring of Fire (Kamis, 2018). Other data supports the idea that the WARS is an active part of the Pacific Ring of Fire:

- Contains a large number of active volcanoes, on a per square kilometer basis the same distribution as the Pacific Ring of Fire, one every 24,000 square kilometers (9,267 square mile) (J. E. Kamis calculation).
- Is home to a large number of active faults, here estimated to be a similar per square kilometer density as the Pacific Ring of Fire.
- Connects in a geologically seamless fashion onto the two currently defined horseshoe ends of the Pacific Ring of Fire located in South America and New Zealand (Kamis 2018, Gurion 2018).
- Has become increasingly active in coincidence with increasing tectonism along the Pacific Ring of Fire, therefore indicating a geological processes connection to the Ring of Fire (Kamis 2018).

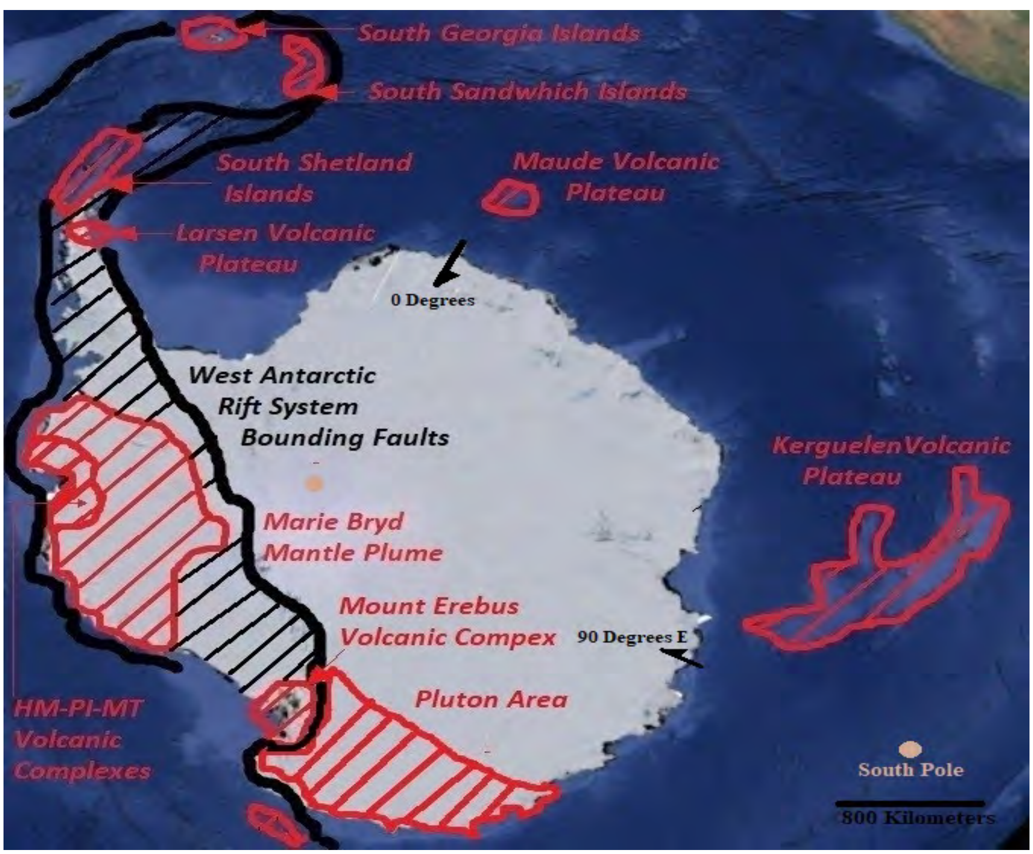

Figure 3.) Location of Antarctica's high heat flow and chemically charged high fluid flow major geological features. High bedrock heat flow cross-hatched black and very high bedrock heat flow areas cross-hatched red (credit Google Earth and J. E. Kamis).

South Georgia and South Sandwich Islands

The South Georgia and South Sandwich volcanic island chains and associated volcanic plateaus were generated by subduction of the South American Plate beneath the Antarctic Plate (Figures 3 & 4, Barker 1981). These island chains are a geologically active 1,600-kilometer (994 mile) extension of the West Antarctic Rift System originating at a location where the rift's major fault traces conjoin to the northern extension of the West Antarctic Peninsula. The island chain's subduction zone fault system continues westward and northward eventually seamlessly connecting to South America's west side subduction zone. These island chains are currently very geologically active as exemplified by recent multiple earthquakes and volcanic eruptions. On December 10, 2018 there was a 7.3 magnitude earthquake located in proximity to Montagu island of the South Sandwich Island chain. On September 29, 2016 the simultaneous eruption of three South Georgia Island volcanoes was captured by NASA satellites. On May 1, 2016 the South Sandwich Island's Mount Curry eruption spewed ash into the region's atmosphere, ocean waters, and onto ice surfaces. This ash adversely affected the South Sandwich Islands one million resident penguins.

These eruptions and the powerful earthquake can be interpreted as evidence that hundreds of other geological features located along this 1,600-kilometer-long (994 mile) extension of the West Antarctic Rift System may also be actively emitting HCF into adjacent ocean waters, land surfaces, and atmosphere.

Recent research in the South Georgia and South Sandwich Islands area discovered the presence of mercury and methyl mercury in the region's sea ice and ocean waters (Rodgers 2012 and Gionfriddo 2016). These author's theorized that this mercury and methyl-mercury was human sourced. However, mercury is a common component of terrestrial volcanic ash. Additionally, mercury and methyl mercury are common components of seamount and hydrothermal vent emissions. These types of geological features are abundantly present and very actively emitting large volumes of HCF enriched in iron, mercury, and methyl mercury into in the South Georgia / South Georgia area (Klar 2017). Geologically induced emissions are the likely source of the area's mercury and methyl mercury thereby strengthening the notion that geological forces have a wide-ranging and likely dominant effect on this region's climate and climate related events.

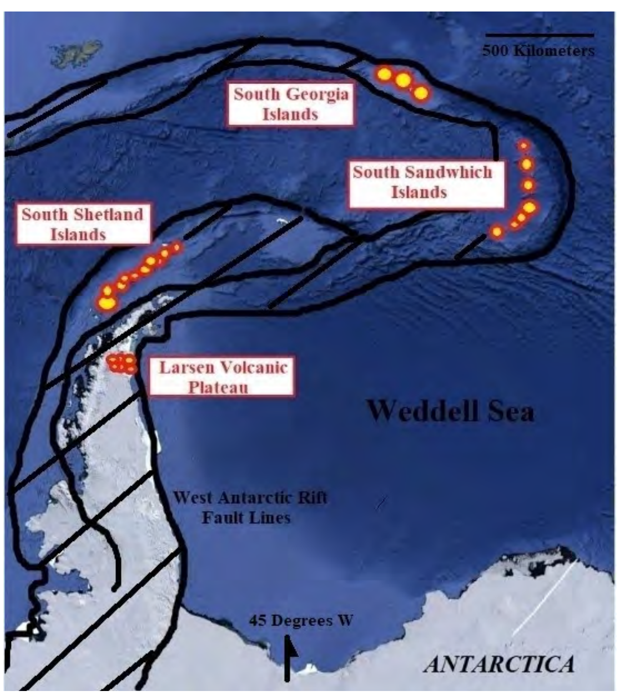

Figure 4.) Detailed location map of the northern extension of the West Antarctic Rift System. Rift faults as black lines, active volcanoes as larger yellow filled red circles, and semi-active volcanos as smaller yellow filled red circles. (map credit Google Earth, labels and faults credit J. E. Kamis)

South Shetland Islands

The 725-kilometer-long (450 mile) and 80-kilometer-wide (50 mile) South Shetland volcanic island chain is an active part of the West Antarctic Rift System. It is home to ten dormant and one currently active volcano, all fueled by West Antarctic Rift System faults (Figure 4). This volcanic chain, and areas immediately adjacent to it, have in past and still to this day emit high amounts of HCF into the overlying ocean thereby acting to warm these ocean water areas. Examples are as follows:

The Deception Island Collapse Caldera which has in past and is still today a very active geological feature. Caldera bay floor hydrothermal vents are currently emitting large amounts of HCF into the caldera's 4 kilometer wide (2.5 mile) circular ocean bay. Emission of these hot fluids into the bay acts to keep much of the bay ice-free and in selected areas elevate the bay water to sauna like temperatures. The Deception Island volcano has erupted ten times from 1827 to 1995. Just released research shows that this caldera violently erupted 3,980 years ago likely acting to change earth's climate for up to twelve months (Antoniades 2018). The current magnitude and geographical extent of ocean warming and chemical charging by the Deception Island Caldera and its associated geological features is unknown, because like most of Antarctica's geological features it is not emission monitored. However, they are likely significant.

Parallel to, and just east of the South Shetland Island chain is the 450-kilometer-long (280 mile) and 50 kilometer-wide (31 mile) Bransfield Strait. Numerous research studies have concluded that this highly complex geological feature is currently very active (Barker 1994 and Klinkhammer 2001). The Klinkhammer research states that… "*data on the high heat flow, active volcanism, and extensional folding, in combination with modeling of the gravity and magnetic anomalies and earthquake focal mechanisms, indicate that the Bransfield strait floor represents a zone of lithosphere extension forming in the Antarctic Peninsula. The most important structural element of the strait floor is the neo-volcanic zone near the South Shetland Islands and the diapirism zone near the Antarctic Peninsula.*".

Larsen Volcanic Plateau

The Larsen Volcanic Plateau is an 81-kilometer-long (50 mile) and 16-kilometer-wide (10 mile) part of the WARS (Figure 3). This plateau and the surrounding sea ice fields have been the focus of many research studies and media articles that conclude that the areas sea ice breakup and melting is the result of manmade atmospheric global warming. An alternative explanation is related to geologically induced HCF from Larsen Volcanic Plateau geological features.

The plateau is home to 16 semi-active / dormant volcanoes and one actively fluid emitting seamount. ~~The~~ volcanoes form prominent circular topographic highs in the ice sheet. Many are void of snow and ice which is a direct indication of ice melting geothermal heat flow.

The breakup of the sea ice adjacent to the Plateau occurs progressively through time farther and farther away from the plateau. This is interpreted to be the result of progressive lateral geologically induced warming of ocean waters in the plateau region. Importantly, other distant areas of Weddell Sea Ice are not melting, just the sea ice adjacent to the Larsen Volcanic Plateau. This indicates that the powerful ice melting heat source is local and not widespread.

Information obtained from the Smithsonian Global Volcanism Program Stated the following;
"In January 1982, geologists from the Universidad de Chile found evidence of recent volcanism at two sites in the Seal Nunataks Group that had not previously been identified as recent volcanic centers. At Dallman (65.02°S, 60.32°W), very fresh-looking basaltic lava had emerged from the central crater and flowed to the NW foot of the volcano. Active fumaroles were observed at the N side of the summit. Abundant basaltic lapilli and ash covered wide areas of the Larsen Ice Shelf in the vicinity of Murdoch Volcano (65.03°S, 60.03°W). Portions of these deposits were covered by fresh snow. Fumaroles were active in a small parasitic cinder cone SE of Murdoch in December 1893, C.A. Larsen saw an eruption of black ash from Lindenberg (64.92°S, 59.70°W) and solfataric activity at Christensen (65.10°S, 59.57°W), but no activity was observed at either of these volcanoes in 1982."

Earliest explorers of Antarctica mentioned in their journals the presence of fresh volcanic ash on glacial ice in the Larsen Volcanic Plateau area. One other recent visit by researchers to the ocean seafloor of the Larsen Volcanic Plateau discovered an actively heat emitting seamount (Dormack 2004). Research by a multi-national team concluded that very rapid uplift in the Larsen Volcanic Complex area in 2002 is difficult to associate with overlying ice sheet melting and subsequent glacial rebound (Nield 2014). Although not proven, the bedrock uplift event is more likely related to upward movement of deep earth magma as is currently occurring at the Marie Byrd Mantle Plume region along the WARS.

Evidence indicates that the Larsen Volcanic Plateau is a geologically active area which is emitting significant amounts of HCF.

Hudson Mountain Volcanic Complex, Pine Island Glacial Valley , and Mount Takahe Volcanic Complex
Melting, fracturing, and breakup of glaciers in this area had for many years been attributed to the effects of anthropogenic warming as per the Climate Change Theory. However, more recent research (Loose 2018, McConnell 2017, Schroeder 2014) combined with the authors observations indicate that modern day and ancient changes of these glaciers are the result of HCF from the areas active geological features, and not anthropogenic atmospheric warming.

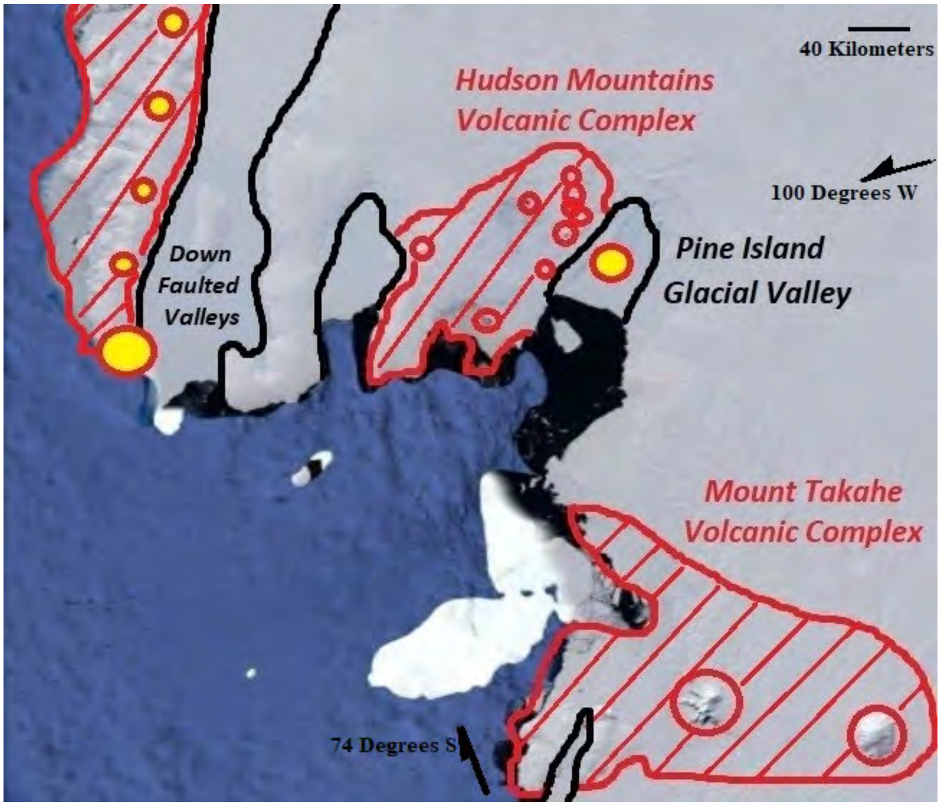

Figure 5.) Very High heat flow Hudson Mountains and Mount Takahe Volcanic Complexes (red cross-hatched). Down faulted valleys (black outline). Active subglacial volcanoes (red outline with yellow fill) and active surface volcanoes (red circle). (credit Google Earth and J. E. Kamis)

Location of the Hudson Mountain Volcanic Complex, the Mount Takahe **V**olcanic complex, and the Pine Island Glacial Valley are illustrated on Figure 5. These geological features were created and are fueled by forces associated with the western bounding regions of the WARS (Kamis 2017 and Kamis 2017). This area's present-day high HCF has been confirmed by numerous research studies (Dziadek 2018, Steig 2009, Lough 2013, Iverson 2017).

The long linear shape and orientation of the Pine Island Glacial Valley is here thought to be the result of down faulting and graben generation associated with WARS. In June of 2018 a multi-national team of researchers made a stunning discovery. They confirmed the presence of a currently erupting volcano beneath the Pine Island Glacier (Loose 2018) thereby strongly indicating that eruptive heat flow is melting this valley's glaciers, not Climate Change. Other recent research shows that there are also active volcanoes beneath the adjacent Thwaites Glacier (see Figure 6 and Kamis 2019). Concerning the Hudson Mountain Volcanic Area, research by the British Antarctic Survey proved that 2,200 years ago a massive sub-glacial volcanic eruption covered this ancient glacial ice area with a thick layer of volcanic ash. Post eruption glacial ice accumulations buried the ash layer (Corr 2008). Based on the extent and thickness of the ash layer researchers described this event as one of the largest Antarctic eruptions in 10,000 years. Research by Nevada's DR Institute showed that 17,700 years ago Mount Takahe erupted on multiple occasions during a 192-year span (McConnell 2017). This world class eruptive phase acted to alter ocean currents, ice extent, and climate of the entire southern hemisphere in an area extending from the South Pole to the sub-tropics.

Marie Byrd Mantle Plume Area

A recent NASA study confirmed what geologists have suspected for many years, that a very large and active mantle plume hotspot is present beneath the glacial ice of West Antarctica (Figure 2 and NASA 2017). Termed the Marie Byrd Mantle Plume, a subglacial hotspot which fuels and is home to approximately 100 active, erupting, or dormant volcanoes (De Vries 2018). Several of these volcanoes are currently erupting beneath the glacial ice (Lough 2013, Schroeder 2014, and Loose 2018). A very recent research study showed that the bedrock surface expression of the mantle plume is uplifting at a very rapid rate (Barletta 2017). An uplift rate which is greater than can be accounted for by glacial isostatic rebound and is therefore almost certainly related to upward movement of the underlying mantle plume magma chambers.

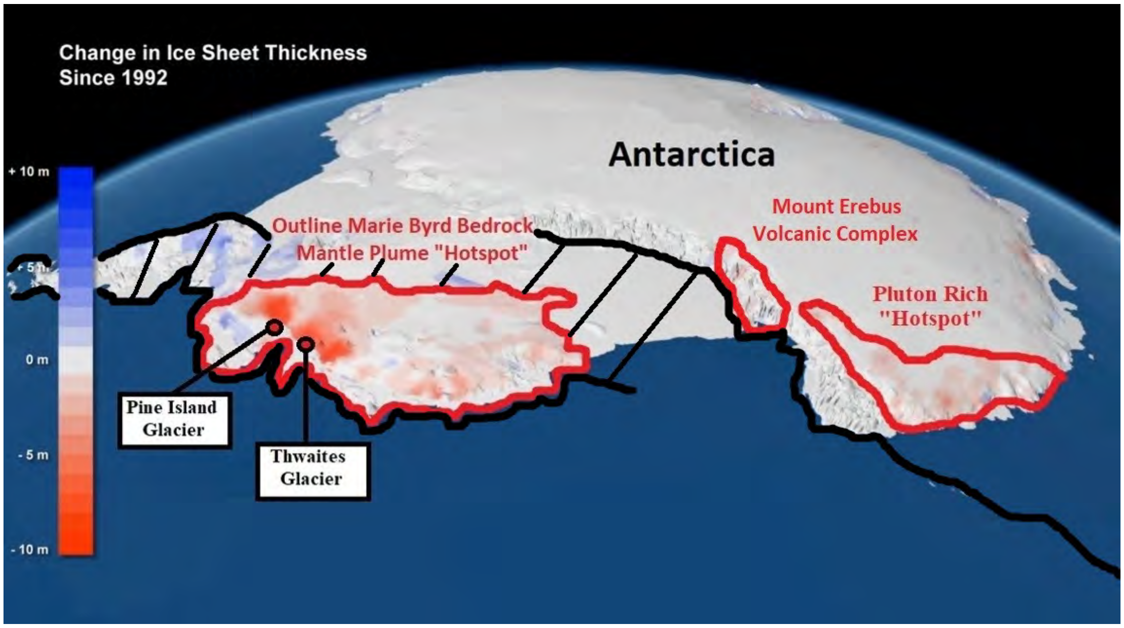

Figure 6.) Marie Byrd Mantle Plume, Mount Erebus, and Pluton areas (red hatched) in relationship to ice sheet melting (red shading). Black cross-hatched is West Antarctic Rift System west and east branches (credit NASA and J. E. Kamis).

Figure 6 illustrates West Antarctic Ice Sheet melting from 1992 to present displayed as varying red shades. Superimposed on this map are the red hatched outlines of the; 1,605,793 square kilometers (620,000 square mile) of the Marie Byrd Bedrock Mantle Plume "Hotspot" (Kamis 2018), Mount Erebus Area (Kamis 2016), 110,000 square kilometer (4,2471 square mile) Pluton Area (Allibone 2010), and the major bounding faults of the WARS (Kamis 2016). The outline of these three subglacial geological features closely matches the outline of the most prominent ice sheet melt regions. This correlation is strong evidence that HCF from these subglacial geological features is the dominant force acting to melt the overlying ice sheet.

HCF induced basal melting of the West Antarctica ice sheet in the Marie Byrd Mantle Plume area acts generate a significant amount of warm liquid water. This basal meltwater outflows downhill into adjacent ocean regions where it then acts to significantly warm the outflow seawater area as illustrated on NASA's Antarctica Skin Temperature Map (NASA 2016). The NASA map also illustrates two other very telling aspects of the ocean waters surrounding the Antarctic Continent. First, the other significantly warmed ocean areas adjacent to West Antarctica are all associated with active geological features. Secondly, East Antarctica which is geologically inactive has only a few adjacent slightly ocean seawater warmed areas. These observations are theorized to demonstrate that warming of ocean waters adjacent to the Antarctic Continent are the result of geologically induced HCF, not manmade atmospheric warming.

Mount Erebus Volcanic Complex / Pluton Rich Area

The Mount Erebus Volcanic Complex is 105,000 square kilometer (40,541 square mile) region that includes three stratovolcanoes, the 5,000 square kilometer (1,931 square mile) McMurdo Dry Valley area, and a portion of an adjacent ocean bay seafloor. All these components lie directly atop and are fueled by an active segment of the WARS (Figure 7).

Mount Erebus has been volcanically active for thousands of years. Records taken from several sources show that eruptions occurred in; 8050 BC, 7050 BC, 4050 BC, 4550 BC, 2950 BC, 2050 BC, 841,1900, 1903,1908, 1911, 1912, 1915,1915,1947, 1955, 1957,1963,1984, 1993, 1995, 1997,1998, 2000, 2001, 2005, 2014, and 2015 (Volcano Discovery and Smithsonain Institution). At present the Mount Erebus summit crater is actively pulsing molten lava and gases. numerous vents located along the flanks of the volcanic cone are also currently emitting heated gases. Research by New Mexico Tech shows that as of 2008 the main magma chamber, which was estimated to be one half mile wide, had recently moved upward to a position 1,219 meters (4,000 feet) below the 3,794-meter-high (12,448 feet) summit (Zandomeneghi 2013). The researchers acoustic imaging of the volcano's internal structure revealed that it is a complex network of deep faults. These faults likely connect to and are part of the WARS.

The noticeable absence of ice and snow in large portions of the McMurdo Dry Valley (MDV) area (Figure 7) is attributed by the author to HCF. The authors geological evaluation of MDV topography showed that the numerous long strongly linear valley trends and cross-cutting long strongly linear valley trends are the result of faulting and cross-faulting related to stresses associated with lateral movement of the WARS. Very high HCF in areas immediately adjacent to the MDV, most notably the Mount Erebus Volcanic Complex, are thought to be connected to and fueling the HCF which is melting the MDV snow and ice.

Recent research confirms that the Blood Falls feature in the MDV area is associated with distinct long linear bedrock trends (Badgeley 2017). These trends are interpreted to be faults associated with the WARS. These local Blood Falls faults are likely acting as conduits that tap into WARS heat flow and iron enriched heated fluid flow.

Figure 7 also illustrates numerous pieces of glacial ice floating in the bay area located between the Mount Erebus High Bedrock Heat Flow Area and the likely high heat flow Pluton Area. This includes floating ice from the Nansen Glacier. This specific glacier has been the focus of numerous research and media articles stating that breakup of this glacier is the result of anthropogenic warming. However, given that; high HCF from the Mount Erebus Volcanic Complex and the Pluton Area are present in the immediate bay area, the Nansen Glacier lies directly atop a major WARS fault segment, and that the Nansen Glacier Valley is a long linear feature it is far more likely that Nansen Glacier ice breakup is related to HCF from this entire region.

Figure 7.) Mount Erebus high bedrock heat flow area located along a very active segment of the West Antarctic Rift System. Note McMurdo Dry Valley Area (MDV) and volcanoes (red circles) (credit google Earth and J. Kamis).

Kerguelen Volcanic Plateau

Figure 3 illustrates the location of East Antarctica's offshore Kerguelen Volcanic Plateau. It is one of the largest igneous provinces in the world covering 1,243,190 square kilometers (480,000 square miles) and rising 2,011 meters (6.600 feet) above the surrounding ocean basins. This plateau has a long and complicated geological history involving multiple movements of major plate boundaries resulting in development of numerous major faults, terrestrial volcanoes, seamounts, hydrothermal vents, and multiple lava flow layers. Recent research has shown that numerous geological features associated with this this vast ocean floor volcanic plateau are actively emitting significant amounts of HCF into surrounding ocean, land and atmosphere.

Australian Antarctic Research Institute studies concluded the following about the effect of geologically induced HCF into the oceans and onto terrestrial regions of the Kerguelen Plateau (Australian Antarctic Division 2016 and Kamis 2016).

- The area is currently geologically active based on observation of a terrestrial volcanic eruption and discovery of numerous very active hydrothermal vents.
- The area's extensive reoccurring plankton blooms are strongly influenced by iron enrichment related to chemically charged heated fluid flow from the area's countless hydrothermal vents and seamounts.
- The alteration of marine animal migration patterns such seals whales, etc. were the result of volcanic activity and associated HCF into the areas ocean waters.

Multiple terrestrial and ocean floor volcanic eruptions since 1992 from the McDonald Islands area portion of the plateau, including the 2016 eruption of the areas Big Ben Volcano, indicate that significant portions of the Kerguelen Plateau are currently geologically active (Smithsonian Institution GVP and Volcano Live,).

April 2016 research by Durham University in the far eastern portion of East Antarctica concluded that very long linear west to east oriented subglacial valleys are likely the result of faulting. These valleys form a subglacial drainage system of numerous interconnecting streams and one large lake all of which flow downhill into the adjacent ocean (Jamieson 2016). The author believes that the existence of a subglacial drainage system in this area is evidence of HCF and that the faults may be a westward extension of the Kerguelen Volcanic Plateau (Kamis 2016).

Weddell Sea

On or about September 9, 2017 a huge sea ice melt hole (polynya) formed in a very thick portion of Antarctica's Weddell Sea Ice (Figure 8). Scientists at the Helmholtz Centre for Ocean Research attributed this melt event to periodic unexplained upward movement of bottom hugging very warm seawater (GEOMAR 2017). Others have speculated that the polynya formation involved lateral movement of deep warm bottom hugging seawater. Once this laterally moving sweater intersected the Maud Rise bathymetric high it was deflected upward and onto the bas of the sea ice thereby melting the overlying sea ice (Swart 2017).
This interpretation has numerous problems as follows:

- The Maud Rise is more correctly termed the Maude Volcanic Plateau, because it is the result lava flow layering (Schandl 1990) and the complex interaction of ocean floor faulting and associated seamounts (J. Kamis observations).
- The other bathymetric highs in this portion of the Weddell Sea are not associated with sea ice melting.
- The sea ice melt hole (polynya) exactly matches the outline of the Maude Volcanic Plateau and does not elongate down current from the bathymetric Maud high (Figure 8).
- The warm sea area is associated with the Maud Volcanic Plateau (Muench 2001).
- Most importantly, the melt hole appeared in 1976 and then did not reappear until 2017(GEOMAR 2017). This is characteristic of the erratic eruptive nature of volcanic heat flow pulses, and not characteristic of moderately rising atmospheric temperatures.

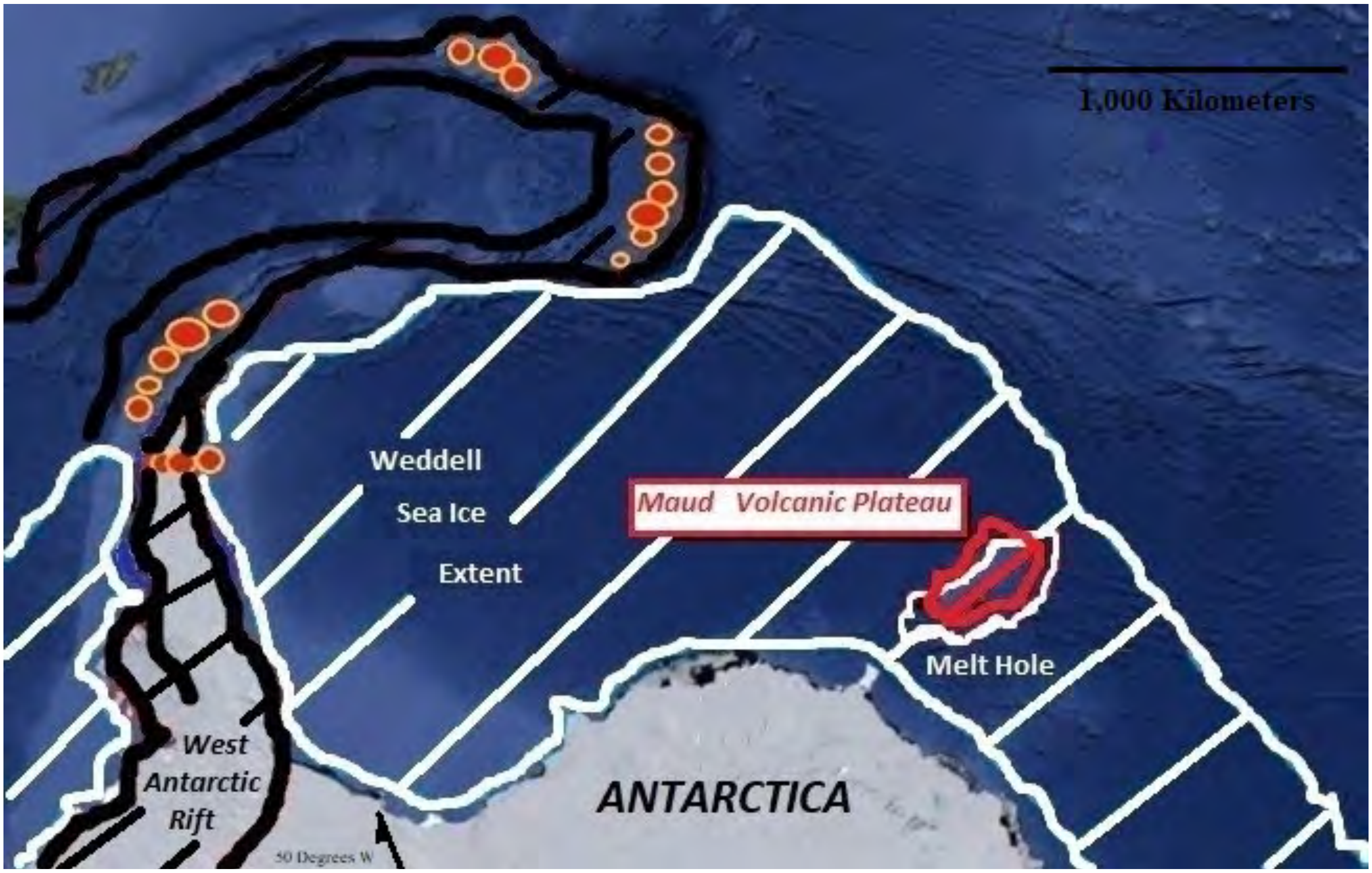

Figure 8.) Bathymetric and geological setting of the Maud Volcanic Plateau Region. Sea ice melt hole outlined in red. (credit Google Earth and J. E. Kamis).

An alternative and data supported explanation of the Weddell Sea polynya associated with the ocean floor Maud Volcanic Plateau is generation by HCF emanating from active geological features present on the plateau surface.

In summary, most of the bedrock geological features of West Antarctica have in past and still to this day actively flow significant amounts of HCF onto the base of the ice sheet and into adjacent oceans. These emissions are the dominant force acting to alter Antarctica's; ice sheet mass and extent, adjacent ocean water temperatures, sea ice composition and extent, plankton bloom vitality, and marine animal migration patterns. In stark contrast, most of East Antarctica's bedrock geological features are currently non-active. In very telling fashion, this portion of the continent is not experiencing the type of significant changes observed in West Antarctica. All this information demonstrates that geological and not manmade atmospheric forces are the dominant cause of observed changes in the Antarctic Continent in accordance with Plate Climatology Theory

Arctic Region

The Arctic region's glacial ice sheets, sea ice, surrounding ocean waters, biological regimes, and lower atmosphere are currently undergoing significant change. Scientists advocating anthropogenic warming have championed these changes as proof positive that anthropogenic warming is the root cause of the changes. Implicit in their argument is the notion that the Arctic's geological features have little or no influence on this region's climate and climate related events presumedly, because they envision these geological features as; inactive, slightly active, active within limited areas, or emitting minimal amounts of heated chemically charged fluid. The author presents data in this section that demonstrates that geological processes are an underappreciated contributor to the modern-day changes seen in the Arctic.

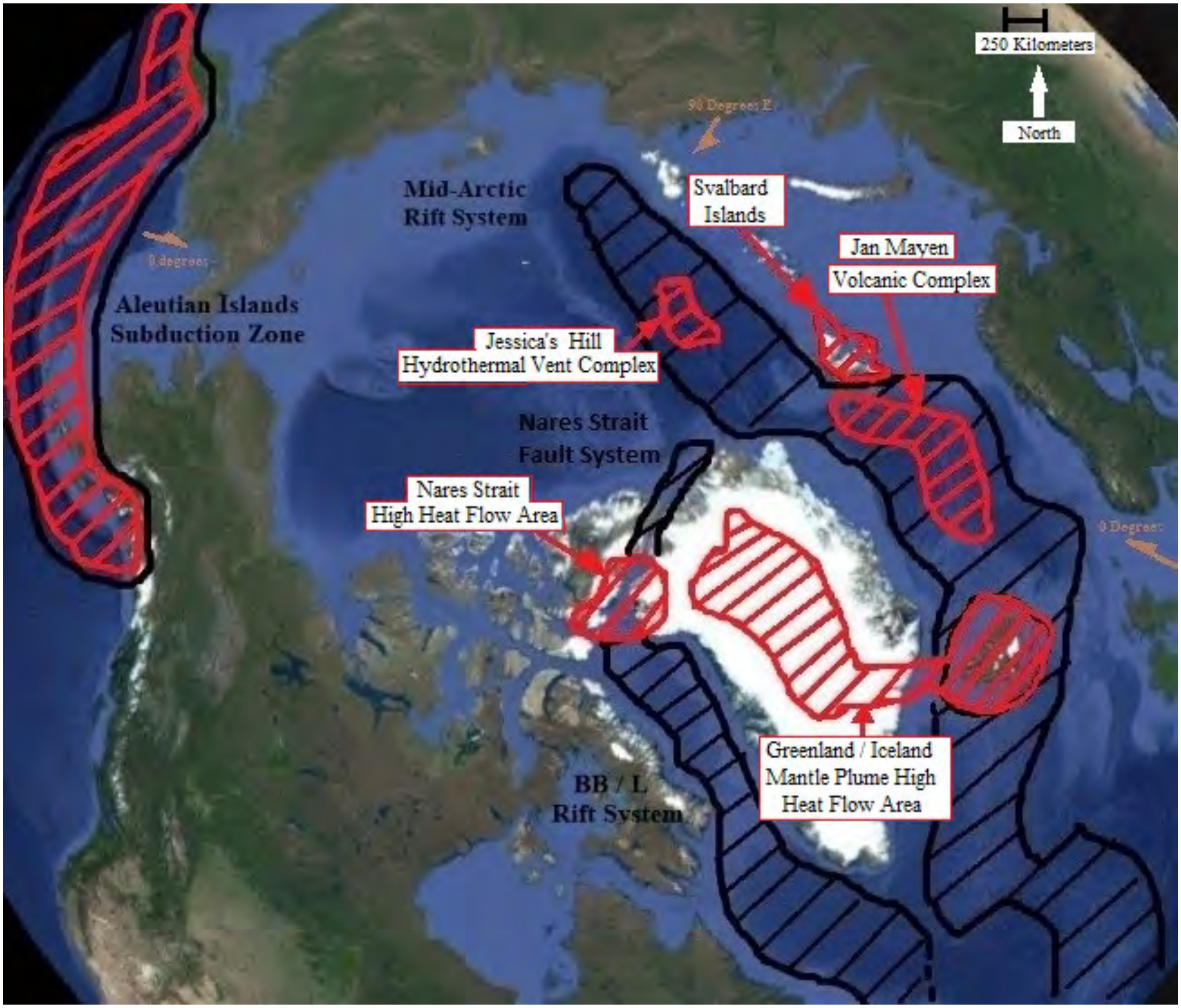

Figure 9. Arctic region active geological features (black cross-hatched) and referenced very high heat flow areas (red cross-hatched) (credit Google Earth and J. E. Kamis).

Significant amounts of data, numerous research studies, and observations by the author indicate that many of the Arctic's geological features are in fact very active and emitting massive amounts of HCF into Arctic region oceans, bedrock, and atmosphere (Carmack 2012). Evidence supporting this idea is abundant, reliable, and convincing.

The major geological features of the Arctic region as shown on Figure 9 are:

- Greenland / Iceland Mantle Plume
- Mid-Arctic Rift System
- Baffin Bay / Labrador Rift System
- Aleutian Island / Kamchatka Convergent Plate Boundary

All these geological features are proven emitters of significant amounts of HCF. Specific examples of emissions from these major geological features and their resulting climate effect are discussed below.

Greenland - Iceland Mantle Plume

Present day accelerated melting of the Greenland ice sheet and associated sea ice is primarily the result of two factors. Geologically induced warming of oceans adjacent Greenland, and most importantly relic heat flow from the Greenland / Iceland mantle Plume.

Figure 10 illustrates ancient position of and present-day relic heat flow the Greenland / Iceland Mantle Plume:

- North-northwest movement of Greenland across the stationary Greenland / Iceland Mantle Plume during the last 100 million years (Martos 2018). The heavy black dashed line illustrates the tract of this movement. Black dots mark the position and date of Greenland relative to the non-moving mantle plume.
- Greenland's current and anomalously high bedrock heat flow. Clearly relic heat from the mantle plume is still greatly affecting and elevating Greenland's current bedrock heat flow. The magnitude and extent of this relic heat flow has been confirmed by three other research studies (Rezvanbehbahani 2017, Rogozhina 2106, Fahnestock 2001). All researchers conclude that this relic heat flow is contributing significantly to basal melting of Greenland's Ice Sheet. It is also possible that outflow from the heated basal meltwaters are acting to warm ocean waters in proximity to the outflow points further exacerbating ice sheet melting.
- Rapid retreat of eastern Greenland's Young's Valley Fiord (Figure 10) is a specific example of how geologically induced bedrock heat flow directly affects the melting and lateral flow rate of individual Greenland glaciers.

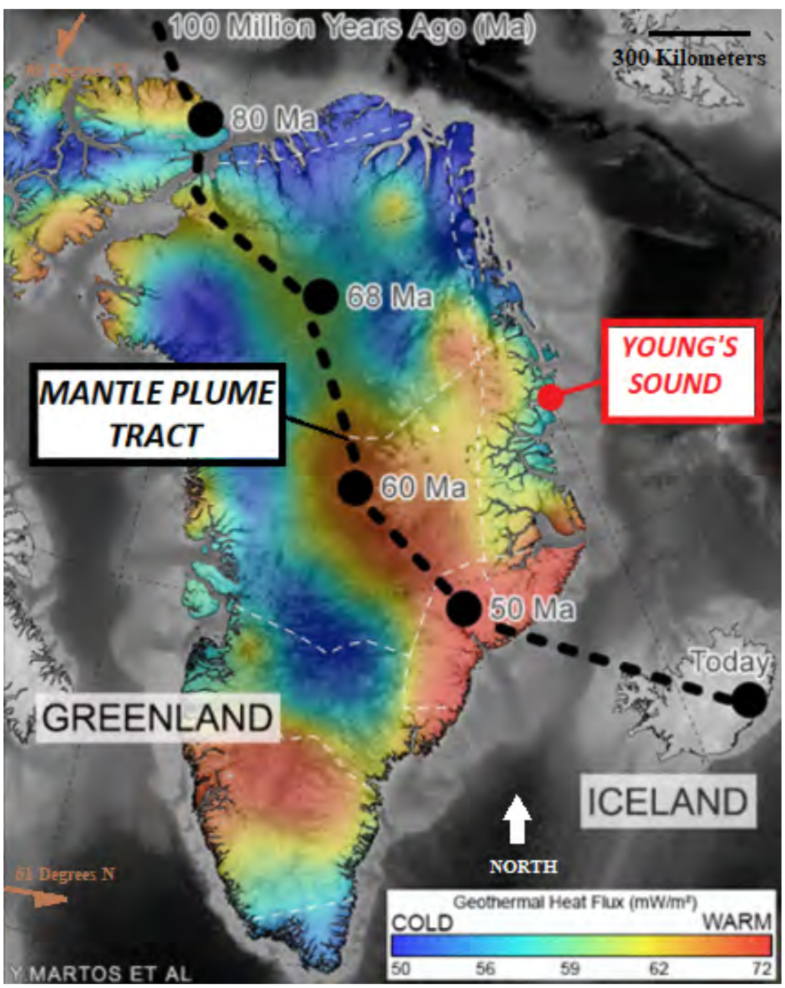

Figure 10.) Ancient tract and present-day heat flow of Greenland / Iceland Mantle Plume (map credit Martos 2018, some of the labels J. E. Kamis).

Researchers from Aarhus University concluded that geothermal heat flow was accelerating the melting and lateral flow rate of the Young's Sound Glacial Valley (Figure 10 and quote below from Rysgaard 2018).

"Currently, there is a large disagreement between observed and simulated ice flow, which may arise from inaccurate parameterization of basal motion, subglacial hydrology or geothermal heat sources. Recently it was suggested that there may be a hidden heat source beneath GIS caused by a higher than expected geothermal heat flux (GHF) from the Earth's interior. Here we present the first direct measurements of GHF from beneath a deep fjord basin in Northeast Greenland. Temperature and salinity time series (2005–2015) in the deep stagnant basin water are used to quantify a GHF of 93 ± 21 mW m^{-2} which confirm previous indirect estimated values below GIS. A compilation of heat flux recordings from Greenland show the existence of geothermal heat sources beneath GIS and could explain high glacial ice speed areas such as the Northeast Greenland ice stream."

The greater Young's Valley Fiord region is home to long linear active hydrothermal vent complexes, ocean floor hot vents, valley trends, and offshore fault trends (Rysgard 2018 and J. E. Kamis observations). The author speculates that the heat source fueling the hydrothermal vent complexes and hot vents is being supplied by the Mid-Arctic Rift System. Heat of the Young's Valley Fiord bedrock is likely from two sources, the Mid-Arctic Rift Fault System and relic heat flow from the Greenland / Iceland Mantle Plume.

Mid-Arctic Rift System

Numerous geological features associated with the Mid-Arctic Rift System have been shown to be emitting significant amounts of HCF into Arctic ocean waters as per the following examples.

The Jan Mayen Volcanic Complex is a 1,500 kilometer (932 mile) long seafloor segment of the Mid-Arctic Rift System (Figure 9). This complex is home to numerous active; hydrothermal vents, seamounts, and faults. It is prone to numerous earthquakes testifying to its active geological nature as per a November 9, 2018 6.8 Richter scale earthquake located in close proximity to Jan Mayen Island. Researchers had this to say about the Jan Mayen geologic feature: *"2,200 F magma pouring into the seas from hundreds of submarine volcanoes – and we wonder why the seas are warming. We have found volcanoes at such a shallow level and they could break the surface at any time and form a new island group. Just for the record, I've been talking about underwater volcanoes for years. In fact, there's an entire chapter in my book "Not by Fire but by Ice" that discusses the importance of underwater volcanoes, and how they're heating the seas" (Ice Age Now 2013, Pedersen 2013 , and Olsen 2014)*

The northern end of the Jan Mayen Volcanic complex includes and is defined by the Svalbard Islands. These islands are currently geologically active as indicated by; significant emissions of hydrothermal methane (Mau 2107), differential melting of its ice sheets (Kamis 2015), and numerous earthquakes (University of Norway 2013 , Kvaerna, and Antonovskaya 2015). The long linear trends of Svalbard area seafloor methane emissions perfectly match the orientation of known seafloor faults that are part of the Mid-Arctic Rift System. This is strong indication that the origin of the methane emissions is hydrothermal, geologically induced heat flow melting of methane clathrate beds, or a combination of both. Melting of one Svalbard Island ice cap, Austfonna, suddenly accelerated in 2012. No other Svalbard Island ice caps, including the adjacent Vestfonna ice cap, experienced increased melting Kamis 2015 and (McMillan 2014). This differential ice cap melting is very likely related to differential HCF from faults related to the Mid-Arctic Rift System which dissect the

Svalbard Islands. Researchers have noticed that in recent decades that areas north of the Svalbard islands have been ice free for longer periods of time (Polyakov 2017). This differential sea ice melting is also likely related to HCF.

In April of 2014 a 4.5 scale earthquake occurred along a segment of the seafloor Mid-Arctic Rift System. This quake was likely triggered by magma chamber movement beneath the Mid-Arctic Rift. The shifting magma chambers released heat and hydrothermal methane into the deeper extent of rift faults. This heat and methane moved upward along the faults and the process acted to melt additional shallow layers of frozen methane locked in methane clathrate beds adjacent to the faults. The upwardly migrating heat and methane was released into the overlying ocean acting to warm the water column. The methane continued to rise through the ocean column and into the atmosphere where it was recorded by NASA satellites (Kamis 2015). Worldwide there are multiple proven examples of massive methane pulses associated with seafloor earthquakes (Fischer 2013 and Hokugo 2018).

On October 11, 2015 a melt hole rapidly developed in a very thick portion of the Arctic Sea Ice (Kamis 2015). The sea ice melt hole was positioned directly above the seafloor location of the currently active Jessica's Hill Vent Complex. The limited size, rapid occurrence, and position above a known hydrothermal vent complex of this melt hole is strong evidence that it is geological in origin.

Ultra-slow-moving rift systems such as the Mid-Arctic Rift System have been the focus of numerous research studies for many years, such as but not limited to, Schlindwein 2005 and Schlindwein 2016. Most of these studies have concluded that ultra-slow-moving rift systems circulate seawater downward along system faults to a depth of 15 kilometers (9.3 miles) or more. Where it is heated and chemically charged, then pulsed upward back into overlying ocean waters. The emission magnitude and effect of these giant ocean circulation systems is not currently well known. However, the author theorizes that these systems are significant contributors of heat and methane into overlying ocean waters thereby having a strong influence on the regions oceans, atmosphere, and climate.

Baffin Bay / Labrador Fault System (BB/L)

The April 2014 4.5 Mid-Arctic Rift System earthquake apparently had effect on the Baffin Bay Labrador Rift System (Figure 9) because it also released a large pulse of methane into the atmosphere immediately after the earthquake (Kamis 2015). The author believes that this seafloor methane release is the result of a HCF pulse from the Baffin Bay / Labrador Rift system.

Nares Strait Fault System

Recent research and observations by the author indicate that geological features associated with northwest Greenland's Nares Strait Fault System emit high amounts of HCF into the area's oceans, base of ice sheets, and atmosphere. Evidence supporting this idea is as follows.

Northwest Greenland's long linear Nares Strait ocean passageway is the surface expression of the 370-kilometer offset left lateral Nares Strait Fault System. This northeast to southwest trending fault system connects to the Baffin Bay spreading center fault system (Figure 9). The Nares Strait Fault System is home to several recently discovered high heat flow features.

First, two long linear and parallel Devon Island subglacial liquid water lakes. Devon Island is located at the structurally complex intersection of the Nares Strait and Baffin Bay fault systems. A recent research study discovered two long linear and very salty sub-glacial lakes on Devon Island. The orientation of the long linear subglacial lakes perfectly matches the trend of known surface faults associated with stresses from the left lateral Nares Strait Fault, including surface faults located at the edge of the glacial ice. Knowing that the overlying glacial ice is composed of freshwater, the high salt concentration of the subglacial lakes implies an HCF cause for lake development (Rutishauser 2108 and Kamis 2018).

Second, significant melting and retreat of one of two large glaciers located in northwest Greenland that are a mere seven miles apart (Kamis 2018 and NASA). Recent NASA research showed that the Tracy Glacier has been bottom melting and retreating to the east, while the adjacent Helprin Glacier has not retreated. The NASA study also showed that the bay water beneath the Tracy Glacier is anomalously warm, while bay water beneath the Helprin Glacier is of normal temperature which is a common occurrence in geothermal heat sourcing configurations involving complex fault systems. The orientation and long linear shape of both the Tracy and Helprin Glacial valleys is strong evidence that they are fault induced features owing their generation to stresses associated with the left lateral Nares Strait Fault System.

Lastly, the rapid melting of the ice covering the world's largest high arctic lake, Lake Hazen Lehnherr 2018). Lake Hazen is located on Ellesmere Island which forms the northern western boundary of the Nares Strait ocean passageway. A passage way which was formed by movement of the Nares Strait / Wegener left lateral fault system (Pipepjohn 2008). Lake Hazen is located within this tectonically active region. The lake owes its very existence to fault movement of the Lake Hazen Thrust which acted to down drop and form an enclosed long linear valley. The Lake Hazen thrust connects to Nares Strait / Wegener Left Lateral Fault System at an angle that implies it is part of this fault system (Pipepjohn 2008). Indications of high HCF in the Lake Hazen area include:

- Structural association with the Nares Strait / Wegener Left Lateral Fault System that is thought to be a source of HCF (Kamis 2018).
- Proximal position to mantle plume relic heat flow and a position directly atop the ancient path of the Greenland / Iceland Mantle Plume.
- Proximity to mineral rich springs. There are a total of four mineral-rich springs located in the Lake Hazen region (Sapers 2017, Pollard 1998, and Omelon 2006). The author believes these springs are associated with faults which tap into relic mantle plume heat flow. Although the temperature of the spring's surface water is cool, it is likely that at slightly deeper depths along the sourcing fault planes the spring's water is warmer.
- The unusually hot spring-like mineral and biological content of these spring's surface water (Kamis 2018)

Aleutian Island Convergent Fault System

The 4,000-kilometer-long (2,485 mile) Aleutian Island Convergent Fault System forms the southern and enclosing boundary of the Bering Sea (Figure 9). A review of historical Sea Surface Temperature Maps of the Bering Sea show that starting on or about 2012 and continuing through the present-day seawater temperatures in this area are greatly elevated.

The Aleutian Island Convergent Fault System is home to an estimated 80 active or semi-active terrestrial volcanoes. Based on bedrock heat flow information, the Aleutian Island Convergent Fault System seafloor regions likely contain a very large number of seamounts, active faults, and hydrothermal vents (Batir 2013 and J. Kamis observations). These geological features and others scattered across the floor of the Bering Sea are likely emitting large amounts of HCF into Bering Sea and warming this ocean region as per analysis of NOAA Shallow Sea Surface Temperature Maps (J. Kamis observations). Once warmed ocean currents carry this warmed seawater northward eventually funneling it through the Bering Strait and into the western Arctic

Ocean where it acts to warm seawater in this area and melt the western edge of the Arctic Sea Ice (Kamis 16 July 2018). Recent research by Yale and Woods Hole Oceanographic Institute is here interpreted to support a Bering Sea heating source for a just discovered very large bottom hugging warm pool located in the western Arctic Ocean (Timmermans 2018).

Evidence that additional warming of western Arctic Ocean waters is from active seafloor geological features comes from a study by Scripps Institution of Oceanography. The study shows that massive amounts of turbulent upwelling very warm ocean water likely originates from the Arctic seafloor (MacKinnon 2015). Lead scientist Dr. Jennifer MacKinnon said this: *"The strength of heat coming up from below the surface has been as strong as the heat coming down from the Sun,….There's a reservoir of heat in the Arctic Ocean, well beneath the surface, that historically – when there's been a lot of ice has been fairly quiescent,….The heat is being brought to the surface by surprisingly strong eddies,…"The strength of [these currents] has been incredible."*

Dr McKinnon and her research team theorize that strong surface winds are acting to generate large turbulent ocean cells that bring very warm bottom hugging ocean water to the surface where it acts to melt Arctic sea ice. The author theorizes that geologically induced seafloor heat flow from active geological features is generating the deep ocean warm pool and creating the turbulent surface reaching eddies, not atmospheric winds.

In summary, the Arctic region is home to numerous active geological features that flow significant amounts of HCF into adjacent oceans and the base of glacial ice sheets. These emissions are the dominant force acting to alter ice sheet mass and extent, ocean water temperatures and chemistry, sea ice thickness and extent, and marine animal migration patterns. All this information demonstrates, as per Plate Climatology theory, that geological and not manmade atmospheric forces are the root cause of observed changes in the Arctic region.

Oceans

Geologically induced HCF from seafloor and terrestrial geological features have in past and still to this day act to significantly alter many aspects of earth's oceans. Altered ocean water then acted, and still to this day acts to significantly influence earth's climate and climate related events. The author believes that due consideration should be given to geologically induced HCF as a possible explanation of present-day; slight decreases in ocean PH, some of the localized oxygen concentration decreases, and some of the decreases in marine animal populations. Evidence supporting these statements is as follows.

Present day changes of PH in several of earth's oceans has been termed "Acidification". However, most research indicates that during the last 300 million years none of earth's oceans have ever had, nor do they currently have a PH equal to or less than 7. Therefore, earth's oceans are not, nor have they for millions of years been acidic. To the contrary, they have varied from basic to slightly less basic, ranging from an estimated ancient PH of 8.2 to a current PH of approximately 8.1 (Nat Geo 2017 and Hönisch 2012).

A specific example of ancient ocean PH alteration by geological forces comes from research of the Paleocene-Eocene Thermal Maximum event. This event occurred 56 million years ago and was the result of a huge worldwide volcanic pulse. A volcanic pulse which acted to infuse the atmosphere with a much greater concentration of CO_2, lower the PH of earth's oceans, and significantly alter ocean biologic environments (Keller 2018).

Another example of how geological forces can alter earth's oceans are ancient worldwide anoxic events that acted to dramatically reduce ocean oxygen content leading to mass extinctions. Several research studies have concluded that the Toarcian Oceanic Anoxic Event (TAE), which occurred 183 million years ago, was generated by a huge pulse of volcanic activity that acted to infuse earth' s atmosphere with massive amounts of CO_2. This atmospheric CO_2 then acted to de-oxygenate earth's oceans and force a worldwide mass extinction (Them 2018 and Zheng 2013). The Ocean Anoxic Event (OAE) occurred 94 million years ago and was fueled by a large volcanic emission pulse (Clarkson 2018). Recent research has shown that the major cause of the KT extinction event was volcanism within India's Deccan Traps area (Keller 2018). An event that effected both oceans and atmosphere.

Pacific Ocean

El Nino

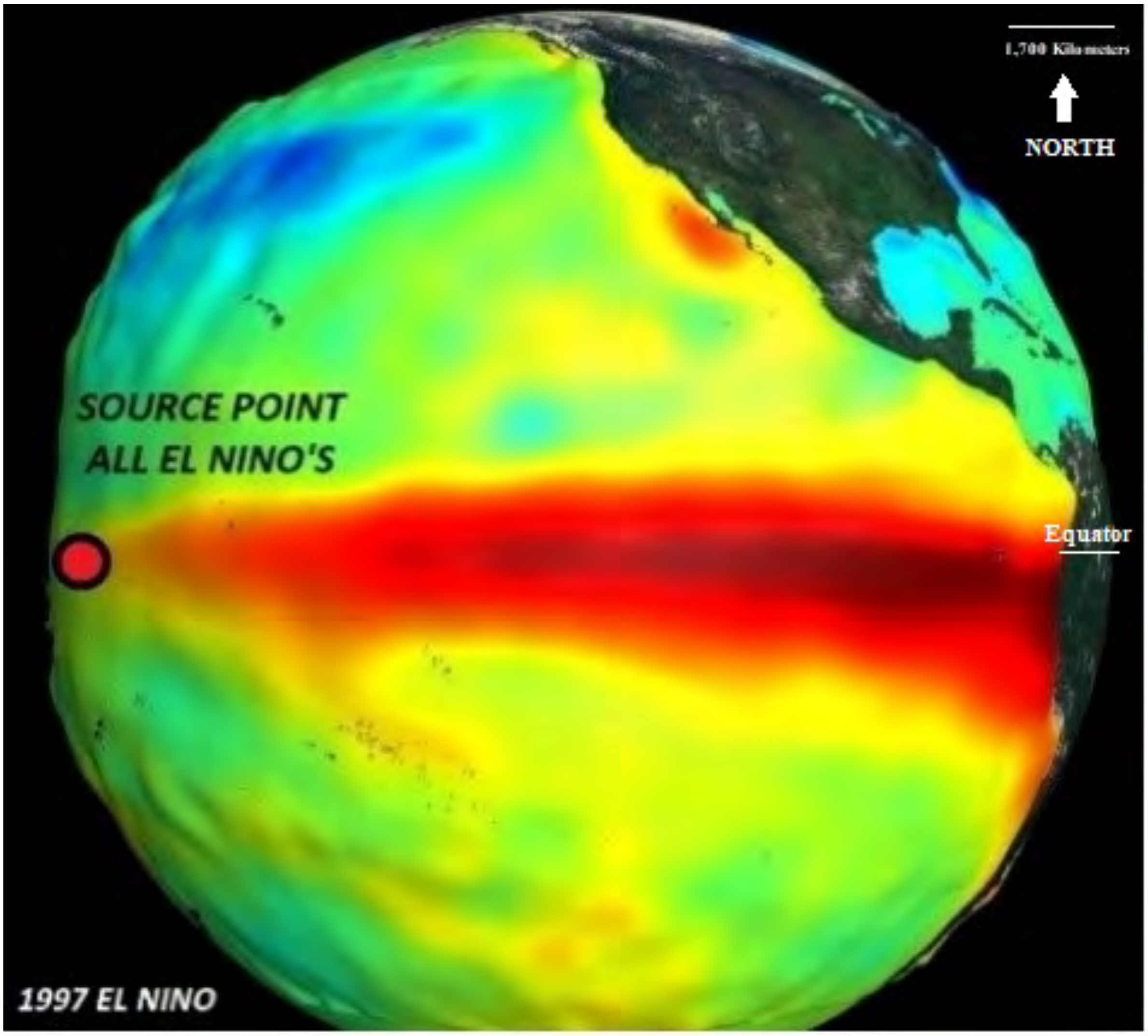

Figure 11. 1997 El Nino Pacific Ocean warming event. Red shades indicate anomalously warm ocean water. (image credit NASA/Goddard Space Flight Center and label credit J. E. Kamis)

El Nino's are one of the most influential climate and climate related phenomena on earth. These massive pulses of warm seawater have in past and still to this day act to dramatically alter many aspects of earth's oceans (temperatures, chemistry, currents, and sea level) and atmosphere (temperatures, chemistry, and winds). These alterations significantly influence; ocean biological regimes, terrestrial biological regimes, human activities, local weather, and worldwide climate. Some attribute the sudden migration of ancient human civilizations to El Nino induced climate changes.

Here we show that generation and maintenance of El Nino ocean warm phases are the result of geologically induced emission pulses of super-heated chemically charged fluid and heat from ocean floor geological features into the overlying ocean waters from a geographically limited ocean floor area / "Source Point" located in the far western Pacific Ocean (Figures 11 & 12, Kamis 2014, Kamis 2015 and Kamis 2017).

El Nino Generation and Maintenance

Evidence supporting El Nino generation by ocean floor geological induced chemically charged heated fluid flow (liquid and air) and heat floor is as follows:

- All El Niño's have originated at the exact same deep ocean seafloor geographically limited fixed area located east of the Papua New Guinea / Solomon Island area. This is one of the most volcanically and seismically active areas on earth. The conjunction of five major plate boundaries, source point for earth's second largest seafloor volcanic plateau, thousands of seamounts, countless numbers hydrothermal vents, and a complex network of significant faults (Figure 12).
- El Niño sea surface temperature and chemical anomalies have linear and intense boundaries inferring that the energy source is stationary and very powerful (Figure 11 and Kubota 2014).
- The shape of all El Niño sea surface temperature anomalies are identical, and not like other sea surface temperature anomalies.
- The fixed source point and cone shape of heat and ash emissions from land based volcanic eruptions are an excellent analog to the cone shape of heat emissions all El Nino's. Additionally, the cone shape of deep-ocean geological hydrothermal vent emissions is another very good mini-analogy of the larger El Niño's.
- El Niño's occurrences do not correlate with atmospheric changes.
- El Nino's often occur in "bundles". Multiple El Nino's occur in a short time span, grouped together. Typically, the first El Nino in a bundle is of lower intensity, subsequent El Nino's are progressively more intense, often ending with a final maximum/high intensity El Nino. This El Nino bundle pattern is very similar to the progression of well monitored and well understood land based volcanic and tectonic events which typically build through time to a final large volcanic eruption or tectonic event.
- El Niño-like events do not occur elsewhere in Pacific. Why? If they are atmospheric in origin there should at least be another mini-El Niño's. There are none.
- Historical records indicate that the first "recorded" El Niño occurred in 1525 as observed by Spanish explorers. Other studies suggest strong ancient El Niño's ended the Moche Peruvian Civilization (Etayo-Cadavid 2013). The main point here is that strong El Niño's are natural, and that they are not increasing in relationship to anthropogenic warming.
- El Nino ocean warming acts to strongly effect ocean coral reef systems, often referred to as "Coral Bleaching". The author believes that these alterations are natural and necessary effects of geological forces. Natural effects which fit into Natural Selection Theory developed by Geologist Charles Darwin in the geologically active Galapagos Island Rift System region (Kamis 2015 and Kamis 2016).
- El Nino warming and chemical changes of Pacific Ocean seawater has a strong influence on Pacific Ocean phytoplankton distribution (NASA 2009).
- La Nina's cool ocean water flows originate at the same fixed-point source as El Niño's indicating fluid emissions from a fixed geological feature.
- El Niño / La Nina prediction models loaded with atmospheric and shallow oceanic data consistently fail, likely because they are modelling the "side effects" of geologically warmed / cooled oceans and not the "cause" of the El Niño / La Nina event (see here).
- El Nino / La Nina events are associated with seismicity and, or volcanism in the point source area (Kamis 2017, and Guillas 2010).
- El Nino's develop in distinctive bursts of heat easily seen on time lapse videos of Shallow Sea Surface temperature data (see here and Figure 13). Massive bursts of heat are indicative of volcanic eruptive pulses and not atmospheric temperature variations that are much more even building.

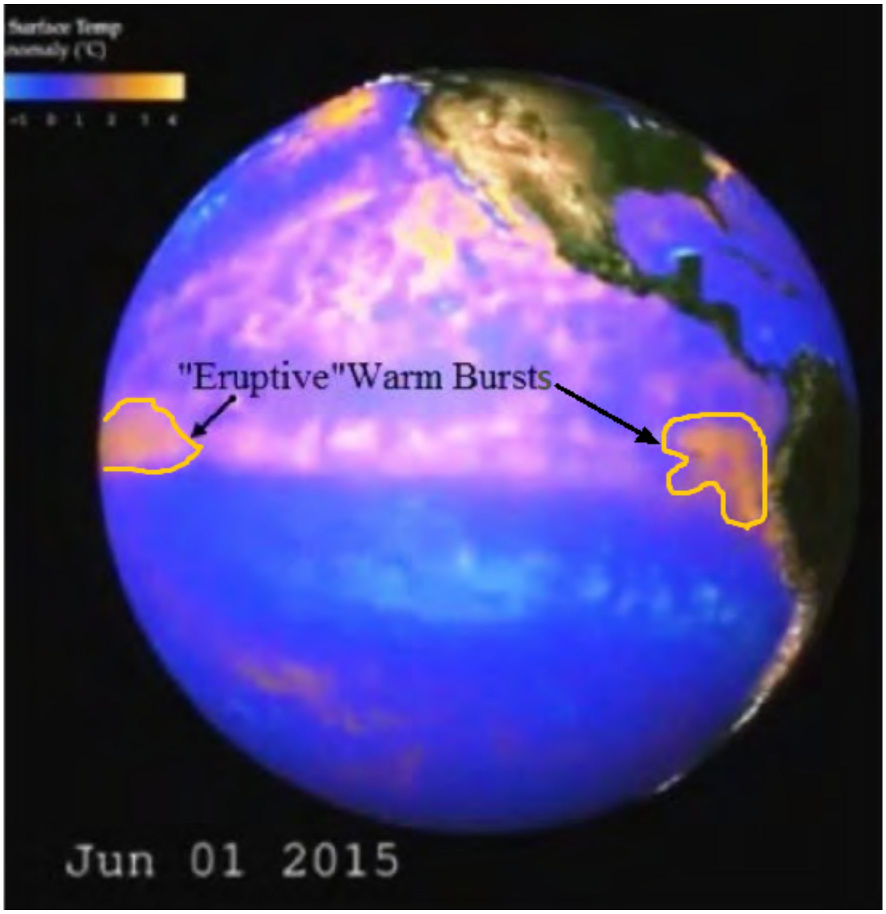

Figure 12.) Geologically induced “Eruptive” Warm Bursts from the 2014-2015 El Niño.

El Nino emission pulses are activated by a sudden increase in ocean floor earthquakes, volcanic eruptions and fault movements in the source point area which is known to be one of the most active geological regions on earth.

This increased ocean floor geological activity acts to alter the permeability and hydrologic fluid flow characteristics of deep ocean floor rock layers. It does this by; generating open fractures in ocean floor brittle rock layers for a great distance away from the fault plane, not fracturing interbedded ductile / soft rock layers rock layers, and opening fault planes that connect to underlying deep earth magma chambers. The result of this activity is to generate large and very powerful seafloor mega-fluid flow systems (see here, here, here, here, here and here) in the source point area. This now active system and associated ocean floor geological features act to capture seawater then circulate it downward into contact with hot lava magma chambers. Once super-heated and chemically charged this seawater then expulsed laterally and eventually upward into overlying ocean waters and atmosphere (Kamis 2015).

The force maintaining this giant circulation system ocean is the immense downward pressure from the very tall overlying ocean column. This pressure forces seawater downward into open vertical deep reaching fault planes and fractures eventually placing it in contact with very deep magma chambers. Once this high-pressure fluid is heated and chemically charged it moves laterally farther and farther away from the open fractures and fault plane until it eventually encounters vertical permeability pathways allowing it to flow upward into lower pressure regimes. Eventually these fluids and heat make their way back to the ocean rock layer interface where they discharge into ocean and atmosphere thereby generating and maintaining El Nino's warm phases.

A time lapse visualization of the generation of El Nino's by chemically charged heated fluids and heat flow being emitted from deep ocean rock layers associated with the circulation system can be seen by watching the following video animation. Pay special attention to the portion of the video animation that speaks to "temperature variations" from normal. You will hear the narrator say that El Nino's are sourced from deep ocean sources and you can visually observe warm spikes / bursts emanating from the rock layers on the ocean floor. Toward the end of temperature variation segment of the video you can also see the rapid formation of the associated La Nina cold fluid emissions. This clearly shows that El Nino's and La Nina's are one continuous event here contended to be geological in origin.

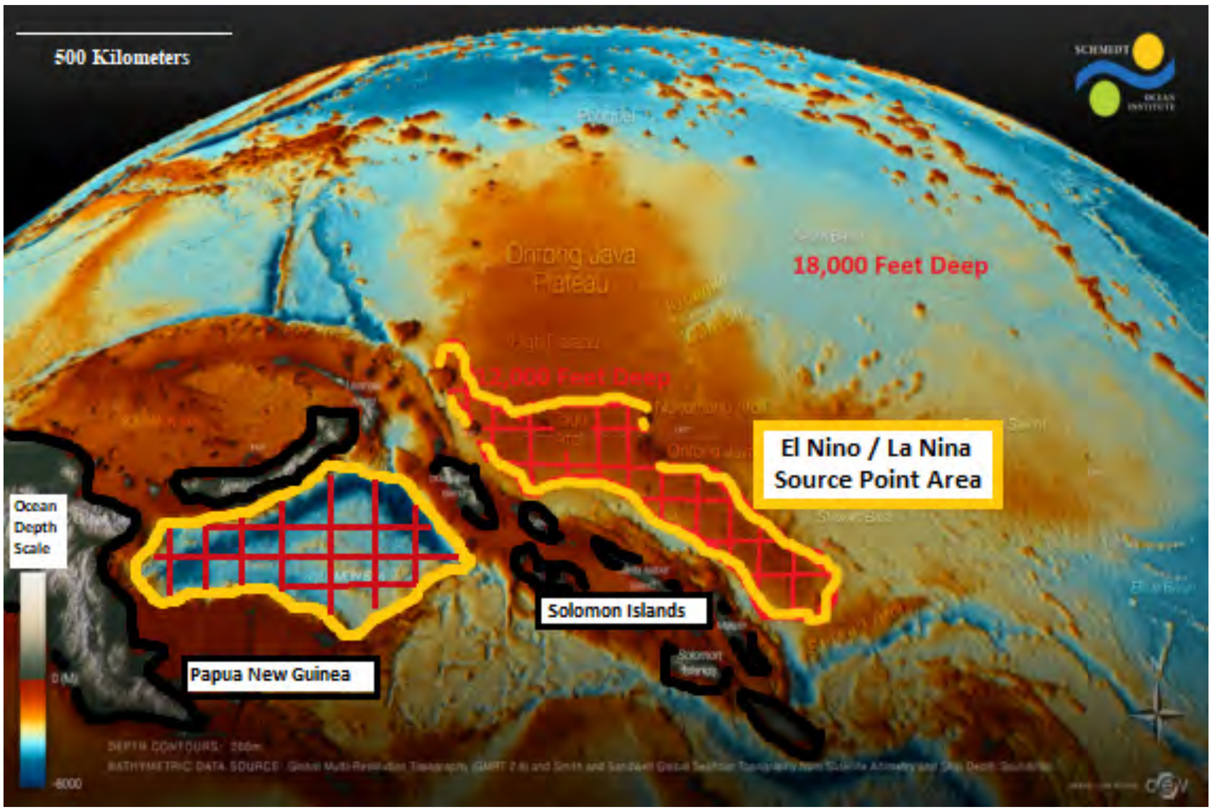

Figure 13.) Bathymetric map of the western Pacific Ocean with El Nino Heat Source Area (Bathymetric map credit Schmidt Ocean Institute, credit "El Nino Heat Source Area" outline and some label J. E. Kamis).

La Nina Generation and Maintenance

The generation and maintenance of La Nina's involves the interaction between deep ocean seawater and ocean floor geological forces located in one specific geographically limited area in the far western Pacific Ocean offshore from the Solomon Islands / Papua New Guinea region (Figure 12). Specifics of exactly how geological forces generate and maintain La Nina cooling are not well understood. However, the author believes that the La Nina cooling phase develops as follows.

Once the heating power of the deep earth magma chambers that fuel El Nino's are exhausted of their heat the Mega-Fluid Fluid Flow System and associated geological features continue emitting fluid, just cooler fluid. This forces a temperature / pressure relationship change at the emission points of the free-flowing methane and seawater mix. A temperature / pressure relationship change which alters the methane seawater mix from free flowing into a solid form of frozen methane hydrate. This frozen methane rich substance attaches and accumulates along open fractures, open faults and into adjacent permeable rocks layers. This cold frozen material now acts to quickly and significantly cool seawater still circulating through the system thereby rapidly generating a La Nina cool phase.

A visualization of conversion from the El Nino warm phase to the La Nina cold phase can be seen by watching the following video animation. Pay special attention to the portion of the video animation that portrays "temperature variations" from normal. You will hear the narrator say that El Nino's are sourced from deep ocean sources and you can visually observe warm spikes / bursts emanating from the rock layers on the ocean floor and the El Nino warm phase developing. As the El Nino warm phase tails off but is still present, you can see the early development of the La Nina cold phase beneath the last remnants of the El Nino warm phase. The two phases overlap one another. One does end and then the other begins. This is a clear indication that the two phases are from the same force and same location. The most likely explanation of this rapid and seamless transition is that emissions are from one specific ocean floor geologically active area.

El Nino and La Nina are One Continuous Geologically Induced Event

It is here contended that El Nino and La Nina are one continuous geologically induced event that is generated and maintained by heat and subsequent cool flow from ocean floor geological features in the Source Point Area.

To achieve the nearly instantaneous transformation from anomalous above normal warm El Nino seawater (+2-2.25 degrees Celsius) to anomalous below normal La Nina seawater (-1.75-2.0 degrees Celsius) requires an immense amount of energy (Figure 14). This energy warming source must rapidly change a huge mass of the Pacific Ocean seawater by 3.75 – 4.25 degrees Celsius.

The total amount of energy, the speed of its delivery, maintenance a warm phase and subsequent development of a cool phase within a significant portion of the Pacific Ocean is not consistent with generation by atmospheric forces. Sudden changes to deep ocean

A much more plausible explanation is alteration by geologically induced forces which have the energy to immediately and significantly alter ocean temperatures across wide regions. Recent research has proven that ancient huge pulses of volcanically induced ocean floor heat flow rapidly warmed / altered earth's oceans thereby causing major ocean anoxic mass extinction events (see here).

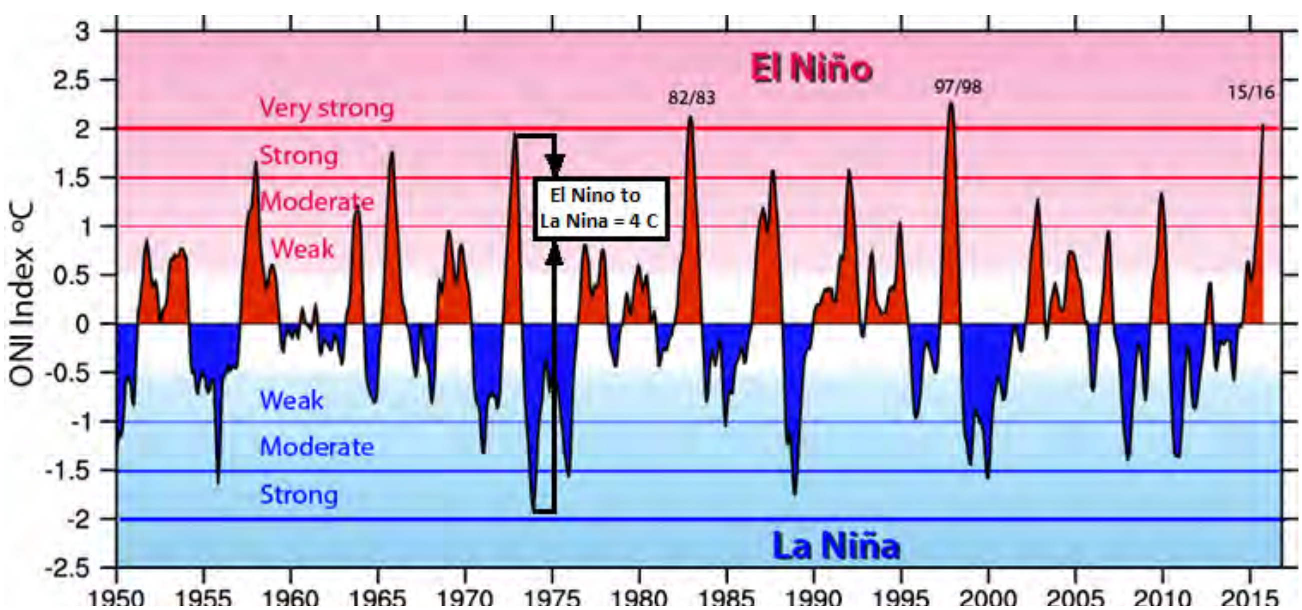

Figure 14.) Ocean temperatures in degrees Celsius of the El Nino / La Nina couplet events (credit "The Conversation")

Scientific Community Fails to Recognize Geological Origin of El Nino's and La Nina's

Scientists have failed to recognize that El Nino and La Nina are one continuous event both fueled by fluid flow and temperature transfer emitted from a limited area ocean floor geological complex positioned offshore of the Solomon Islands and Papua New Guinea (Figure 12). Recognition failure is for two reasons, insufficient data and "Atmospheric Bias".

Concerning insufficient data, the earth's oceans cover 361,821,339 square kilometers (139,700,000 square miles) of our planet's surface, however as per NOAA there are only 3,908 floats in the worldwide Argo Buoy System that record shallow to upper mid-level ocean temperatures. This equates to one buoy every 117,000 square kilometers (45,174 square miles). Furthermore, the oceans can be generally divided into three depth range layers; shallow, mid-level and deep. So, at any time the buoys may be stationed at different ocean levels. Therefore, the weekly or monthly amount of buoy measurements per square mile within a specific ocean layer may be less dense than the 117,000 per square kilometer (45,174 square mile) average coverage. Many of earth's deep-ocean geological heat and fluid sources are located at depths greater than 2,000 meters (6,562 feet) which is beneath the ARGO Buoy depth limits. Therefore, emission temperatures from, and the exact geographical extent of these deep geological features are not accurately recorded. Instead the buoy system records a shallower inaccurate version of the feature emission temperatures and geographical extent because as the emissions migrate laterally and upward from their ocean floor point, they lose temperature and spread out or diffuse in geographical extent.

The Pacific Ocean has an average depth of 4,270 meters (14,000 feet) and the El Nino / La Nina source point area (Figure 12) is at a depth of 3,660 meters (12,000 feet). Therefore, the buoys which recor down to 2,000 meters (6,562 feet) are incapable of locating or precisely measuring heat flow from deep Pacific Ocean geological features including the El Nino source point. The El Nino heat source area represents 233,000 square kilometers (86,100 square miles) which is a mere 1.4 percent of the Pacific Ocean's 166,000,000 square kilometer (64,092,958 square mile) area.

The Argo Buoy System does in the opinion of this author supply sufficient data to recognize the importance and power of deep ocean floor geologically induced heat flow emission areas and their role in generating and maintaining El Nino / La Nina couplets. However, is easy to see why oceanographers and climatologists have overlooked data from the Argo Buoy system and considered it insufficient.

Atmospheric Bias has played a large role in preventing scientist from discovering the origin of and locating the heat source point of El Nino warming. Lacking large amounts of HCF emission data from seafloor geological features in the western Pacific Ocean, scientists looked to the immense atmospheric and shallow ocean emission data set for answers concerning what force or forces generate and maintain El Nino's.

These scientists have in fact discovered correlations between atmospheric and shallow ocean data with El Nino generation and maintenance. However, the author contends that these correlations are not cause and effect, rather cause and side effect. One example is that when geological forces warm the western Pacific Ocean waters, they act to alter overlying trade winds. Scientists have mistakenly assumed that this switch in trade wind direction is the root cause of El Nino's. This is not correct. Trade wind changes are a side effect, not the root cause.

Arctic Ocean

Arctic Amplification

Arctic Amplification which is generally defined as changes in net radiation balance such as intensification of greenhouse gas related warming, has been a long-standing tenet of the Global Warming / Climate Change Theory. However new research (Stuecker 2018) concludes that many aspects of this tenet are incorrect or in need of significant modification as follows:

- Increased atmospheric CO2 concentrations and resulting Arctic atmospheric warming are not the result of worldwide CO2 sources, rather the result of local CO2 sources.
- Warming of the Arctic's lower atmosphere does not mix with the overlying or lateral atmosphere, rather is strongly restricted vertically and geographically.
- The "Ice Albedo Affect" does not significantly contribute to Arctic atmospheric warming, rather has an insignificant warming effect.
- Worldwide cloud, ocean current, or hot winds such as those related to El Nino do not significantly contribute to Arctic region atmospheric warming, rather have little or no effect.

These conclusions indicate that Arctic Amplification is the result of local, not worldwide forces. The author believes that these local forces and resulting changes to the Arctic atmosphere are the result of seafloor HCF from two active Arctic geological features, the Aleutian Island Subduction Zone and the Mid-Arctic Rift System.

As previously discussed in this paper, these two active geological features are thought to be emitting significant amounts of HCF into the Arctic Ocean thereby warming, in varying degree, the entire Arctic seawater column. This warmed seawater then acts to significantly warm the overlying Arctic atmosphere especially in areas of the atmosphere located in close geographical association with HCF ocean warm pockets.

Figure 14, taken from NOAA's 2018 Arctic Report Card, clearly shows that:

- The extent of recently elevated Arctic atmospheric temperatures closely matches the outline of the Arctic Ocean.
- The configuration of the western intensely atmospherically warmed area can be interpreted to be the result of HCF warmed seawater inflow from the Bering Sea into the Chukchi Sea.
- The configuration of the eastern atmospherically warmed area can be attributed to HCF from the underlying Mid-Arctic Rift System.

The above information supports the idea that Arctic Amplification is largely the result of geological and not atmospheric forces.

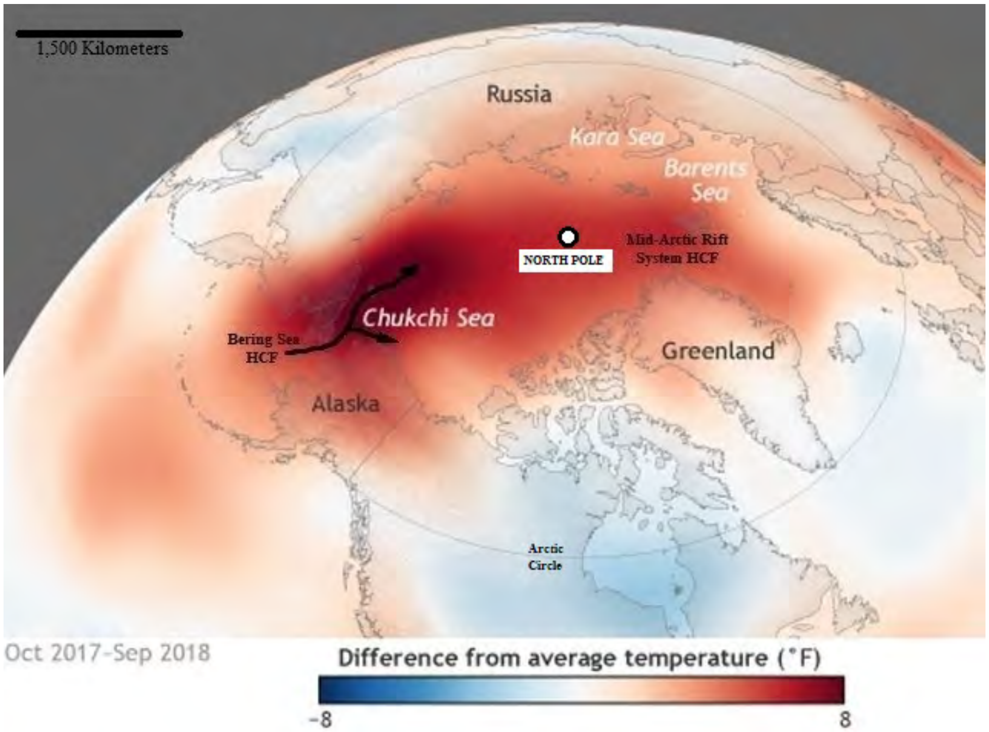

Figure 15.) Arctic region difference from average lower atmosphere temperature October 2017–September 2018 (map credit NOAA, HCF lines and labels J. Kamis).

North Atlantic Ocean

Gulf Stream "2010 Slowdown"

The strong climate influencing Gulf Stream Current slowed down in May 2010. This significant ocean current event was given many names, "Gulfstream Shutdown", "2010 Slowdown", etc. Most climate scientists attributed the root cause of this event to the general effects of anthropogenic warming. Others attributed this slowdown to the effects of a stationary shallow water North Atlantic warm water cell of unspecified origin that acted to block or inhibit eastern flow of the Gulf Stream current (Buckley 2015).

The author believes that this blocking warm cell was generated by a massive pulse of HCF from ocean floor rift faults (Kamis 2015). There are several lines of evidence that support this claim. The outline and geographic position of several major North Atlantic seafloor faults perfectly matches the outline and geographic position of the overlying shallow water warm cell. This is compelling evidence of a cause and effect relationship between fault heat flow and warm cell generation. It is thought that a massive long-lasting pulse of heat from seafloor faults rose vertically through the ocean column and acted to warm shallow ocean water directly above the faults thereby forming the blocking warm cell. Additionally, the warm cell has a distinct and well-formed outline that developed rapidly. This is very characteristic of the erratic and sudden development of geological features. Lastly, the stationary position of the warm cell implies a powerful and non-moving heating mechanism, again characteristic of a geological feature.

Terrestrial Volcanic Regions

Quantifying the climate effect of terrestrial volcanic emissions is a complex and difficult task. Most researchers have focused their attention on detailing the climate effects of major world class volcanic eruptions. The climate effect of these events on ocean, atmosphere, and climate have been well documented, especially during the last 5-10 years. However, several aspects of the climate effect of terrestrial volcanic eruptions has been lost in the shuffle, specifically the:

- Climate effect of CO_2 and other gas emissions from non-erupting but active volcanoes are much more significant that given credit by climate scientists (see here).
- Climate effect of CO_2 and other gas emissions from minor volcanoes is considerably more significant than given credit (see here). Keep in mind virtually none of these minor volcanoes are heat and gas emission monitored.
- Climate effect of all geologically induced sources including both terrestrial and oceanic geological features is almost certainly far greater than given credit by the consensus scientific community. Numerous recent groundbreaking research studies have concluded this exact thing as exemplified by a quote from one scientist who headed such a study. *"We discovered that Katla volcano in Iceland is a globally important source of atmospheric carbon dioxide (CO2) in spite of being previously assumed to be a minor gas emitter. Volcanoes are a key natural source of atmospheric CO2 but estimates of the total global amount of CO2 that volcanoes emit are based on only a small number of active volcanoes. Very few volcanoes which are covered by glacial ice have been measured for gas emissions, probably because they tend to be difficult to access and often do not have obvious degassing vents. Through high-precision airborne measurements and atmospheric dispersion modelling, we show that Katla, a highly hazardous subglacial volcano which last erupted 100 years ago, is one of the largest volcanic sources of CO2 on Earth, releasing up to 5% of total global volcanic emissions. This is significant in a context of a growing awareness that natural CO2 sources have to be more accurately quantified in climate assessments and we recommend urgent investigations of other subglacial volcanoes world-wide." (see here).* Also see "CO_2 flux emissions from the Earth's most actively degassing volcanoes, 2005–2015"
- The isotopic carbon fingerprint of terrestrial volcanic CO_2 emissions versus the carbon isotopic fingerprint of CO_2 emissions from the burning of fossil fuels has been a point of argument for many years (see NOAA's "The Data: The Story Told from CO_2 Samples). As per this NOAA story, identifying the source of atmospheric CO_2 is a far more difficult task than portrayed by those advocating the Global Warming / Climate Change Theory. The NOAA study states that the source of CO_2 in the atmosphere is a complex mixture of many sources each source having varied carbon isotopic CO_2 fingerprints. It is accepted fact that the carbon isotope C14 is depleted in both volcanic and fossil burning CO_2. Other than that, the source and meaning of varying ratios of carbon isotopes in atmospheric is still under debate. The author believes the carbon isotopic fingerprint of natural volcanic CO_2 and carbon isotopic fingerprint of CO_2 from burning fossil fuels will eventually be proven to be near identical. This will lead to the need of more accurate measurement of CO_2 the flow rate, magnitude and climate affect of earth's estimated 1,500 terrestrial volcanoes and estimated 900,000 ocean floor volcanoes / hydrothermal vents.

Knowing that most of earth' s estimated 1,500 volcanoes are not monitored for heat, chemical, or matter emissions it is highly likely that the climate effect of terrestrial volcanic emissions are greatly underestimated and definitely not properly accounted for in computer climate models. The percent of atmospheric CO_2 that is volcanic in origin is also most certainly underestimated.

Non-Erupting Volcanic CO2 Emissions

Just released research of Iceland's non-erupting Katla Volcano indicates that scientists have greatly underestimated the emission amount and significance of non-erupting terrestrial volcanoes (Ilyinskayasee 2018). The study concluded that Katla is emitting massive amounts of CO_2 into the atmosphere.
"The emissions are in the order of 12 to 24 kilotons a day which means 4 to 8 megatons a year. That's the same output as an extra 1 – 2 million cars on the road each year. Ilyinskaya et al, Geophysical Research Letters We discovered that Katla volcano in Iceland is a globally important source of atmospheric carbon dioxide (CO2) in

spite of being previously assumed to be a minor gas emitter. Volcanoes are a key natural source of atmospheric CO2".(Ilyinskayasee 2018)

Minor Eruptive Volcanic CO2 Emissions

Results of a 2014 research study by MIT concerning the climate influence of minor volcanic eruptions concluded that emissions from these geological features have a tangible and possibly significant effect on climate and climate related events. MIT said that the global warming hiatus was forced in part by the cooling effect of volcanic eruptions and that most climate models have not accurately accounted for the effects of volcanic activity (MIT 2014). Other MIT research entitled " *Small Volcanic Eruptions could be Slowing Global Warming*" (MIT 2014) speaks to the underappreciated climate effect of eruption emissions from earth's numerous small volcanic features.

Volcanic vs Fossil Fuel CO2 Emissions

Some have presented convincing evidence that natural terrestrial volcanic and man-made CO2 emissions have the exact same and very distinctive carbon-14 isotopic fingerprint (Casey 2014). Scientists advocating the GWCC theory believe, based on supposedly reliable research (Gerlach 2011), that volcanic emissions are minuscule in comparison to human-induced CO2 emissions. As a result, they assert that modern day volcanic emissions have little or no effect on climate. I believe that these assertions are based on less than sufficient evidence.

Gerlach's volcanic CO2 calculation was based on just 7 actively erupting land volcanoes and three actively erupting ocean floor hydrothermal vents (seafloor hot geysers). Utilizing gas emission data from this very limited number of volcanic features, Gerlach estimated that the volume of natural volcanic CO2 emissions is 100 to 150 times less than the volume of man-made CO2 emissions from the burning of fossil fuels and therefore of no consequence. To put this calculation process into perspective, the Earth is home to an estimated 1,500 land volcanoes and 900,000 seafloor volcanoes/hydrothermal vents. By sampling just an extremely small percent of these volcanic features the data is insufficient to validate this calculation. Especially knowing that volcanic activity varies greatly from area to area, volcano to volcano, and through time. Utilizing just 0.001 percent of Earth's volcanic features to calculate volcanic CO2 emissions does not inspire confidence in the resulting value.

So-Called Ice Ages

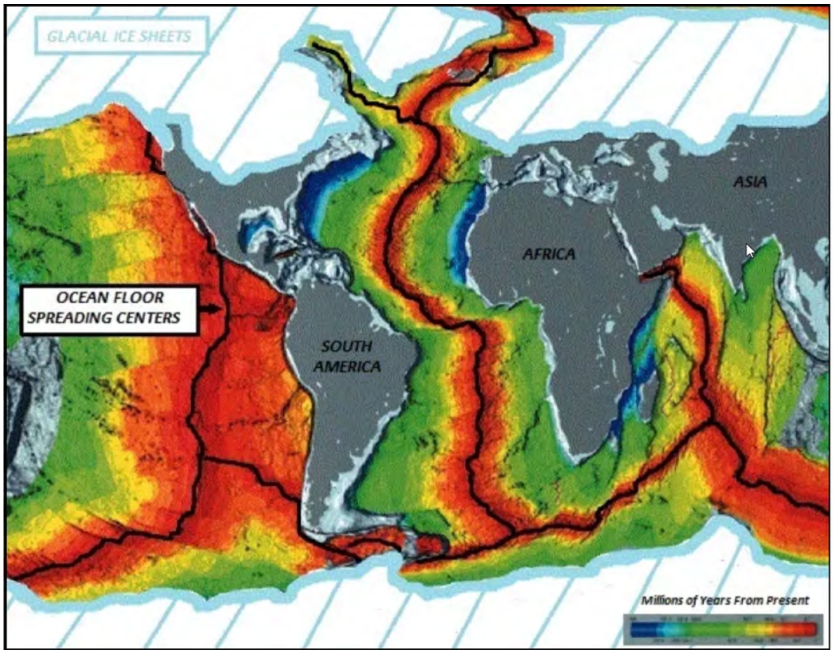

Figure 16: Major deep inner in earth reaching geological features termed Spreading Centers are shown as black lines surrounded by red and yellow shades. Shading indicates the age of the ocean floor hot lava flows that has been expulsed from the Spreading Centers. Extent of Glacial Ice Sheets during the last four so-called glacial periods is shaded white with cross-hatched light blue (credit Estrada et. al. 2013, labeling and Ice Sheets by J. Kamis)

The very rapid and nearly instantaneous end of so-called Ice Ages is here contended to the result of powerful, short lived, and massive pulses of geologically induced heat and super-heated chemically charged fluids (liquid and air) emitted primarily from **major ocean floor geological features** into ocean and atmosphere (Figure 16). It is important to understand the differential effect of geologically induced emissions from terrestrial versus ocean floor geological features.

Most research studies have concluded that both modern and ancient terrestrial eruptions act to cool/decrease atmospheric temperatures. This is the result of solar radiation blocking particulate matter ejected into the atmosphere.

In contrast, most research studies, especially those completed within the last five years, indicate that geologically induced emissions from ocean floor geological features act to heat the atmosphere. This is the result of lack of very little expulsed particulate matter making it way upward through the ocean and into the atmosphere. The ocean captures this matter and deposits it as muddy sediments on the ocean floor. However, most of the ocean floor emissions of heat, CO_2 and methane move upward through the ocean column and into the atmosphere where they act to warm the atmosphere.

For many year's scientists have accepted as fact that accelerated movements of earth's Tectonic Plates (continents and large segments of ocean floor rock layers) have a significant influence on earth's ancient climates including so-called Ice Ages. The movement of these tectonic plates is termed Continental Drift.

The Continental Drift Theory was formally presented on January 6, 1912 after years of research and compilation of other scientists work by Alfred Wegener to the German Geological Society. It was resounding dismissed by the worldwide consensus science community, especially major geological organizations, and the media. Finally, in 1958 enough evidence was compiled to prove Wegener's theory was correct scientific methodology should work. The development and final acceptance of the Continental Drift Theory is an excellent example of how scientific methodology should function. Always keep an open mind and support re-evaluation of supposedly "settled" scientific theories.

Beyond this general acceptance that Continental Drift influences so-called Ice ages the present-day science community has not completely detailed exactly how geological forces influence so-called Ice Ages. The Plate Climatology Theory provides a more detailed explanation of exactly how geological forces in the form of heat and super-heated chemically charged fluids (liquid and air) emitted primarily from major ocean floor geological features end and influence many aspects of so-called; Ice Ages, Glacial Periods and Inter-Glacial Periods. As was true with the development of the Continental Drift Theory, the explanations of exactly how geological forces influence so-called Ice Ages, was pulled together by compiling work of many previous scientists' ideas and the authors observations.

The end so-called Ice Ages occurs in as little as 1,000 years and is the result of **Massive Geologically Induced Emission Pulses.** In a geological timeframe, 1,000 years can be thought of as instantaneous. Immediately following these geological heat pulses earth enters into what is here termed **Recovery Periods** which last 80,000 to 100,000 years. Earth eventually recovers to its here termed **"Normal" Climate Status** which can best be described as colder than, and of far greater glacial ice sheet extent than present day. Our present-day climate status is neither "normal" or stabilized, rather in constant flux in response primarily to natural forces, especially those geological in nature.

Massive Geologically Induced Emission Pulses

Evidence supporting the hypothesis that the end of so-called Ice Ages is caused by short lived Massive Geologically Induced Emission Pulses is abundant and reliable.

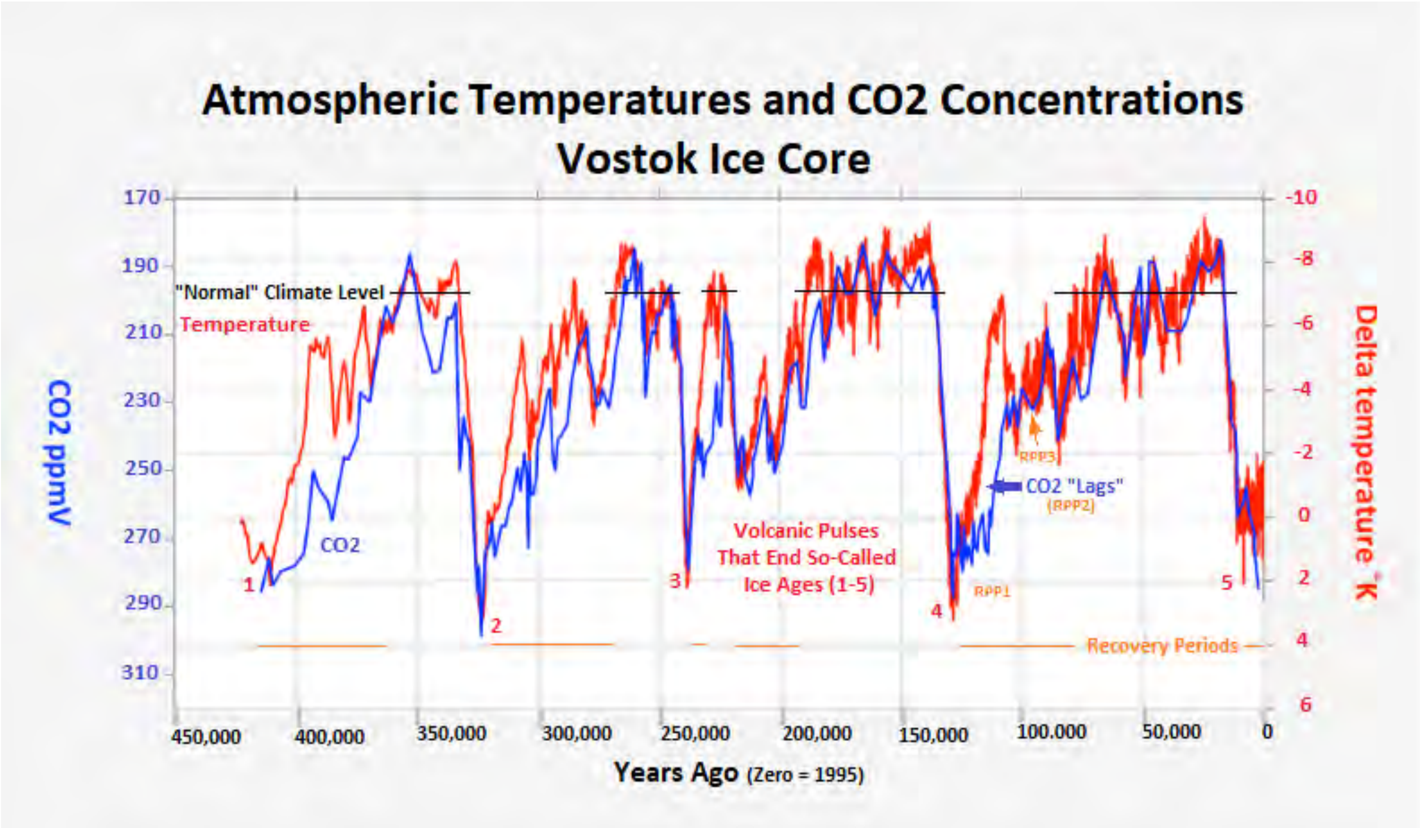

Figure 17.) Atmospheric Temperatures and CO2 concentrations from Vostok Ice Core data (credit see here). Labeling of "Normal" Climate Level, CO2 "Lags", Volcanic Pulses That End So-Called Ice Ages (1-5), and Recovery Periods by J. Kamis 10-2-2019)

Atmospheric temperatures immediately rise by as much as 12 degrees Kelvin acting to end so-called Ice Ages (Figure 17). This sudden temperature increase is most plausibly explained by the combined force of several geologically induced phenomenon. Massive pulses of ocean floor geologically induced heat pulses which act to rapidly warm overlying ocean waters. Warmed oceans then rapidly transfer this massive heat pulse to the overlying atmosphere leading to significant increases of global atmospheric temperatures. However, of equal importance this pulse of atmospheric heat dissipates vey rapidly (Figure 17). It is here thought that this sudden massive drop in atmospheric temperature is the result of the volcanic heat pulse overwhelming, and then punching through earth's normal solar radiation process and into outer space.

Atmospheric methane concentrations immediately rise and track atmospheric temperature increases during the ends of so-called Ice Ages (Figure 18). This very rapid methane increase is almost certainly the result of massive and instantaneous emissions of free-flowing methane (liquid and gaseous) from two geologically induced sources; melting of methane clathrate beds and activation of hydrothermal methane. An example of geologically induced ocean floor methane emissions that very rapidly rise upward into the atmosphere come from NASA methane detecting satellites positioned above the Arctic Ocean on March 6-10-2014 (see here). The satellites showed that the atmospheric methane anomaly was a combined 3,400 miles long and was offset into two separate pieces, each 1,700 mile long. Geological analysis showed that these two atmospheric methane anomalies were positioned directly above two major ocean floor geological features, specifically two separate and offset 1,700-mile-long active ocean floor Spreading Center segments.

The rapid increase of geologically induced atmospheric methane concentration during the massive volcanic pulses does NOT assist in ending so-called Ice Ages, because just like increases of atmospheric CO2 concentrations during the volcanic pulse the magnitude of increase is not enough to overwhelm and add to the effect of heat transfer from the volcanic pulse (Figure 17). Additionally, as is true with rapid loss of atmospheric heat, atmospheric methane concentrations diminish very rapidly. Scientists state that methane escapes earth's atmosphere into outer space in 5-10 years.

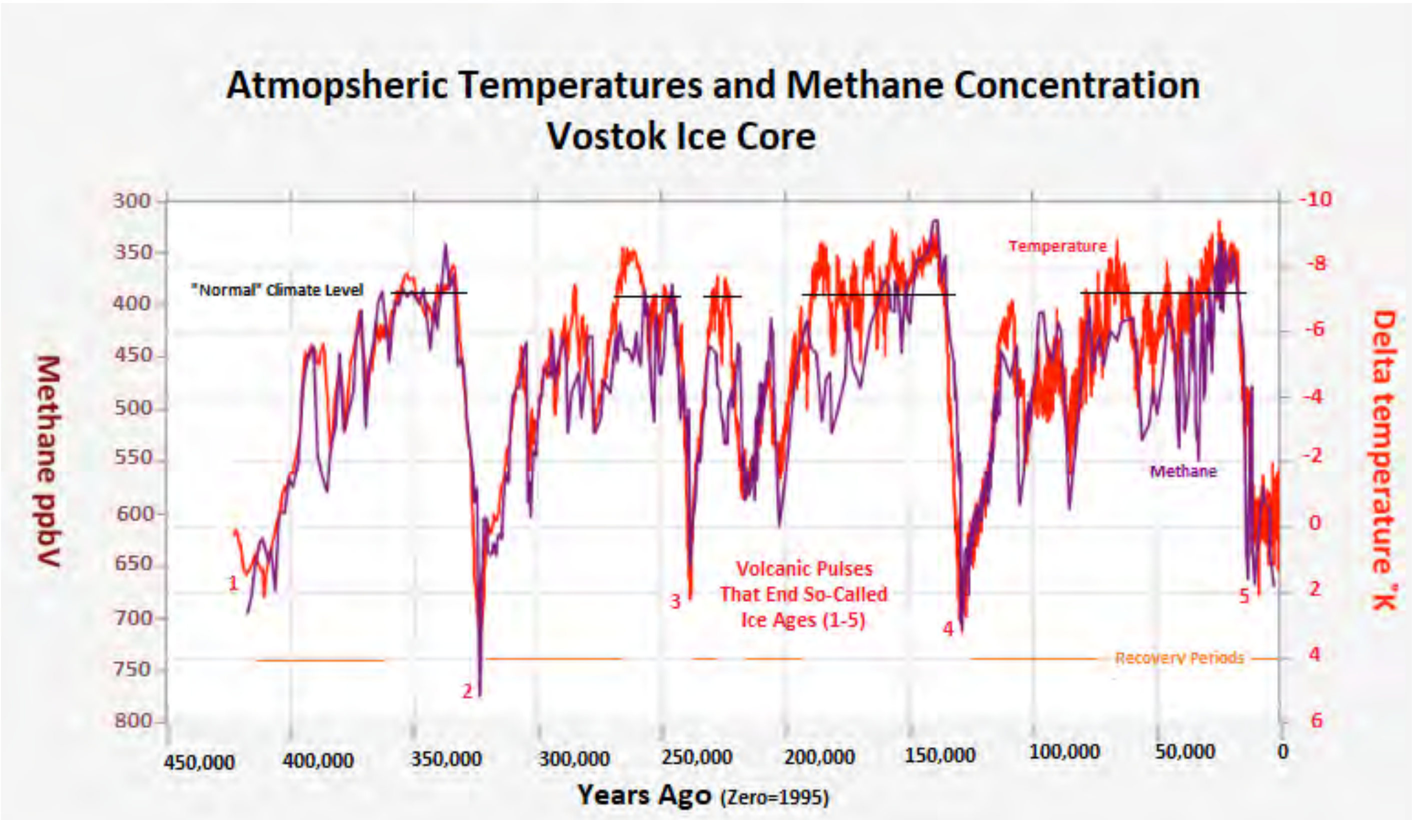

Figure 18.) Atmospheric Temperatures and CO2 concentrations from Vostok Ice Core data (credit see here). Labeling of "Normal" Climate Level, CO2 "Lags", Volcanic Pulses That End So-Called Ice Ages (1-5), and Recovery Periods by J. Kamis 10-2-2019)

Atmospheric CO2 concentrations immediately rise and track atmospheric temperature increases during the massive emission pulse that ends of so-called Ice Ages (Figure 17). This very rapid and large CO2 increase is almost certainly the result of massive and instantaneous emissions of free-flowing CO2 (liquid and gaseous) by geologically induced activation of hydrothermal CO2 vents (see Figure 19).

The rapid increase of geologically induced atmospheric CO2 concentration during the massive volcanic pulses does NOT assist in ending so-called Ice Ages, because just like increases of atmospheric methane concentration during the volcanic pulse the magnitude of increase is not enough to overwhelm and add to the effect of heat transfer from the volcanic pulse (Figure 17). However, unlike atmospheric heat and methane scientists very roughly estimate that CO2 concentrations stay in earth's atmosphere for thousands of years. This explains the existence of the so-called CO2 "Lag" (see Figure 17). In other words, CO2 emitted from the massive geologically induced ocean floor pulse rises rapidly into the atmosphere but does not diminish for a long time thereby creating a "Lag" / gap between atmospheric temperatures and CO2 concentration.

A research documented example of geologically induced ocean floor emissions of free-flowing gaseous CO2 from hydrothermal vents located at the source point of all El Nino's, Papua New Guinea area, comes from a February 1, 2019 research study by the University of Southern California (Figure 19). This research study concluded that…"*The large 14C anomaly was accompanied by a ~4-fold increase in Zn/Ca in both benthic and planktic foraminifera that reflects an increase in dissolved [Zn]throughout the water column. Foraminiferal B/Ca and Li/Ca results from these sites document deglacial declines in [- CO3 2] throughout the water column; these were accompanied by carbonate dissolution at water depths that today lie well above the calcite lysocline. Taken together, these results are strong evidence for an increased flux of hydrothermally-derived carbon through the EEP upwelling system at the last glacial termination that would have exchanged with the atmosphere and affected both Δ14C and pCO2. These data do not quantify the amount of carbon released to the atmosphere through the EEP upwelling system but indicate that geologic forcing must be incorporated into models that attempt to simulate the cyclic nature of glacial/interglacial climate variability. Importantly, these results underscore the need to put better constraints on the flux of carbon from geologic reservoirs that affect the global carbon budget".* https://iopscience.iop.org/article/10.1088/1748-9326/aafe28/pdf

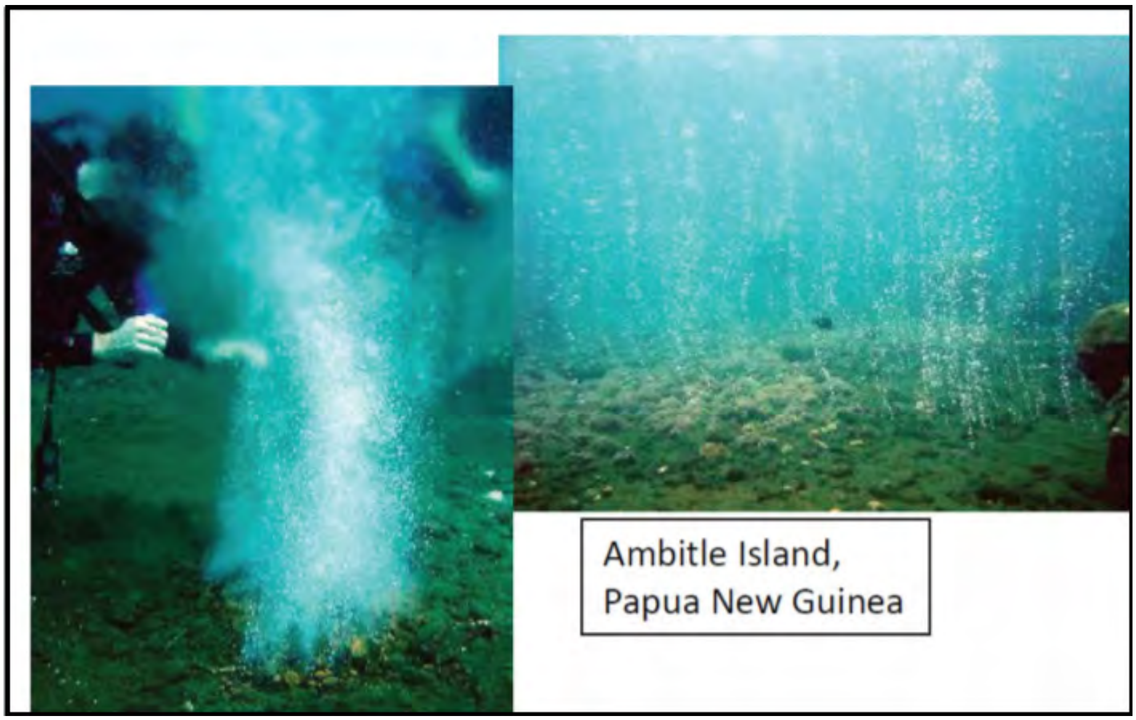

Figure 19.) Nearly pure CO2 bubbles emanating from sediments that blanket an active hydrothermal system in the western tropical Pacific. (Photos by Roy Price, courtesy of Jan Amend).

The rapid increase of geologically induced atmospheric CO2 concentrations during the volcanic pulses acts to rapidly increase the atmospheric CO2 greenhouse gas effect which warms the atmosphere, thereby accelerating ice sheet, change of climate and change s to climate parameters. As a side note, the University of Southern California research study is also a strong verification that the building block principles of the Plate Climatology Theory, geological forces greatly influence climate and climate related events, are correct.

All of Earth's Major Extinction Events, both on land (see here) and in oceans (see here) have been proven to be the result of volcanism and associated changes to earth's atmosphere and oceanic parameters . Scientists no longer contend that atmospheric forces cause major extinctions, instead accepting that these atmospheric changes are side effects and not root causes.

Milankovitch Cycles (see here) greatly effect earth's volcanic and tectonic activity (earthquake, volcanism, plate boundary movements, and mantle convection systems every 80-100,000 years. These astronomically induced cycles act to significantly increase gravitational stresses on earth especially the outer crustal plates and mantle convection systems. It is here contended that this increased stress results in 80,000 to 100,000-year pulses of increased volcanic and earthquake emissions of heat, methane and CO2, primarily from major ocean floor geological features.

In summary, geologically induced pulses of heat and heated chemically charged fluids primarily from major ocean floor geological features, and not atmospheric forces acted to instantaneously end so-called Ice Ages.

Recovery Periods

Immediately following the end of a so-called Ice Ages from massive geologically induced volcanic pulses, earth enters a here termed **Recovery Period**. Technically this Recovery Period is not a separate event initiated by any type of force, rather a time when earth essentially acts to heal itself through normal and natural oceanic, atmospheric and solar radiation processes. This recovery involves the complex interaction between many different oceanic, atmospheric, and land regions each affecting one and another in a back and forth fashion until earth's oceans, atmosphere and land masses achieve a "Normal" Climate Status (see next chapter below). Also, the beginning of the Recovery Period is here defined as the very sharp and significant decline of atmospheric temperatures (Figure 17) and NOT the slower / "Lagged" fall of CO2 concentrations.

Atmospheric temperatures begin to lessen immediately after the ocean floor geologically induced volcanic pulse. This is obvious when reviewing Figure 18 which illustrates that this overall decreasing atmospheric temperature trend continues for 40,000 to 50,000 years. However, it is not a perfectly smooth trend, rather there are many small-scale temperature decreases and increases that do not exactly follow the overall trend. This is a result of the back and forth fashion earth's oceans, atmosphere and land masses naturally adjust from the end of the volcanic pulse.

Atmospheric methane concentrations begin to lessen immediately after the ocean floor geologically induced volcanic pulse. This is obvious when reviewing Figure 18 which illustrates that this overall Recovery Period decreasing atmospheric methane concentration trend continues for 40,000 to 50,000 years. However, as is true with atmospheric temperatures, it is not a perfectly smooth trend, rather there are many small-scale methane concentration decreases and increases that do not exactly follow the overall trend. This is the result of the back and forth fashion earth's oceans, atmosphere and land masses naturally adjust from the end of the volcanic pulse. Methane concentrations track atmospheric temperature during the Recovery Period as would be expected. However, this tracking is not a perfect match, rather there are times when the ratios between temperature and methane vary, again to due natural variation. The reason methane concentrations decease during the Recovery Period is because diminished overall ocean floor heat emissions equate to less melting of methane clathrates from rock layers associated with major geological features, especially ocean floor Spreading Centers. Additionally, as ocean floor volcanic and earthquake activity diminishes there is a decrease in ocean floor hydrothermally vented methane.

Atmospheric CO2 concentrations alter their relationship to atmospheric temperatures in a complex and not well understood fashion during the Recovery Period (Figure 17). They begin to lessen immediately after the ocean floor geologically induced volcanic pulse and track atmospheric temperature for brief time interval, typically 5,000 years (RP Phase 1). During the next 20,000 to 40,000 years atmospheric CO2 concentrations very definitely "Lag" atmospheric temperatures for 20,000 to 40,00 years (RP Phase 2). During the remainder of the Recovery Period CO2 concentrations vary back and forth in their relationship to atmospheric temperatures as they near adjustment o normal climate status (RP Phase 3). In a general sense it is difficult to attribute these repeatable (RPP1-RPP3) CO2 concentrations to atmospheric forces. It seems much more plausible that are the result of the post geologically induced volcanic pulse readjustment.

- RP Phase 1 (RPP1) is the result of a geothermally and volcanically activated pulse of free-flowing ocean floor CO_2 from ocean floor high CO_2 concentration sediment layers, hydrothermal vents and seamounts (ocean floor volcanoes). It is a continuation of CO_2 gas emissions form the initial geologically induced heat and heated chemically charged fluid pulse. rapidly rise upward through oceans and into the atmosphere. However, their greenhouse gas effect on atmospheric temperatures is minimal to non- existent. Atmospheric temperatures plummet at the end of the volcanic pulse because release of heat to the (5-10 years) is more rapid than release of CO_2 to the outer space.
- RP Phase 2 (RPP2) is the result of greatly lessoned geothermal heat flow which acts to lesson emissions of CO_2 emissions from ocean floor CO_2 bearing sediment layers, hydrothermal vents and seamounts. This limits the flow rate and emissions of CO_2 thereby forcing a "Lag" with atmospheric temperatures.
- RP Phase 3 (RPP3) is a time when ocean floor geothermal temperatures are no longer anomalous and stores of CO_2 in ocean floor sediment layers, hydrothermal vents, and seamounts attempt to return to normal conditions.

"Normal" Climate Status

Evidence supporting the hypothesis that earth enters into here termed "Normal" Climate Status at the end of Recovery Periods is indeed a very bold contention. However, when it is eventually proven correct it will revolutionize the sciences of climate and weather. Evidence supporting this hypothesis is more abundant than given credit by the scientific community.

Atmospheric temperatures, Atmospheric methane concentrations, and Atmospheric concentrations of CO_2 all reach a more or less stabilized level and track each other approximately 50,000 years after the massive volcanic pulse, Figures 17&18. This point marks the end of the Recovery Period and beginning of "Normal" Climate Status

Summary of So-Called Ice Ages

Consensus scientific theory has stated for many years that so-called Ice Ages are composed of distinct and separate Glacial and Interglacial Periods induced by changes in atmospheric forces. This interpretation is not correct. Information and data taken from numerous sources has been integrated with the author's own observations to formulate a new more plausible alternative theory that contends that the end of so-called Ice Ages and intervening times which can be divided into three successive time intervals:

- An initial **Massive Geologically Induced Emission Pulse** of geologically sourced heat and chemically charged heated fluid emitted primarily from ocean floor geological features that acts to end so-called Ice Ages. This massive pulse exists for an extremely short time frame of 1,000 – 3,000 years, has a very significant effect on earth's climate, and regularly occurs every 80,000 to 100,000 years.

- A subsequent **Recovery Period** when oceanic, terrestrial, and atmospheric regimes complexly interact until a Normal Climate Status is achieved typically within 75,000 years. This Recovery Period can best be thought of as a natural healing process by earth adjusting from the anomalous pulse of ocean floor geological heat and chemically charged heated fluid flow.

- An ending **Normal Climate Status** which marks the time when earth has fully recovered from the initial geologically induced emission pulse. This time is referred to as "normal" because it; represents 60% of time during the last 450,000 years, is clearly defined by stabilized values of atmospheric temperature - CO_2 concentration - methane concentration and lastly by consistent tracking of atmospheric temperatures, CO_2 concentrations and methane concentrations.

In the vernacular there are no such things as Ice Ages, Glacial Periods or Inter-Glacial Periods, just a pulse of geologically induced fluid emissions then recovery to normal climate.

SUMMARY

Figure 20.) Schematic Illustration of Upper Mantle Convection Cell (Image credit public domain and label credit J. Kamis).

The present day and ancient climate effect of geological forces has been greatly underestimated and underappreciated. A more realistic assessment of their significant climate effect has been realized by integrating and then evaluating numerous examples, many by other scientists, of how geological forces effect or have affected climate and climate related events. This assessment clearly shows that geological forces have a very significant, and in some cases, dominating effect on earth's climate and climate related events. Effects that have remained hidden for several reasons:

- Most of earth's active major geological features are in remote and difficult to research deep ocean or sub-ice sheet polar regions. As a result, their activity, function, heat flow and flow of heated chemically charged fluids are not well understood.
- Underestimation of heat, CO2 and methane emissions from terrestrial non-eruptive volcanic features and medium to small size mildly erupting volcanic features.
- Incorrectly attributing many climate and climate related events to atmospheric or oceanic side effects when the root cause is related to geological forces. Here termed atmospheric basis.
- Unappreciation and lack of integrating into modern day climate trends the lesson of analog geologically induced mass extinctions, ocean anoxic events, and alterations of Polar Ice Caps.

Finally, The Plate Climatology Theory provides a plausible alternative explanation for many of our planet's climate phenomenon, trends, and climate related events. It is deserving of strong consideration by mainstream climate scientists.

James Edward Kamis is a retired professional Geologist with 42 years of experience, a B.S. in Geology from Northern Illinois University (1973), an M.S. in geology from Idaho State University (1977), and a longtime member of AAPG who

has always been fascinated by the connection between Geology and Climate. More than 14 years of research/observation have convinced him that the Earth's Heat Flow Engine, which drives the outer crustal plates, is an important driver of the Earth's climate as per his ***Plate Climatology Theory*** (plateclimatology.com)

APPENDIX 1

Text of Gerlach (1991)

About this Web Page.

I have included the full text of Gerlach's 1991 paper concerning volcanic carbon dioxide emissions because so few people who cite Gerlach's work have actually read it. This is hardly surprising, considering that until now, this paper has not been available online. Contrary to the claims of Monbiot, the USGS, and many other authors, Gerlach (1991) includes no measurements of actual submarine volcano emissions, makes no attempt at modal representation, and Gerlach's global volcanic emission estimate is based on measurements taken from only seven subaerial volcanoes (Gerlach, 1991, §4, ¶1) and three hydrothermal vent sites (Gerlach, 1991, §3, ¶3). Although a hydrothermal vent site can be a feature of a volcano, hydrothermal vent site emission and the submarine volcanic emission are two completely different measurements. To his credit, Gerlach (1991, §1, ¶4) points out the fact that the data available at the time was woefully inadequate to a global estimate. Although Gerlach (1991, §3, ¶3) does mention some proxy measurements for mid-oceanic ridge degassing, he also demonstrates that these are nonetheless doubtful as the degree of fractionation remains unknown (Gerlach, 1991, §3, ¶4). While he talks about "volcanos of the mid-oceanic ridge system" Gerlach (1991) neither offers nor includes emission estimates of any submarine volcano. Moreover, Gerlach (1991, §3, ¶1) asserts "There are no estimates for off-ridge volcanos ". For more information concerning why I've included Gerlach (1991) among the most misquoted and abused papers in the public domain, see http://geologist-1011.mobi.

Although I do not attempt to correct the English or the arithmetic of T. M. Gerlach (e.g. Gerlach, 1991: §3, ¶3, 1st sentence; §6, ¶1 - 2nd sentence, 1st clause), I have gone as far as to update the typesetting by:

- Eliminating the first-line indentation of paragraphs.
- Altering the page identifier to optimize clarity for online reading.
- Setting citation elements within the references to bold for ease of use.
- Change incorrect use of square brackets on references to the proper round brackets, because Square brackets are reserved for additional explanatory material added by persons other than the original author.

A list of any obviously unintended errata in the text of Gerlach (1991) can be found at the end of this web page. However, this list excludes any and all scientific assertions that may disagree with current knowledge, because such assertions remain, nonetheless, valid and correct in their historical context. This ensures that the views of the original author remain protected from over-zealous pedantry. Thus, you are afforded an uncensored view of science from the perspective of the time and of the original author.

The text provided here is entirely typed in by hand from photocopied materiel. Picking off any typos will, no doubt, be an ongoing endeavor. This web page, like others on this site, is protected by copyright and all rights are reserved. However, the actual text of the Gerlach (1991) paper itself, presented here, is sourced to pages explicitly marked by the publisher as "*This page may be freely copied*". This permission to copy the source pages freely -i.e. without restriction- appears to me a clear submission of the material therein to the public domain.

The photocopy I've acquired is from an edition with no specific pagination, and is spread over five mysteriously unnumbered pages, instead of the three specified by EOS as, 249, 254, and 255. For this reason, I've assembled a numbered list of sections by heading. The first section, being unnamed, I've designated as the "Introduction". Specific references to the text are thereby made by section (§) and paragraph (¶) number -from the first paragraph in the section-, which exclude headings, tables, figures, and captions.

1. Introduction
2. Modes of CO_2 Degassing
3. Submarine Emissions
4. Subaerial Emissions
5. Comparisons with Anthropogenic Emissions
6. Conclusions
7. Acknowledgements
8. References

If I receive the correct page break locations, I'll paginate this copy of Gerlach (1991) accordingly.

Source

Gerlach, T. M., **1991**, "Present-Day CO_2 Emissions from Volcanoes", *EOS, Transactions, American Geophysical Union*, Vol. 72, pp. 249, 254-255.

Gerlach (1991): Main Article

Gerlach (1991, § 1)

Present-Day CO_2 Emissions from Volcanos

In an effort to better understand processes that control sources of CO_2 in the carbon cycle, the U.S. Global Change Research Program (CEES 1990) identifies improving understanding of both volcanic emissions and natural sources of CO_2 in the carbon cycle as priority items for research. To implement these goals, the program plan calls for monitoring CO_2 emissions from volcanos.

Without the resupply of CO_2 by volcanic and metamorphic degassing, removal of atmospheric CO_2 by silicate weathering, carbonate deposition, and burial of organic matter would deplete the CO_2 content of the atmosphere in 10,000 years and the atmosphere-ocean system in 500,000 years (Holland, 1978; Berner et al., 1983). The CO_2 content of the atmosphere-ocean system has varied in the past, but not at the rate expected if CO_2 were removed and not replenished. It is assumed, therefore, that CO_2 degassing from the earth's interior restores the deficit from the surficial processes and balances the atmospheric CO_2 budget on a time scale of 10^4-10^6 yr. Earlier atmospheric balancing calculations imply present-day (pre-industrial) CO_2 degassing rates of 6-7 x 10^{12} mol yr^{-1} (Holland, 1978; Berner et al., 1983); recent calculations suggest degassing rates may be as high as 11 x 10^{12} mol yr^{-1} (Berner, 1990).

Atmospheric balancing calculations have inherent drawbacks, however. They do not distinguish volcanic, metamorphic, and diagenetic sources of CO_2 degassing—they give an aggregate CO_2 degassing rate obtained for all sources. Since the CO_2 obtained in these calculations is the difference between several CO_2-producing and CO_2-consuming processes affecting the atmospheric CO_2 budget, it includes the accumulated error in the rate estimates for each contributing process. To minimize these problems, Berner (1990) suggested basing degassing rates on direct measurements, to the extent possible, in future carbon budget calculations.

In this article, I review the results and implications of past efforts to measure rates of CO_2 degassing from volcanos, and I attempt to arrive at an estimate of the global rate of volcanic CO_2 degassing. My principle aim, however, is to emphasize unsettled problems requiring further study and uncertainties due to inadequate data. I make a few comparisons between volcanic and anthropogenic CO_2 emission rates because of current concern about the buildup of CO_2 in the atmosphere.

Gerlach (1991, § 2)

Modes of CO_2 Degassing

Most of the data on volcanic CO_2 emissions come from active volcanos that are in a state of quiescent degassing, that is, degassing without extrusions of lava or explosive ejections of disrupted and fragmented lava. Data biased in favour of quiescent degassing are not, in my view, a serious limitation. First, the low solubility of CO_2 in silicate melts at upper crustal depths, where magmas tend to reside before erupting, causes magmas underlying volcanos to leak CO_2continuously and to become depleted in CO_2 by diffusive loss through volcano flanks and by advective loss through fractures feeding hydrothermal fluids and atmospheric plumes (Carbonnelle et al.,1985; Gerlach and Graeber, 1985; Allard et al., 1987; Bottinga and Javoy, 1989; Gerlach 1989a,b). Second, the annual quiescent release of CO_2 from all active volcanos appears to be more than an order of magnitude greater than that emitted directly from all forms of erupting lava, as discussed below.

Gerlach (1991, § 3)

Submarine Emissions

Submarine volcanic systems provide about 80% of the present-day magma supply to the crust (Crisp, 1984). Estimates of CO_2 emission rates for submarine volcanos are restricted to volcanos of the mid-oceanic ridge system, which provides about 75% of the present-day magma supply (Crisp, 1984). There are no estimates for off-ridge volcanos or volcanos on back-arc spreading centers.

Several investigators have attempted to constrain the CO_2 emission rate of the global mid-oceanic ridge system by calculating the product of oceanic ^3He flux and measured $CO_2/^3He$ ratios of hydrothermal vent fluids and converting the CO_2 flux obtained to a mole per year emission rate. These calculations have tended to employ the original oceanic ^3He flux of 4 atom $cm^{-2}s^{-1}$ instead of the corrected value of 3 atom $cm^{-2}s^{-1}$. (The original ^3He flux assumed a mean $^3He/^4He$ ratio for injected ridge-crest helium of 11 times the atmospheric value; it was subsequently shown that ridge-crest helium has a ratio 8 times the atmospheric value, thus reducing the oceanic ^3He flux proportionately (Welhan and Craig, 1983).) All CO_2 emission rate estimates based on this approach and presented below for the mid-oceanic ridge system have been recalculated for the corrected ^3He flux.

$CO_2/^3He$ data are available for hydrothermal vent fluids from only three locations, all in the eastern Pacific: the Galapagos Rift, and 13º and 21ºN on the East Pacific Rise. The CO_2 emission rates that have been estimated for the mid-oceanic ridges from the data for these sites are 0.6 x 10^{12} mol yr^{-1} (De Marais and Moore, 1984), 0.75 x 10^{12} mol yr^{-1} (Des Marais, 1985), and 0.7 x 10^{12} mol yr^{-1} (Gerlach, 1989b). Because vent fluid $CO_2/^3He$ data are restricted to so few sites, there is concern about just how representative they are of the mid-oceanic ridge system. In an ingenious attempt to obtain more representative data, Des Marais (1985) and Marty and Jambon (1987) used the $CO_2/^3He$ values of MORB glasses from many locations as proxies for the $CO_2?^3He$ ratios of ridge-crest emissions. This greatly increases the number of $CO_2{}^3He$ data sets and leads to CO_2 emission rate estimates for the global mid-oceanic ridge system that cluster around 1.5 x 10^{12} mol yr^{12} (Marty and Jambon, 1987). This value is about double that obtained from vent fluid because $CO_2/^3He$ ratios for MORB glasses are about twice those of vent fluids examined so far.

The assumption that the ratio is not affected by fractionation during degassing prior to eruption on the seafloor is a critical issue in the use of MORB glass $CO_2/^3He$ values as proxies for $CO_2{}^3$ in ridge-crest emissions. Pre-eruptive degassing of CO_2 and He from MORB magma is expected to be significant (Bottinga and Javoy, 1989; Gerlach, 1989b), and it has been suggested that quiescent degassing from subridge magma chambers may be primarily responsible for ridge-crest CO_2 and He emissions (Gerlach, 1989b). Marty and Jambon (1987) argue that because the Henry's law solubility constants for CO_2 and He in molten MORB are similar, the $CO_2/^3He$ ratios for the vapor and melt will be about equal during degassing and that the value of the ratio for MORB glasses is therefore a good predictor of the ratio for ridge emissions. However, a slight difference in CO_2 and the solubilities could, with sufficient degassing, cause enough CO_2 and He fractionation to account for a factor of 2 difference between glass and vent fluid ratios and, thereby, the factor of 2 difference in the calculated CO_2 emission rates for ridges. This possibility and the possibility that $CO_2/^3He$ ratios of vent fluids may themselves be affected by fractionation processes (for example, differential hydrothermal solubilities of CO_2 and He, carbon precipitation, etc.) need more study.

In view of the disagreement in results thus far for the mid-oceanic ridge CO_2 emission rate, alternative approaches should also be pursued. For example, a mass balance approach based on data for the carbon content of MORBs and the CO_2 content of volcanic gases from transitional basalts of the Afar region suggests a ridge CO_2 emission rate in the range 0.2-0.9 x 10^{12} mol yr^{-1} (Gerlach, 1898b). Updating this estimate with new data for carbon in MORBs (Kingsly, 1989) gives a range of 0.5-0.9 x 10^{12} mol yr^{-1}, which agrees with estimates based on the CO_2 ratios of hydrothermal vent fluids.

Gerlach (1991, § 4)

Subaerial Emissions

Published rates of CO_2 degassing exist for only seven active subaerial volcanos (Table 1, Figure 1): five convergent plate volcanos, an intraplate continental volcano, and an intraplate oceanic island hotspot volcano.

Measurements made on quiescent volcanic plumes provide the basis for most of the CO_2 emission rates for the seven volcanos. The quiescent plumes include examples that preceded the initial explosive episode of an eruption (White Island), examples that followed the initial explosive episodes of an eruption (Mount St. Helens, Redoubt), examples that were present between explosive or dome-building episodes of an eruption (Mount St. Helens, Redoubt), and examples that exhibit long-term stability and continuity during, between, and long after eruptions (Kilauea, Mount Etna, Vulcano). One emission rate estimate (Augustine) is based on plume measurements during a low-level explosive episode.

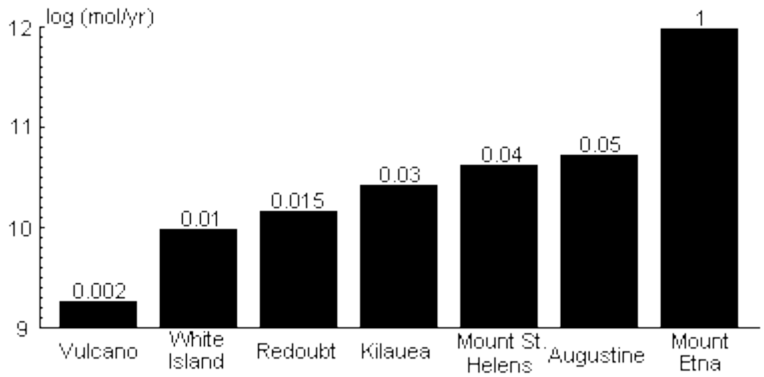

Fig. 1. CO_2 emission rates in log (moles per year) arranged in ascending order for subaerial volcanoes from Table 1. The numbers on the tops of the bars are emission rates in 10^{12} mol yr^{-1}. The median emission rate used in a calculation described in the text is 0.03 x 10^{12} mol yr^{-1}(Kilauea).

The plume observations onsist of airbourne MIRAN infrared spectrophotometer measurements of above-background CO_2 concentrations, or airbourne COSPEC ultraviolet spectrophotometer measurements of SO_2 column abundances combined with measurements of the CO_2/SO_2 ratio of gases supplying the plume. Most studies neglected the diffusive flux of CO_2 through volcano flanks; soil gas surveys carried out at Mount Etna and Vulcano suggest this source can be significant (Table 1).

Continuous, long-term measurements of CO_2 emission rates do not exist for any volcano. Most estimates are based on spot measurements. The only record of closely spaced measurements over several (15) months is for Mount Sy. Helens (Harris et al., 1981; Casadavall et al., 1983). The long-term emission rate for Kilauea (0.03 x 10^{12} mol yr^{-1}) (Gerlach and Graeber, 1985) is based on the CO_2 content and average supply rate of magma emplaced in Kilauea's summit chamber from July 1956 to April 1983. Rose et al., (1986) suggest a long-term CO_2 emission rate for White Island of approximately 0.01 x 10^{12} mol yr^{-1}; they consider the larger 0.03 x 10^{12} mol yr^{-1} rate in November 1983 (Table 1) to be representative of degassing during periods of new magma emplacement prior to an eruption.

Kilauea Volcano provides an example of simultaneous eruptive and quiescent degassing. Lava production rates combined with estimates of the CO_2 content of the erupting lava (Greenland et al., 1985; Gerlach, 1986; K. Hon, personal communication, 1991) give a CO_2 emission rate of 0.001-0.003 for the current east rift zone eruption. Quiescent degassing of Kilauea's summit (Table 1) is therefore at least 10-fold greater than contemporaneous eruptive degassing at the present time. Casadawell et al., (1984) report similar eruptive CO_2 emission rates between April 2 and April 16 for the 1984 eruption of Mauna Loa Volcano, Hawaii. Unfortunately, the background quiescent emission rate is not known for Mauna Loa.

Marty et al. (1989) estimated the total output of CO_2 from island arc volcanos to be in the range 0.1-0.5 x 10^{12} mol yr^{-1}. This estimate is based on the global SO_2 output from subaerial volcanos of 0.24 x 10^{12} mol yr^{-1} (Berresheim and Jaeschke, 1983). It assumes that island arc volcanos are primarily responsible for the global SO_2 output and that the CO_2/SO_2 ratio for arc emissions is 1.5±1. It is possible in principle to follow this approach in estimating the global CO_2emission rate of all subaerial volcanos from the corresponding global volcanic

SO_2 output. The difficulty in doing so is that the appropriate global volcanic CO_2/SO_2 value is unknown. Combining the total CO_2 emission rate for Etna (summit plume plus diffusive flank), which is exceptionally large, and on the order of 1 x 10^{12} mol yr^{-1} (Table 1), with the global volcanic SO_2 output suggests that the global volcanic CO_2/SO_2 value is at least 4.2. (Williams et al. (1990) calculated a global emission rate of 1.2 x 10^{12} mol yr^{-1} from the global volcanic SO_2 output and CO_2/SO_2 data for 30 volcanos suggesting a global volcanic CO_2/SO_2 value of 5.

Another approach to estimating the global subaerial CO_2 emission rate of volcanos is to extrapolate the rates for the volcanos in Table 1 to all active subaerial volcanos. The 5-year running average for the number of active volcanos per year is approximately 60 (Simkin and Siebert, 1984). I base the extrapolation on the median emission rate of the seven volcanos (Figure 1) because the data set is small, and the median, unlike the mean, is less sensitive to outlying data. The median value of 0.03 x 10^{12} mol yr^{-1} indicates a global subaerial emission rate of approximately 1.8 x 10^{12} mol yr^{-1}. Reassuringly, this result is larger than the rate for Mount Etna alone and similar to the estimate of Williams et al. (1990). Applying the same procedure to the median SO_2 flux for the same seven volcanos (0.0035 x 10^{12} mol yr^{-1}) gives a global volcanic SO_2 output of 0.21 x 10^{12} mol yr^{-1}, which agrees well with the 0.24 x 10^{12} mol yr^{-1} estimate of Berresheim and Jaeschke (1983).

Table I. CO_2 Emission Rates for Subaerial Volcanos.

Volcano	Geologic Setting	Source Characteristics	Period of Observation	Method	Rate[a] 10^{12} mol yr^{-1}	Reference
Mount st. Helens Cascades Volcano Range Western U.S.	convergent plate continental margin dacitic magma	quiescent summit plume between explosive or dome-building episodes	July 1980- September 1981	A	0.04	Harris et al. (1981) Casadavall et al. (1983)
White Island Taupo Volcanic Zone New Zealand	convergent plate island arc andesitic magma	quiescent crater plume before explosive episode	November 1983	B	0.03	Rose et al. (1986)
		December 1983; quiescent crater plume	November 1984 January 1985	B B	0.0073 0.081	Rose et al. (1986) Rose et al. (1986)
Augustine Aleutian Volcanic Arc Alaska	convergent plate island arc andesitic-dacitic magma	summit plume during low- level explosive episode	April 1986	B	0.05	Symonds et al. (1991)
Vulcano Aeolian Islands North of Sicily	convergent plate island arc trachyandesitic magma	quiescent summit plume; flux through flanks	September 1984 September-October 1988	B C	0.0015 0.0004	Carbonnelle et al. (1985) Baubon et al. (1990, 1991)
Redoubt Aleutian Volcanic Arc Alaska	convergent plate island arc andesitic magma	quiescent summit plume between explosive or dome-building episodes	June 1990	A	0.015	Casadevall et al. (1990)
Mount Etna East Coast of Sicily	intra-plate continental volcano	summit plume during intense degassing, sometimes	September 1984 Jun 1985	B B	0.58 0.58	Carbonnelle et al. (1985) Allard et al. (1987)

	alkaline basaltic magma	Strombolian; flux through flanks	September 1984 June 1985	C C	0.46 0.46	Carbonnelle et al. (1985) Allard et al. (1987)
Kilauea North Pacific Ocean	intra-plate oceanic hot spot tholeiitic basalt magma	quiescent summit plume	9 December 1983 13 February 1984 July 1956-April 1983	A A D	0.03 0.01 0.03	Greenland et al. (1985) Casadevall et al. (1987) Gerlach and Graeber (1985)

[a]Average emission rate over period of observation.
A, measurement by airborne MIRAN infrared spectrophotometer of CO_2 content of volcanic plume.
B, measurement by airborne COSPEC ultraviolet spectrophotometer of SO_2 column abundances in volcanic plume coupled with data for CO_2/SO_2 ratio of plume or high-temperature fumarolle gases supplying plume (corrected for atmospheric contamination).
C, soil gas measurements of diffusive CO_2 flux through unvegetated volcano flanks.
D, based on volcanic gas data, volatile concentrations in matrix glasses and glass inclusions, and long-term magma supply rate.

The above estimates for the global CO_2 emission rate from subaerial volcanos are based almost entirely on measurements during quiescent degassing. They are about an order of magnitude larger than the estimated annual CO_2 emission of 0.15 x 10^{12} mol yr^{-1} released from all forms of erupting lava (Leavitt, 1982). Leavitt's estimate is based on a chronology for subaerial eruptions between 1800 and 1969, and it assumes an average eruption volume of 0.1 km^3 magma (2.7 g cm^3) and a release of 0.12 wt% CO_2 during eruption. Taken at face value, this estimate implies the predominance of quiescent CO_2 degassing from volcanos, as suggested previously by Rose et al. (1986).

Gerlach (1991, § 5)

Comparisons with Anthropogenic Emissions

Man's emissions of CO_2 from fossil fuel burning, cement production, and gas flaring alone not amount to 500 x 10^{12} mol yr^{-1} (Boden et al., 1990). Contributions from man's management of the biosphere (for example, deforestation) are less well known but potentially of the same magnitude. Thus, man's activities replenish the atmospheric CO_2 deficit by more than 45 times over. They are equivalent in terms of CO_2 production to turning on about 17,000 additional Kilauea Volcanos or 350-700 additional mid oceanic ridge systems.

Gerlach (1991, § 6)

Conclusions

The results reviewed above suggest that constraining the global CO_2 emission rate by direct measurement is feasible. Both subaerial and submarine volcanos appear to emit CO_2 at global rates on the order of 1-2 x 10^{12} mol yr^{-1}; thus, while the global rates from subaerial and submarine volcanos are uncertain at the present time, a total global estimate of 3-4 x 10^{12} mol yr^{-1} seems reasonable and conservative. This estimate for volcano degassing is consistent with estimates of total CO_2 degassing 6-10 x 10^{12} mol yr^{-1} based on atmospheric CO_2 balancing, and it indicates that CO_2 emissions from volcanos contribute about 35-65% of the CO_2 needed to balance the deficit in the atmosphere-ocean system. Although the present-day global emission rate of CO_2 from volcanos is uncertain, anthropogenic emissions clearly overwhelm it by at least 150 times.

The global rate of emission of CO_2 from the mid-oceanic ridge system is estimated to be in the range 0.7-1.5 x 10^{12} mol yr^{-1}. Thus, mid-ocean ridges probably account for less than half of the global volcanic CO_2 flux, despite the fact that mid-oceanic ridge magmatism provides over 75% of the present-day magma supply to the crust. Efforts should be made to reduce the uncertainty that exists presently in estimates of CO_2 degassing from the global mid-oceanic ridge system, but an equally or more important priority in submarine studies is to begin acquiring data for CO_2 emission rates at off-ridge volcanic systems such as submarine hot spot volcanos and back-arc basin spreading centers.

The available data suggest that CO_2 emissions from all subaerial volcanos are probably greater than from mid-oceanic ridges. This conclusion is at variance with the widely held view that the ridge system produces orders of magnitude larger emissions than do subaerial volcanos (e.g. CEES, 1990, p. 97). Indeed, the output from Mount Etna alone is about equivalent to that of the entire mid-oceanic ridge system. However, CO_2 emission data for subaerial volcanos are sparse, and the global contribution from subaerial volcanos is poorly constrained. Improving the data base for CO_2 emissions from subaerial volcanos is the highest priority for future work. The available data suggest that contributions of CO_2 in the range 0.01-0.05 x 10^{12} mol yr^{-1} can be expected from most active subaerial volcanos (Figure 1). however, alkaline volcanos (for example, Mount Erubus, Nyiragongo) may produce 1-2 orders of magnitude larger contributions, if Mount Etna is any indication. On the other hand, Etna's large CO_2 output may be augmented by contamination from underlying carbonates (Allard et al., 1987).

Investigations to date suggest that most of the CO_2 emitted by volcanos is released during quiescent degassing instead of eruptive degassing. This proposition needs further investigation, however, and should be tested against more data for quiescent degassing and measurements of CO_2 emissions from volcanos during episodes of vigorous eruptive degassing. Techniques are sorely needed for making direct CO_2 emission measurements, especially during large explosive eruptions, by remote spectroscopic techniques similar to the widely used COSPEC technique for measuring volcanic SO_2 emission rates.

Berner and Lasaga (1989) have characterized the calculation of CO_2 degassing from igneous and metamorphic activity as the most vexing problem encountered in modelling the carbon geochemical cycle. In hopes of getting at least a reasonable approximation of CO_2 degassing over geologic time, modelers have coupled all degassing to seafloor spreading rates (Berner et al., 1983). This approximation is reasonable for CO_2 degassing at mid-oceanic ridges and subduction zones. The adequacy of seafloor spreading rates as a predictor of mid-plate volcano degassing rates is less clear, and it is possible that CO_2 degassing at mid-plate volcanos is outside the conceptual framework of the current carbon cycle models. The high CO_2 degassing rates for Mount Etna underscore the need to ensure that mid-plate volcano degassing is satisfactorily represented in models of the carbon geochemical cycle.

Gerlach (1991, § 7)

Acknowledgements

I thank R. Berner, T. Casadevall, and T. Hinkley for several suggestions that improved this paper. Support from the USGS Global Change and Climate History program is gratefully acknowledged.

Gerlach (1991, § 8)

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