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Comparing Large Scale Geothermally Related Topographic and Bathymetric Features and the Mantle Convection Rolls Model

Steingrimur Thorbjarnarson

Oddabraut 13, 815 Thorlakshofn, Iceland

steingrims@outlook.com

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ABSTRACT

Two main features of the Geology of Europe are the Mediterranean-Mjosa Zone, extending from the Mediterranean to Norway, and Teisseyre-Tornquist Zone along with its extension of Sorgenfrei-Tornquist Zone. Both of those zones can be described mathematically with formulas describing division lines between convection rolls, then drawn as infinitively narrow theoretical lines, and the two main lines of the mantle current system are found to cross each other in Denmark at the geothermal plant of Amager in Copenhagen. This corresponds to the anticipated alignment of mantle convection rolls and how they affect the tectonic plates. The relevant formula has been derived according to information about inner layers of the Earth and the expected properties of convecting mantle within the said layers. The formula can also be derived from distinct geological features on the surface. The Reykjanes Ridge follows the mathematical formula of a circle, on a regular grid of latitudes and longitudes, centered on the 32nd parallel. Juan de Fuca, follows exactly the same formula as the Reykjanes Ridge, centered exactly 90 degrees farther to the west on the same parallel. The Rheine Graben, follows the same formula, also with central point on the said 32nd parallel, 45 degrees farther east than the Reykjanes Ridge mathematical central point. The Rheine Graben is 1.5 degrees wide from east to west, equal to the width of the East Volcanic Zone of Iceland. All this is in harmony with an analysis of a mantle convection rolls model, where each roll of the uppermost layer has the width of 1.5 degrees, aligned according to the formula of a circle centered on the 32nd parallel. The rolls extend horizontally out from equatorial plane, swaying in harmony with rotation and shape of the Earth. The repeated occurrence of orientation according to the relevant mathematical formula is an argument for the real existence of a convection rolls system, where each main layer represents a set of parallelly aligned convection rolls. Referring to the complete mantle convection rolls model. On global scale, examining the so-called tectonic equator, the GPS Nasa database shows precise relationship between tectonic drift and the convection rolls model. It shows that tectonic drift is not random, and the surface shows resemblance to the active mantle current system underneath. The 30 degrees steps of main topographic delimitation precisely along equator, from the West Coast of South America to the Amazon Estuary, to the Mid-Atlantic Ridge (a point of the same mathematical equation as the Reykjanes Ridge), to the West Coast of Africa, to the Great Rift Valley, to the Mid-Indian Ridge, to the Indonesian West Coast, to the Indonesian East Coast, indicates long-term (even though ever-changing) relationship between surface topography and convection rolls system of the mantle. Whereas the Convection Rolls Model indicates that large scale convection rolls of lower mantle should span 30 degrees from east to west each, the fit between theory and direct mapping is perfect, and the real existence of the said convection rolls is the only logical solution in sight. As the relevant mathematical solutions point directly to established sites of geothermal utilization, this knowledge should be useful for pinpointing new geothermal areas as well.

1. INTRODUCTION

Convection within the mantle is a well-known concept, and a comprehensive convection rolls model was derived according to the physical properties of mantle material under stable conditions (Walzer, 1971). When the convection rolls system was introduced at the World Geothermal Congress in Iceland in 2021, emphasis was laid on how the system was derived and how it could be used to explain the geological circumstances in Iceland (Thorbjarnarson, 2021). The first reaction was to ask for a similar world-wide analysis of the system, and to comply with that request, some basic examples are provided here. The convection rolls model has been extensively compared with mapped and indirectly observable features for over two decades. At the equator, the centrifugal plane and convectional plane are unified, and convection rolls, with equal height and width, fit precisely into the measured layers (Figure 5). The horizontal alignment of convection rolls is also calculated, with its basic diameter found at 32°N and 32°S, equal to Earth's radius (Paldor & Killworth, 1988). The lower mantle contains convection rolls 30° wide from east to west, and above the 410 km discontinuity, smaller, 1.5° wide convection rolls, fit within in the so-called asthenosphere, also with a 1:1 height to width ratio. Within the transition zone in between 410-670 km, the same proportions are found for convection rolls. The resulting convection rolls system can be compared with main features mapped on the surface, and some extremely large-scale structures are selected here, such as the spatial intervals of 30° along equator, and the 90° relationship between Reykjanes Ridge and Juan de Fuca, besides the Mid-Indian Ridge. These three ridges all have a similar function, producing new material adding to the bottom of the oceans. Juan de Fuca was located centrally within the Pacific Ocean before, and it is therefore no surprise that it shows resemblance to the Mid-Atlantic and Mid-Indian Ocean Ridges. The mathematical formula describing the convection rolls is crucial. The Reykjanes Ridge follows the equation of the convection rolls, considered to be found at each side of it. Extending the line of the ridge according to the equation, leads us to the center of the Atlantic Ocean at equator. From that point, the distance to S-America on one side and Africa on the other spans exactly over 30° of the equatorial parallel, as the Atlantic is altogether 60° wide there. The evidence then piles up, revealing the real mantle convection rolls system within the Earth. Understanding the basic system, we can leave these simple preconditions behind, starting with more sophisticated methods to investigate the relationship between the convection rolls system and surface characteristics. An example from the European Continent is taken, as two main features, the

Mediterranean-Mjosa Zone, extending from the Mediterranean to Norway, and Teisseyre-Tornquist Zone along with its extension of Sorgenfrei-Tornquist Zone, cross each other where geothermal activity is found in Denmark. Finally, the rather newly found tectonic equator does show resemblance to the derived convection rolls model. With all these indications, the convection rolls system should become a very useful tool for geoscience, and essential for understanding the Earth's interior. The system also tends to form N-S or E-W oriented topographic or bathymetric features, because different layers with mirrored alignment of convection rolls compared with a NS-axis can affect the same area.

2. THE REYKJANES RIDGE AND ITS RELATION TO JUAN DE FUGA AND THE MID-INDIAN RIDGE

Juan de Fuca is known to be the remaining part of a formerly much larger ridge in the middle of the Pacific Ocean. We can therefore look at it as a counterpart of the Mid-Atlantic Ridge. The shape of the mid-ocean ridges has been explained by anticipating the existence of convection currents (Hess, 1962). Elaborating on that idea, a system is presented here as the convection rolls model, based on the physical properties of mantle rolls with 1:1 height and width ratio. The solution is simple but would be difficult to find without referring to conditions in Iceland, both its volcanic zones and the Reykjanes Ridge. The length of Reykjanes Ridge, mathematically consistent for over 1,000 kilometers, provides a very solid foundation for testing the analysis of mantle convection rolls based on the Earth's layers.

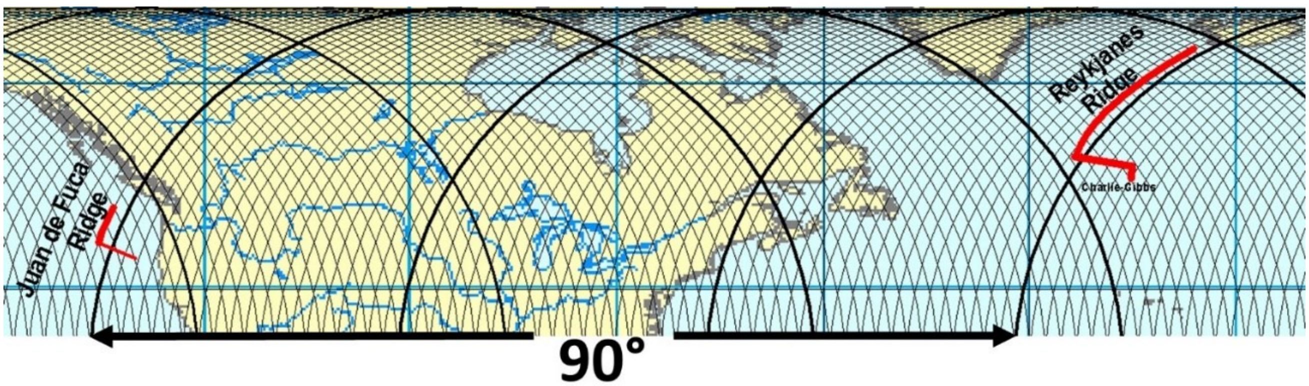

Figure 1: Juan de Fuca and Reykjanes Ridge compared. Wide black lines show large-scale convection rolls divisions. The relevant convection rolls are 90° apart. Three large-scale mantle convection rolls separate the ridges, spanning 30° each from east to west. Thinner lines show upper convection rolls divisions. Drawn on GIS map.

Understanding the geophysical properties of Juan de Fuca is crucial for analyzing the geological processes of the West Coast of North America. We can look at it as the Pacific counterpart of the Mid-Atlantic Ridge. The location of both ridges complies with the equation (Thorbjarnarson, 2021):

$$(x-C_n)^2 + (y-32)^2 = 35.34^2 \quad (1)$$

Where x stands for latitude, y for longitude, and C_n for each central point of the circular path on the x-axis, found along the 32nd latitude, respectively with 1.5° interval. The values are: C_n = {-178.7, -177.2, -175. 7,…, -0.2, 1.3, 2.8, … ,179.8} for n from 1 to 240. 35.34 is the horizontal diameter (in units of degrees of latitude and longitude) of the mathematically circular rolls.

The value of Reykjanes Ridge is C_n = -7.7 and for Juan de Fuca is C_n = -97.7, with a difference of 90°. Many more examples can be provided, showing resemblance between the convection rolls model and the topography clearly mapped on the surface. The double nature of the convection rolls emerging as the result of interaction between lower large-scale convection rolls and upper convection rolls of smaller scale is quite intriguing. The pattern of small-scale convection rolls is the same above down-welling and up-welling divisions between large-scale rolls. This is an important factor, especially regarding the examples given here, because up-welling is always offset 1.5° compared with the lower mantle convection rolls. It can be pointed out that the next 30° step leads mathematically to Hawaii, and according to that, the island is found in relation to the next large scale mantle rolls division line west of Juan de Fuca. It has been shown that the Emperor Chain was formed due to volcanic propagation along a line, not due to tectonic drift above a relatively fixed area. The point where Hawaii is found now was at the southern-most end of that line (Foulger, 2010). Hawaii can therefore be considered as located on a hot line, rather than a hot spot. Similarly, the Yellowstone hot spot has been associated with formation of linear dike swarms, found to adhere to the same mathematical equation of a circle as presented here.

The apparently perfect match between the Reykjanes Ridge and Juan de Fuca might be overlooked or somehow ignored, because it might, at first, look like a coincidence. Adding the third large-scale structure should eliminate the factor of pure chance. We do not even have to search for an additional example, because there is only one option left out of the three large oceans of the North Hemisphere. Looking into the other direction, namely to the east, a similar relationship between the Reykjanes Ridge, and the Mid-Indian Ridge appears:

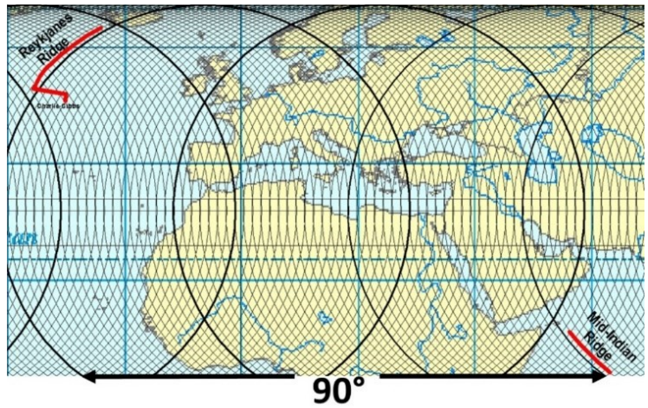

Figure 2: The Reykjanes Ridge and the Mid-Indian Ridge compared, marked with red lines. Both ridges are found in context with large scale convection rolls division lines, being 90° apart. Drawn on GIS map.

These ridges are both over 1.000 km long, and follow calculated lines, representing distinct divisions between convection rolls drawn on the map. As mentioned before, the reason for this consistency is explained by referring to the thickness of Earth's layers and physics. All three ridges are found at different latitudes, but all of them follow the predicted alignment of convection rolls. The position is also consistent with the analysis. How the ridges are found to be offset by 1.5° from the large-scale divisions is explained here:

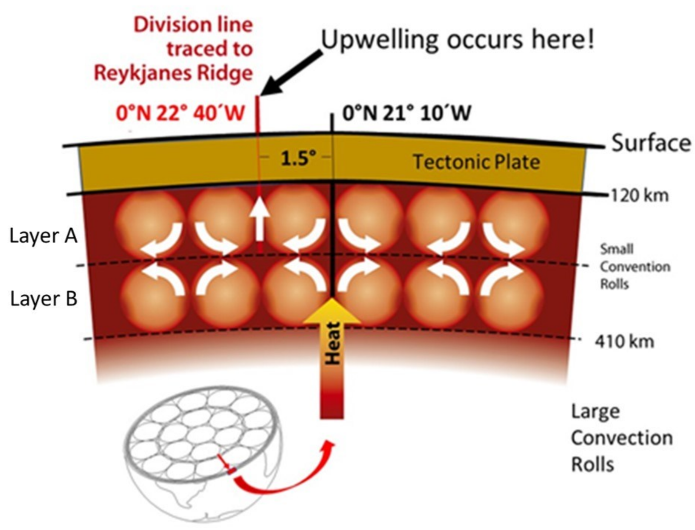

Figure 3: Small red square of Earth's equatorial section is enlarged. White arrows show the direction of convection.

The analysis begins with the equatorial plane, where many reference points can be used to find the exact location of the division lines. The three-dimensional shape of the convection rolls can be calculated, making it possible to locate the convection rolls globally. Comparison with large scale topographic and bathymetric features, which are likely to be formed directly by the convection rolls, provides feedback for evaluating the validity and accuracy of those calculations. As seen in figure 3, heat flow from large-scale divisions between rolls of lower mantle causes upwelling directly above within the next layer, here called layer B, found at 410 km depth. The upper most layer rolls rotate the opposite way along equator, and therefore final upwelling directly affecting the tectonic plate is always offset by 1.5°. The difference is maintained all over the globe, as all convection rolls are horizontally aligned in the same way, following the equation of a circle, as previously mentioned: $(x - Cn)^2 + (y - 32)^2 = 35.34^2$. This example (figure 3) leads mathematically to the Reykjanes Ridge. The other ridges can then be analyzed in the same way.

It is obvious that 1:1 width to height ratio convection rolls sections, of vertical circulation, fit into the equatorial plane (see figure 6). To test the validity of whether that is the case or not, a model must be made where the said rolls are prolonged northwards and southwards. Measuring the dimensions of a convection rolls north of equator, it is immediately realized that the height should be maintained, but the width diminishes! What about the relevant physics of equal height and width then? The answer is that the plane of centrifugal effect and the plane of convectional flow have been separated. These two planes can be imaged as acting on the same infinitely small flowing particle, and can therefore be mathematically unified at each latitude. Doing so, the physical properties are maintained of equal height and width of the convection roll at each latitude. This sounds complex, but one can always look back at the simplicity of the equatorial plane, where convection and centrifugal effect are combined in 2D, and start working from there. The difficulties can be overcome, because for decades scientists have solved the problems related to moving particles within the rotating Earth. The weather system and sea currents also provide some analogy which can be useful to understand the horizontal component of mantle flow. Therefore, it is possible to trace a particle found within a Newtonian fluid, in this case where no oscillation takes place, gradually following a path where it sways according to the Earth's curvature on one hand and equally gives in to the rotational effect on the other hand. The result is a mathematically circular path, in the form of convection rolls, which perfectly fit into the Earth's total volume and ensure continuous flow of mantle material.

3. THE 30 DEGREES INTERVALS BETWEEN TOPOGRAPHIC AND BATHYMETRIC DELIMITATION POINTS ALONG EQUATOR

Pointing out the divisions of coasts and mid-ocean ridges along equator, delimitations are found with intervals spanning 30°:

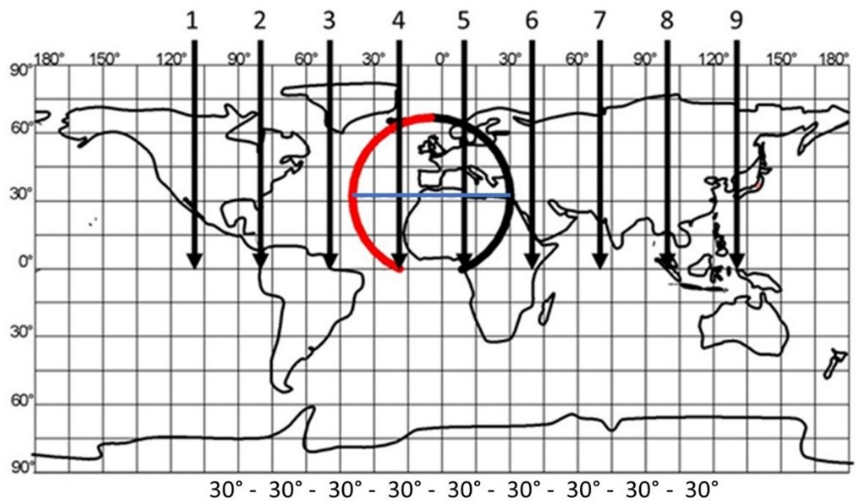

Figure 4: The equatorial '30° delimitation points' marked with arrows. Red curve shows an upper most convection roll (within layer A) extending from the Mid-Atlantic Ridge at equator to Iceland, also revealed by the Reykjanes Ridge. Black curve shows its counterpart, a convection roll of layer B. Blue line is the horizontal diameter spanning 35.341°, being equal in length to Earth's radius, along the 32nd parallel.

The regular interval between delimitation points along equator conflicts with the feeling that tectonic drift should be random. The ocean ridges are constantly changing, and the continents continuously shift position. According to that feeling, should this 9 or even 10-point sequence be disturbed soon in Earth's history, probably never to appear again? (The tenth point has been found indirectly as the intersection between the rotational and tectonic equators.) Perhaps the Great Rift Valley is the best example to deny that feeling. It shows how the 30° interval system is renewing itself within a mainland drifting over equator. In this case, facts, and measurements, compared with physics, logic and calculations provide a better background for a scientific conclusion than the assumption that we already know things well enough. Looking at the equatorial plane systematically according to the main features on surface, indicating the real existence of the 30° wide convection rolls, this picture emerges:

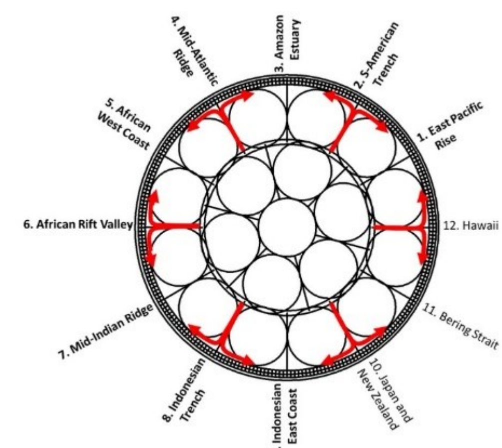

Figure 5: The twelve large-scale lower mantle convection rolls division lines. Nine are directly detectable at equator. The remaining three lines indicated at other latitudes, Hawaii, Bering Strait, and Japan/New Zealand, are also identified here. Iceland is also pointed out as a location in addition to the crossing between equator and the Mid-Atlantic Ridge.

The 30° steps of topographic delimitation along equator shows exact resemblance between convection rolls model and surface mapping. The sequence of eight times 30° is statistically far beyond any possibility of being a coincidence. The main reasons for the equatorial arrangement have been pointed out systematically (Walzer, 1971). The trend of mantle material to form convection rolls, accompanied with 1:1 height to width ratio, has been confirmed (Manneville, 2010). North of equator, any moving particle flowing northwards will sway to the right, and likewise deviation is found to the left for southwards flowing particles. A popular statement is that horizontal Coriolis Effect at equator is zero. At equator, the centrifugal effect of Earth's rotation reaches maximum. It can be reasoned, that within the equatorial plane the convection rolls sections are arranged exactly on top of each other (Walzer, 1971). All these special aspects of equator can lead to a special spatial arrangement of topographic and bathymetric features on the surface along it. Examination immediately leads to the finding of regular arrangement, which in turn is spatially the same as the result of analysis of the upper mantle layers, where convection rolls of same height and width would fit exactly in between the Gutenberg layer (CMB) and the 410 km discontinuity. The Gutenberg layer is an intersection layer and the layers between 410 and 670 km are known as a transition zone, being integral parts of the large-scale convection of the lower mantle rolls. Thereby, the expected outcome of convection pattern on one hand, and the regular distribution of land mass, trenches, ridges, and rifts along equator on the other hand, accurately correspond to each other. The layers of the Earth have been measured accurately and crucial division points along the 0° parallel can be defined quite easily.

Looking at some details along equator, South America is the first to mention, with 30° separating the Peru-Chile Trench and the Amazon River Estuary. The Amazon River is larger than any other river, so it can be considered to have isostatic effect, with an estuary forming at a site of weakness found below the tectonic plate. An interval of 60° separates the Amazon Estuary and the West Coast of Africa. A section of the Mid-Atlantic Ridge almost follows equator, but the central point is easy to find, exactly in the center where a span of 30° is found to both S-America and Africa. From the West Coast of Africa, again we have a distance equivalent to 30° to reach the Great Rift Valley, the only place along equator where the existence of convection rolls division line is manifested on land. From there, again the arc of 30° separates the Great Rift Valley from the Mid-Indian Ridge, and from there we have a 30° span over to the trench at the western side of Indonesia. Tracing the equatorial line over Indonesia, we find the east coast exactly 30° away from the west coast. This sequence is reckoned to form because of large-scale convection rolls extending from the depth of 2.900 up to the 410 km discontinuity. A more detailed understanding of the geological processes is achieved by investigating the interaction between the upper most convection rolls, covering 1.5° each along each parallel and equator itself.

An explanation of the 30° delimitation sequence along equator has been provided with the comprehensive convection rolls model (Thorbjarnarson, 2021). Other large-scale features follow the corresponding horizontal settings of convection rolls all over the globe. The system underneath the tectonic plate, responsible for this regularity found on the surface, can be derived by inserting convection rolls sections of equal height and width into the Earth's layers. Searching accordingly along equator provides the said manifestations 9 times in a row, allowing us to consider the statistical probability to be calculated as $1/30^8$, which is impossible to achieve without physical cause.

In this context, the so-called tectonic equator, which has been traced according to results of GPS monitoring of tectonic drift, should be examined. (Doglioni & Panza, 2015). The consistency between the two models, of the convection rolls and the tectonic equator, is apparent in two different ways. First, it passes the rotational equator at two locations, 120° apart, comprising exactly four times the basic unit of 30° for one convection roll. The location of crossings over equator also coincides with model division lines, one over the Great Rift Valley of Africa, and the other over a division point within the Pacific, central of the lines extending to the volcanic areas of Japan (Fuji) and New Zealand. Another aspect of the tectonic equator is that it reaches towards 32°N and 32°S. These parallels also have central qualities in the convection rolls model, because the convection rolls are oriented exactly north-south there, and an imaginary horizontal trajectory following the roll alignment has the same string diameter as Earth's radius (6,371 km, or 35.341° of an arc) along the said parallels.

The tectonic equator is an important argument for the existence of a regular mantle flow centered around the rotational equator. It was mentioned before that another delimitation point along equator appears as a counterpart of the Great Rift Valley, 120° to the east:

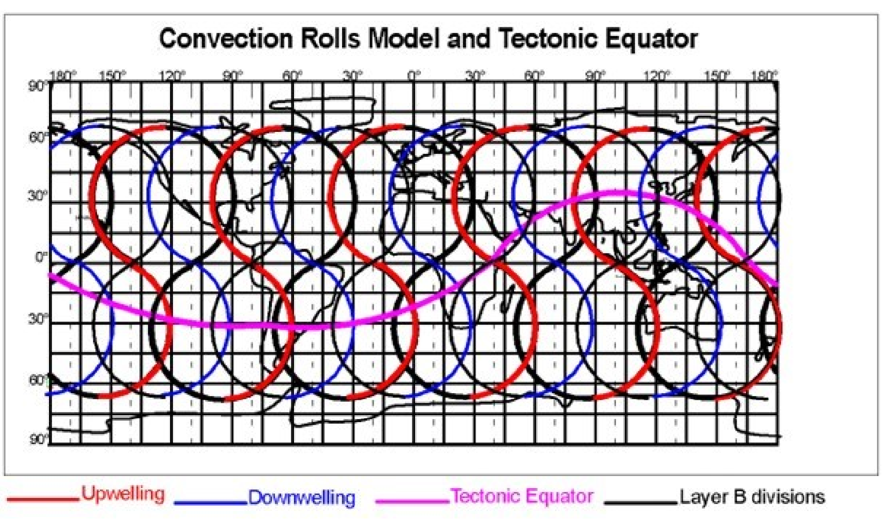

Figure 6: The tectonic equator and its relevance to the convection rolls model.

The tectonic equator is shown with a blue line. Crossings at Great Rift Valley of Africa, which is also a point of division of the convection rolls model between large scale convection rolls. The other crossings over equator in the south-western Pacific are also found to be a division point between convection rolls, thereby becoming the tenth point of 30° delimitation revealed with observation of the surface.

The long distance of lateral tectonic drift is then driven by the convection rolls with upper part rotating the same way as the plate drifts. Coupling and de-coupling will occur, as a convection roll rotating the same way as the tectonic plate above will consolidate with it to some extent, whereas the one opposing the drift will de-couple itself due to extra friction and partial melting. This happens because the temperature of mantle material at the border between convection roll and rigid tectonic plate is exactly at the relevant melting point. An analogy is found with glacial landforms, so called whalebacks, frequently found in Iceland. The ice at the bottom partly melts when sliding over a rock, easily passing it. On the contrary, at the other side when friction is minimized, the glacier and the rocky obstacle will freeze together and plucking of rocks takes place.

3. THE MEDITERRANEAN-MJOSA ZONE, EXTENDING FROM THE MEDITERRANEAN TO NORWAY, AND THE TEISSEYRE-TORNQUIST ZONE ALONG WITH ITS EXTENSION OF SORGENFREI-TORNQUIST ZONE

Large scale features of the Earth can be represented with mathematics. The western side of the East European Craton is associated with the zone, and it can be clearly defined seismically (Grad, 2019). The mathematics of the convection rolls system fit to the alignment of the Teisseyre-Tornquist Zone and its Danish counterpart Sorgenfrei-Tornquist Zone. The seismicity follows the pattern of polygons very accurately, as shown here by numbering the adjacent polygons.

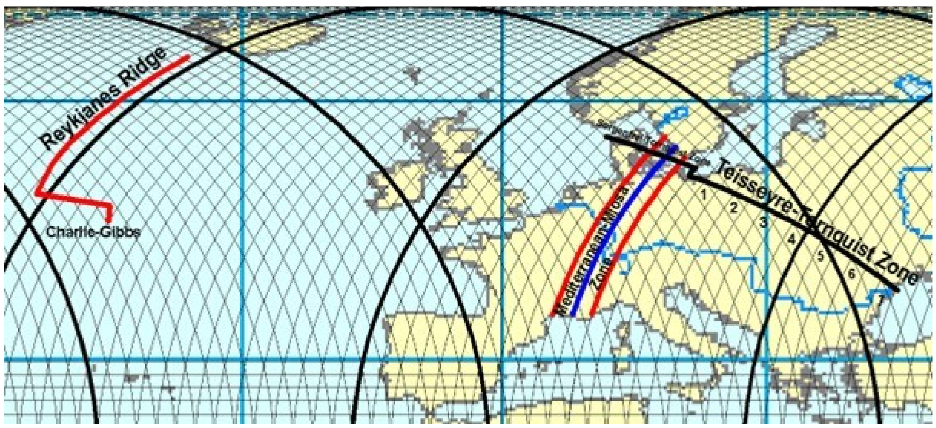

Figure 7: The Convection Rolls System, with the three large scale features, of Reykjanes Ridge, Mediterranean-Mjosa Zone and Teisseyre-Tornquist Zone along with the Sorgenfrei-Tornquist Zone, inserted theoretically. Superimposed on a GIS map.

This is a main feature of Europe's geology, and it coincides with the estuary of the Danube River into the Black Sea. The shift from Sorgenfrei-Tornquist Zone to Teisseyre-Tornquist Zone also fits mathematically to the pattern of convection rolls, as shown here. The mathematical sequence is illuminated by numbering every two polygons. The relevant upwelling division lines are marked with red lines, and the downwelling one with a blue line. NE-SW oriented lines stand for the upper layer and the NW-SE oriented lines for the lower layer. Both layers, A and B, (see figure 3) affect the zone, but only layer A, with convection rolls aligned NE-SW, is considered here.

This arrangement is not random at all. The Reykjanes Ridge is located on top of the ascending convection rolls division line, offset to the west by 1.5° compared to the large-scale lower mantle division line. The Mediterranean-Mjosa Zone is in the middle of the range of the large-scale convection roll underneath mainland Europe, and the western edge of the Rheine Valley (Rhönetal) and the Bresse-Graben complex is found to coincide with convection rolls division line 45° east of the line marking the Reykjanes Ridge. The blue convection rolls model downwelling line of the Mediterranean-Mjosa Zone is prolonged over Denmark on the map, to show where it crosses the Sorgenfrei-Tornquist Zone theoretical line. It is intriguing that the two lines cross each other exactly at the site of a geothermal power plant, of Amager, near Copenhagen.

The European Cenozoic Rift System, including the Rhine Valley, can hardly be understood without deciphering the forces below leading to tension within the crust, because compression is the main trend in the surroundings, and the current existence of a hot spot, and thereby ascending magmatic material, has repeatedly been suggested (Sippel, 2008).

Taking the ECRS as an example here, is mainly due to how it resembles the Icelandic volcanic zones and the Reykjanes Ridge mathematically. All those three geological structures have different characteristics, the ridge being divided in a clear-cut way in between rolls, the volcanic zones constituting an area being torn apart above a roll, and the rift valleys in Europe being the outcome of complex processes of formation of the mainland. The different aspects of seafloor and mainland might also make this comparison seem obsolete. In this case the concept of tectonic plate must be emphasized. Both seafloor and mainland crust are just the uppermost parts of tectonic plates, which can be divided into brittle and ductile parts with no convection taking place within them. The division between brittle and ductile parts of a tectonic plate is known as the Moho division, and is not to be confused with the bottom of a tectonic plate, which here is considered as the division between ductile and convecting material. According to Francis (1993), that discontinuity marking the thickness of tectonic plates is found at the depth of 120 kilometers. The convection rolls model can be used to predict the interaction between the slowly flowing mantle material found below 120 km depth and the rigid material of the tectonic plates themselves. Comparison leads to the result that the convection rolls system does maintain itself despite eventual impact from above, such as subduction of tectonic plates into the mantle, but the tectonic plates show considerable resemblance to the arrangement of mantle convection rolls. The transition from rigid-ductile to flowing-ductile phase takes place at a high-pressure related melting point, vulnerable to small effects that can lead to either coupling or de-coupling between the layers. These effects can occur systematically around structures like the ECRS and the Icelandic volcanic zones and reveal themselves as mathematically identical topographical markings on the surface.

The Teisseyre-Tornquist Zone is another geologically different example, found to be aligned regularly along a row of polygons automatically drawn according to the mathematical properties of the convection rolls model, The polygons appear as a pattern when the division lines of the two convection layers (labelled as A and B in this article) between 120 and 410 km depth are all drawn on a single map. Those polygons are marked with the numbers 1-7 on the map, to make the relationship between model and zone explicit. The Sorgenfrei-Tornquist Zone is a continuation aligned parallel to its larger counterpart.

The combined effect of convection rolls of different depth is quite apparent. The two layers, here called A and B, of convection rolls, where each roll spans 1.5° from east to west, are underlain by the similar, but much larger convection rolls. All of them play a role affecting the surface. For instance, the 30° wide convection rolls have shaped the Atlantic Ocean and determine its width at equator, but the 1.5° wide upper rolls determine the scope of the volcanic zones in Iceland, and the Reykjanes Ridge is offset from the main large-scale division by 1.5°. Other curious aspect of the convection rolls model is when two layers affect the surface simultaneously, one determining the length and the other the width of the relevant topographical or tectonic structure.

4. COMPARING THE LARGE-SCALE GLOBAL FEATURES WITH GEOLOGY OF ICELAND

The statistics mentioned for the equatorial spatial divisions and harmony of the mid-ocean ridges are convincing, but referring to geophysical data is needed for a scientific approach. The 30° pattern along certain latitudes, especially equator, and similar smaller-scale 1.5° intervals, might have been left unnoticed, if it was not for the geology of Iceland. Therefore, the volcanic and seismic zones of Iceland are included here as examples of large scale geothermally related structures. The South Iceland Seismic Zone (SISZ) covers exactly 1.5° from east to west along the 64th parallel (Einarsson & Björnsson, 1979). It connects two volcanic zones, the West Volcanic Zone and East Volcanic Zone. The eastern end of the SISZ is the center of the volcano Hekla. Exactly 1.5° farther east, the other border line of the East Volcanic Zone is found. Accurately 1.5° east from there, also on the 64th parallel, is the center of Öraefajökull, Iceland's largest volcano.

The SISZ is very important in this context because it is aligned exactly E-W, with earthquake faults oriented N-S and regularly distributed (Einarsson, Böttger & Thorbjarnarson, 2002). The pressure vectors inducing relevant earthquakes are measurable, and the eastern and western end points of the zone are therefore known. To achieve this degree of regularity, a regular framework surrounding this part of the tectonic plate is a necessary precondition. The diamond-shaped area shaped by the division lines, as suggested to be found between convection rolls, comprise exactly that kind of framework, here called polygon, which leads to the modelled formation of the SISZ. The North Volcanic Zone (NVZ) of Iceland is also clearly north-south oriented. This kind of alignment can therefore be expected to occur on a very large scale. Consequently, ocean ridges can be shaped either due to pulling of convection rolls from each side, or due to the break-up of areas comparable to the polygon of SISZ, leading to long N-S oriented structures. Other alignments can also emerge, such as for the Teisseyre-Tornquist Zone, which follows a pattern provided by the polygons of the convection rolls system underneath at given latitudes.

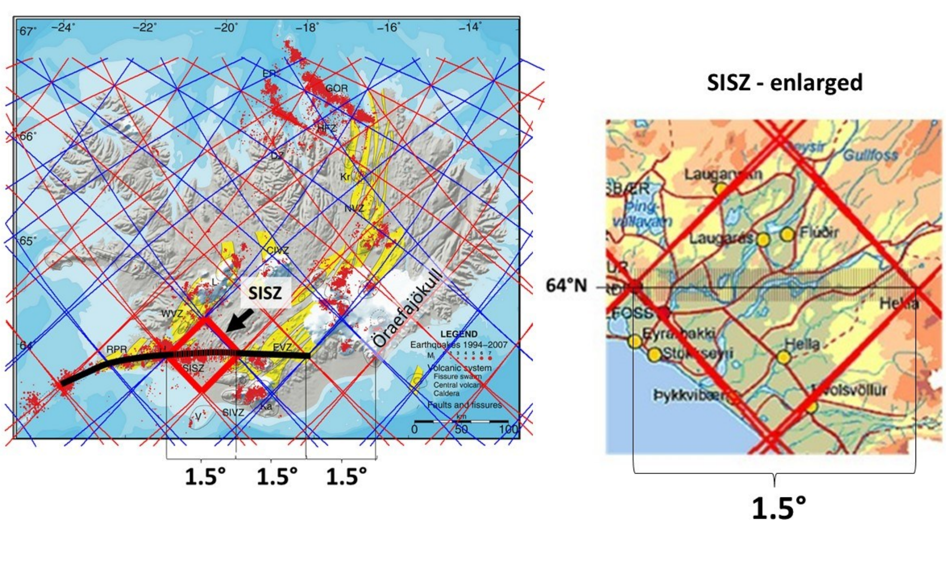

Figure 8: The South Iceland Seismic Zone (SISZ) is well defined according to geophysical data. It is aligned from east to west spanning exactly 1.5°, along the 64th parallel, shown with black horizontal line through the red polygon. An outer framework is necessary to create such a distinct zone, and the division lines between the modelled convection rolls form a polygon providing the necessary preconditions for creating the SISZ. Map from National Land Survey of Iceland.

The South Iceland Seismic Zone is found above one of those smaller-scale convection rolls of layer A, spanning 1.5° from east to west. Along the 64th parallel, the modelled convection rolls are arranged directly above each other, and therefore the roll of layer B coincides exactly along the 1.5° span of the entire length of the SISZ. This makes the 64th parallel an excellent case to study.

The key for understanding the convection rolls system is adhering to the equation, and simply following the resulting lines on the map. These two layers of convection rolls, 1.5° wide, as measured directly from east to west, are found in between 120 and 410 km depth:

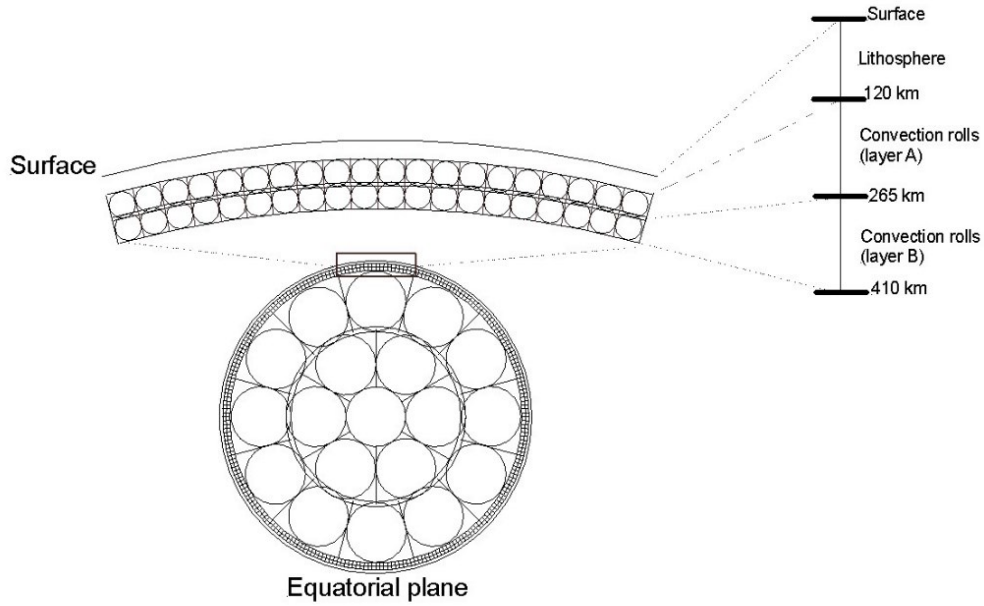

Figure 9: A 30° section of the Convection Rolls System enlarged, with the upper most layers, here called layer A and B. Each upper roll covers 1.5° from east to west everywhere on the globe. A 3D model is then accomplished, adding horizontal alignment.

The main features of the geology of Iceland suddenly become explainable by referring to this convection rolls system. But Iceland is within the latitudes where two different sections of the system intersect each other. This makes it harder for us to keep track of what is going on, but the calculations according to the given equation lead the way. Two layers extending from the North Pole intersect with two layers originating from equator, resulting in four layers.

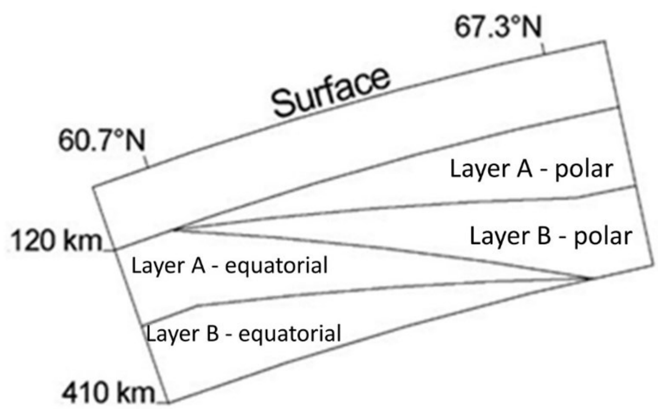

Figure 10: The intersection zone found between 60.7°N and 67.3°N according to the convection rolls model. Layer A and B extending from equator are subducted by the northern convection rolls A and B layers. Therefore, there are four layers underneath Iceland, according to the convection rolls model of equation (1).

Comparing the volcanic zones of Iceland with the Reykjanes Ridge, shows consistency with the West Volcanic Zone, as the upwelling line following the crest of the ridge for 1.000 km, and the western edge of the WVZ is found exactly 1.5° west of the mathematical central line of the Reykjanes Ridge. The study of how the forces creating the Reykjanes Ridge are also at work underneath Iceland is important for studying some main geothermal areas, as shown here:

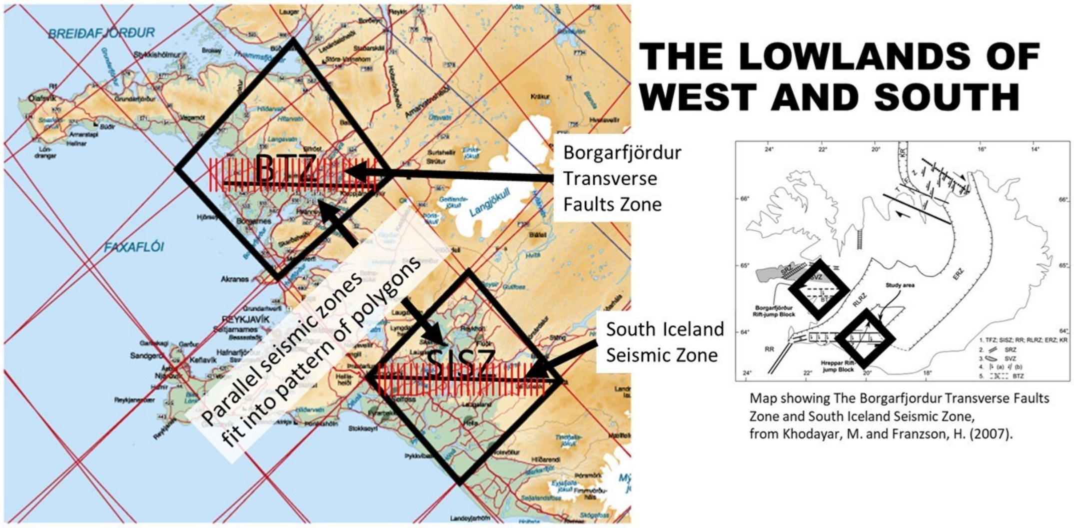

Figure 11: Two lowlands found at each side of the West Volcanic Zone, which is formed as a continuation of the Reykjanes Ridge. The lowlands have very similar seismic zones of parallel N-S faults, complying with the polygons of the model. Many of these faults are geothermally active, and better understanding of their formation is important for overall utilization. Map base from the National Land Survey.

The consistency of 1.5° intervals in Iceland, found east of the Reykjanes Ridge, is considered to be of the same nature as the intervals of 30° found along equator. The Reykjanes Ridge line is well defined mathematically, and the eastern edge of West Volcanic Zone coincides with the downwelling side of the convection roll forming the Ridge at its eastern side. The match between convection rolls system on one hand, and the volcanic and seismic zones of Iceland on the other hand, is thereby obvious.

The volcanic zones of southern Iceland mainly follow the alignment of the upper most layer (layer A). To eliminate the confusing effect of lines showing different layers of convection rolls, relatively short bits of imaginary convection rolls are inserted. It is emphasized here that these imaginary straight bits of rolls, just as the curved rolls of the model, have the width of 1.5° from east to west:

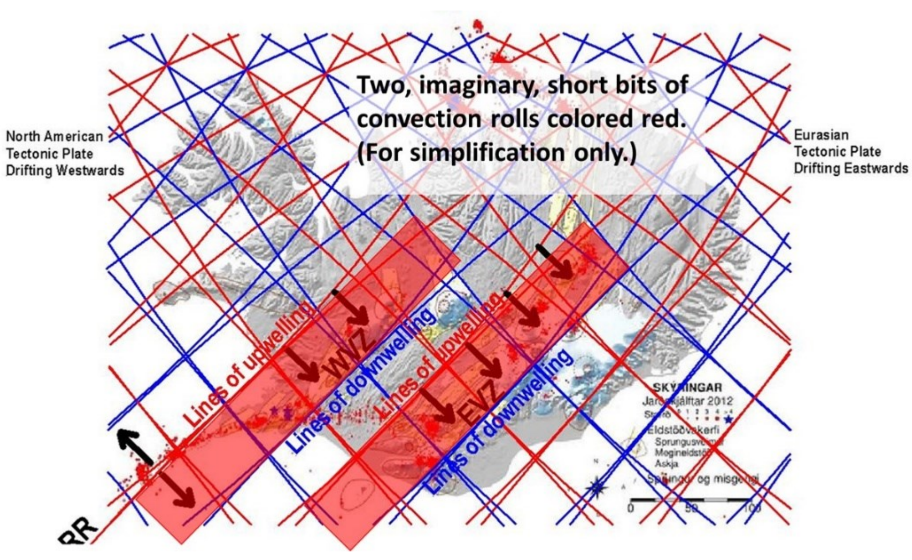

Figure 12: Two short bits of imaginary convection rolls inserted in red color and drawn with straight lines for clarification (as real mantle convection rolls are always curved). The arrows show rotational direction of convection. The rolls explain both the existence of the volcanic zones and the Reykjanes Ridge. Volcanic systems and active faults are from Einarsson and Sæmundsson (1987).

The system of rift valleys found in Europe, known as the European Cenozoic Rift System, resembles the volcanic zones of Iceland in a few ways. The valleys follow the same equation of alignment, mainly to the NE-SW, but also in a mirrored way, that is NW-SE. Edges of the valleys of the ECRS are found along lines 1.5° apart from east to west, corresponding to the division lines between convection rolls. The direct context between volcanic zones and the Reykjanes Ridge can be seen, because the WVZ and the ridge are partly shaped by the same convection roll. The Pacific and Indian Oceans then provide us with examples of ridges in context with large scale convection rolls division lines, mathematically found to be separated by a 90° span from the large-scale rolls division of the Atlantic Ocean, where the Reykjanes Ridge is found. These long features can hardly be explained with any other factor than convection rolls, and all attempts to investigate that possibility further have been successful.

Comparing model and real topography, or in this case bathymetry, can be surprising. The Reykjanes Ridge is found to be the central foundation of harmonic settings for the Greenland-Iceland-Faroe Ridge Complex (Hjartarson et al, 2017), as shown here, with the convection rolls model superimposed on a geological map. Why the shelf, on which Iceland is formed, shows this resemblance with the elliptical form is not clear, but logical, because the area is commonly known to have developed symmetrically to the east and west from a central line, which can basically be represented by the Reykjanes Ridge.

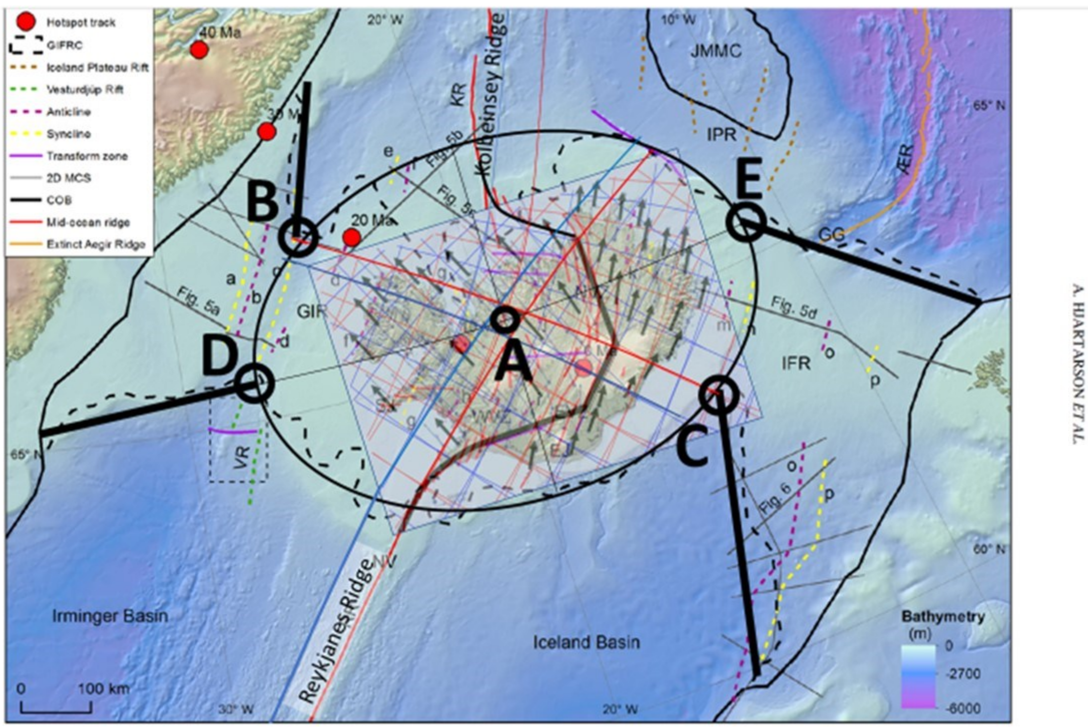

Figure 13: Convection Rolls Model superimposed on a map showing the outlines of the Greenland-Iceland-Faroe Ridge Complex. The Reykjanes Ridge and Kolbeinsey Ridge can be extrapolated to meet in point A, with points B, C, D and E symmetrically distributed around it. The NS-axis through Iceland appears, with equal distance to points D and E. Map base from Hjartarson et al (2017).

The symmetry between the Reykjanes Ridge and the elliptical form of the shelf, as drawn here, is quite perfect, and if two more letters, F and G would be added where the red, mathematical, line of the Reykjanes Ridge intersects the theoretical elliptical outline, they would fit perfectly into the sequence of letters surrounding the ellipse.

The interplay between swayed features like the Reykjanes Ridge, and clearly N-S or E-W oriented large-scale topography, can be explained by the symmetry between convection rolls of different layers, especially layers A and B in between the depth of 120-410 km. The NS-axis found through point A can be used on global scale, to emphasize on the likelihood that a regular mantle current system is found within the Earth, explaining the consistency found when comparing the Convection Rolls Model with topographical features. For the sake of simplification, another map is added with the NS-axis exaggerated. A high degree of consistency is achieved by referring to the convection rolls model, derived from the inner structure of the Earth, revealing the fact that distance is equal to the edges of a basically elliptical bathymetric shelf and the eastern and western outposts of the Icelandic volcanoes, Snaefell and Snaefellsjökull, from the NS-axis. To further elaborate on the drawing of the elliptical shelf, the SE-quarter is almost perfectly shaped, and that part is extrapolated to the other three quarters.

Some long features follow the predicted convection rolls model directly (Reykjanes Ridge). Besides that, the inherent possibility of forming E-W and N-S oriented structures is consistent with the intervals between convection rolls (equator delimitation points, SISZ, NVZ). Other types of alignment, mapped features directly comparable with the model are also found (Teisseyre-Tornquist Zone). Diamond-shaped polygons marked by divisions within layers A and B, can be examined in context with the convection rolls underneath. It is meant to be an additional tool for understanding the processes of interaction between mantle currents and tectonic plates, and to open possibilities for employing all other research tools more systematically and utilize resources in more effective ways.

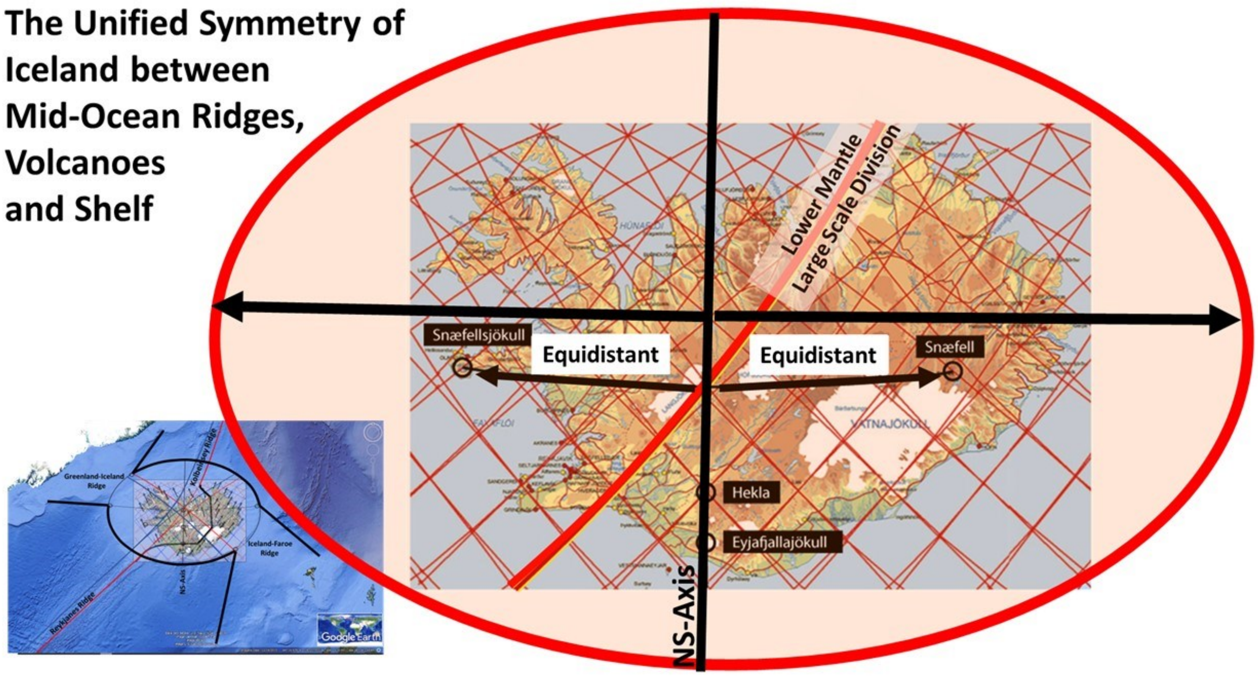

Figure 14: The elliptical shape of the Icelandic shelf shown in context with the convection rolls model. The imaginary connection point between the two ridges north and south of Iceland coincides with a direct NS-axis, which for instance can be traced through the volcanoes Hekla and Eyjafjallajökull. Map from National Land Survey of Iceland.

The NS-axis is then shown in a much larger context. The Icelandic elliptical shelf has been marked red and framed in along with the Greenland-Iceland-Faroe Complex.

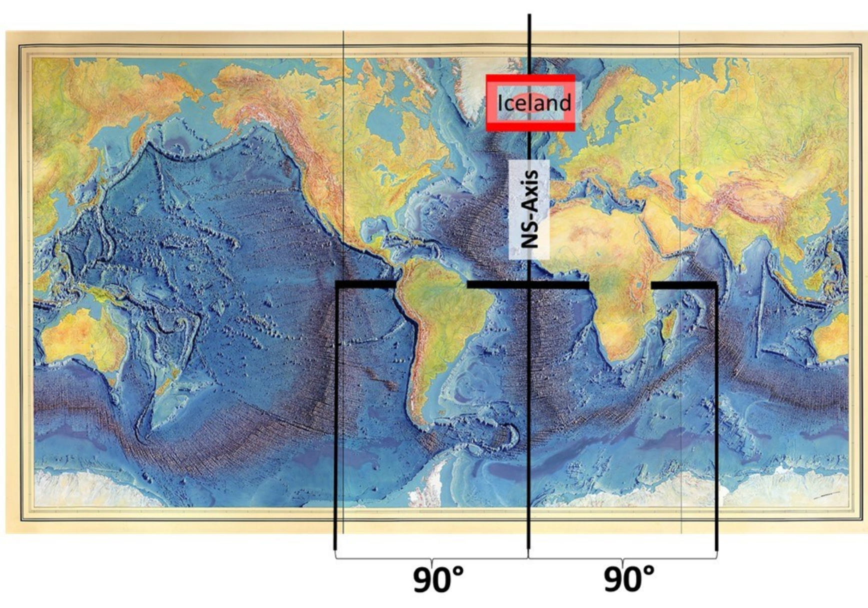

Figure 15: Just as the Reykjanes Ridge can be seen in context with Juan de Fuca and the Central Indian Ridge by using the equation for convection rolls, the NS-axis found through Iceland can be used to roughly show harmony between the main N-S oriented ocean ridges in the South Hemisphere. Map painted by Heinrich Berann (1977) according to mapping by Marie Tharp.

The purpose of representing the Convection Rolls Model is to show that it might be descriptive for the real circumstances found within the mantle. The rolls can shape long features in between them like the Reykjanes Ridge, and besides that the aggregate pattern formed by rolls of different layers can lead to N-S and E-W tectonic and topographic features, some rather small-scale, like the South Iceland Seismic Zone, or other large-scale ones such as the Mid-Atlantic Ridge south of equator. The shape of the ridges can be explained according to the convection rolls model, firstly by referring to physics of constantly heated mantle material flowing within the rotating Earth, and secondly by deriving it mathematically from long structures, acting as 'outcrops' where the shape of the rolls is reflected on the surface. The swayed 'S-shape' of the North Atlantic and the 'I-shape' of the South Atlantic are thereby explainable as two outcomes of the same convection rolls system.

CONCLUSIONS

The Reykjanes Ridge has a central role of the northern hemisphere, and its existence can be explained by a model of convection rolls pulling at its sides to east and west. A mathematical equation of a circle, centered on the 32^{nd} parallel, can be applied to describe its shape and alignment. The same equation applies to the alignment of Juan de Fuca, geologically shown to be of the same nature within the Pacific as the Mid-Atlantic Ridge of the Atlantic Ocean. This equation was derived according to the physics of slowly convecting mantle material within the rotating Earth. Comparison shows resemblance between alignment and relative position of mid-ocean ridges on one hand and the convection rolls model on the other hand. The relevant calculations using the equation to examine these relationships are very accurate, even to the extent of pinpointing individual geothermal sites. The match between surface mapping and the convection rolls model can be shown to be statistically very high for different latitudes of the globe. For instance, a row of 9 delimitation points revealing intervals, which span 30° each, along equator is statistically virtually impossible to occur without an underlying cause. The modelled large-scale mantle convection rolls span 30° each, thereby being precisely consistent with the expected 1:1 ratio of height and width of mantle rolls in between core and asthenosphere, and their existence can explain this equatorial sequence. The mid-ocean ridges of the North Hemisphere; Reykjanes Ridge, Juan de Fuca, and Mid-Indian Ridge, are aligned in coherence with the convection rolls model with defined 90° intervals. Another example is how the Reykjanes Ridge, superimposed on the comprehensive convection rolls model, is consistent with an elliptical form of the Icelandic bathymetric shelf. The NS-axis of the said elliptic shelf can then be directly compared to the N-S trend of large sections of mid-ocean ridges of the South Hemisphere, with roughly 90° intervals. The continuous appearance of the entire Mid-Atlantic Ridge of both North and South Hemispheres, indicates that it is shaped by a single pair of large-scale convection rolls within the lower mantle, and the exact location of those rolls is suggested with calculations according to the equation given in this article. The convection rolls model is also consistent with a series of delimitation points in Iceland separated by 1.5° from east to west, matching the calculated dimensions of modelled upper convection rolls. This confirms the validity of the equatorial plane as a starting platform for analyzing and modelling the comprehensive mantle convection rolls system of the Earth. It is therefore suggested that the explanatory and predictive properties of the convection rolls model should be applied for systematically exploring geothermal resources, and become a tool for geoscience in general to enhance our understanding of tectonics for utilization of different types of resources.

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