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A Comprehensive Model of Mantle Convection Rolls

Steingrimur Thorbjarnarson

Oddabraut 13, 815 Thorlakshofn, Iceland

vardeldur@vortex.is

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ABSTRACT

A model of Earth's inner structure based on Rayleigh-Bénard convection shows resemblance with geothermal activity, as well as topography, tectonics and volcanism all over the world. According to the model, convection rolls fill each mantle layer in a predictable way and the position of division lines between them have been calculated. This model works like key to open new possibilities for the utilization of geothermal energy. The division lines between convection rolls can be calculated. The convection rolls have equal height and width, and the horizontal flow vectors of each pair are opposite to each other. With the convection rolls map at hand, the detailed tectonic drift history, along with volcanic activity, geothermal activity and tectonics become more understandable, and the possibility of exact calculations is introduced. In Iceland, tectonics often follow exactly the calculated values of convection rolls below, due to divergent effect. Lower layers can also affect the tectonic plates above and thereby the surface. The best known volcanic and geothermal areas are found at points where mantle rolls division lines of different layers cross each other. A single formula is used to calculate the alignment of all convection rolls for the entire world. Features like the Reykjanes Ridge show direct resemblance with the said alignment, as convection rolls at each side of the geological structure have a pulling effect, which in turn is directly measurable on the sea floor. The whole model could in fact be drawn by extrapolating the shape of the Reykjanes Ridge. Whereas explicit surface topography can be directly traced according to calculated alignment of convection rolls, unseen tectonic features can be anticipated by applying the same calculations. The seemingly variable characteristics of all the Icelandic volcanic zones can be explained accordingly. The nature of the low temperature areas can be clarified by analyzing distinct areas, here called polygons, marked by mantle rolls division lines. The Southern Lowlands of Iceland, with the South Iceland Seismic Zone, is a clear example, found within such a polygon. The SISZ faults pattern along the parallel of 64°N and the dynamics within the seismic zone can then be explained in detail according to the interplay between tectonic drift and the dimensions of the polygon, thereby adding to our understanding of the preconditions of the well-known book-shelf model of the zone. Here, the intention is to emphasize on the effects of convection rolls system on the surface. The utilization of this model can lead to findings of new geothermal resources and more effective utilization of those sources already found. Once the system of convection rolls had been fully developed, it became possible to explain the location of both volcanic and geothermal sites, both on big scale and in the finest detail. The formula for calculation is based on presuming that convection of the mantle is stable, and the basic length scale of a horizontal flow vector along the convection rolls should adhere to Earth's radius, resulting in a comprehensive model of the whole globe.

1. INTRODUCTION

The inner structure of the Earth can be analyzed according to the general information available about the Earth's layers and physics. Accurate formula for position and shape of convection cells within the Earth's mantle is then derived according to these preconditions. This formula can be tested with the help of geological maps from all over the world. To take one specific example, maps of rift zones in Iceland follow exactly the results of calculations with the said formula. The convection rolls system follows the same formula everywhere, and thereby should open the possibility of calculations, in addition to field exploration, all over the world. Before, no one would think that the orientation of the volcanic zones in Iceland could be calculated according to rather simple preconditions. The convection cell system of the Earth's mantle can be analyzed quite accurately, greatly increasing our understanding of geology.

The model can be derived in a few steps, beginning with the Equatorial Plane, where a regular system of convection would match with the well-known layers of core and mantle. It is presumed that sections of convection rolls are thereby directly detectable within the Equatorial Plane, and the rest of the convection rolls system of the whole world can thereby be calculated. By comparing the resulting convection rolls model with the geology of Iceland, the model can be tested. If coherence is found between calculations and the geology of Iceland, the model has then proved its predictive value.

2. THE EQUATORIAL PLANE

The large volume of the mantle and the fact that convection has taken place for billions of years, conditions must have achieved a balanced state as explained by Walzer (1971). The layers of Earth have been measured quite accurately and everyone can check how circles can be drawn into them, representing convective cells with equal height and breadth. The reasons for the physical tendency of Rayleigh-Bénard convection rolls, under stable conditions within the Earth to have these dimensions, are examined mathematically by Manneville (2010). The result is that, under these conditions, the rolls should not have exactly same height and breadth, but the proportion close to $\pi/3.12$. Deriving the vertical aspect of the convection along the two-dimensional plane of equator requires minimal calculations. It is a coincidence of mathematics of the circle, that the radius of the Earth's core is the basic unit used for these calculations, that is 1221 km (Allen, 1983). The sequence of *1-6-12* identical circles, all connected with only one tangential point, fits as a mathematical model within Earth's layers of inner core, outer core, mantle and the Gutenberg discontinuity.

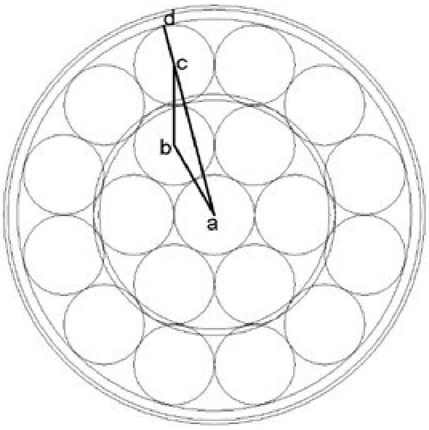

Figure 1: A mathematical model used to find the coherence between cells of equal height and breadth with the Earth's layers. The Gutenberg discontinuity is found to function mathematically as upper limit for outer core rolls and lower limit for lower mantle rolls.

Point *a* is the Earth's center, and point *d* is mathematically the upper most limit of the model of large cells of equal height and width, including the inner core, outer core rolls (with central point *b*) and the relevant part of the mantle (with center at point *c*). We find that the length of the line $ad=4*(\cos 15°)(1221*(\pi/3.12))+1221$; $ad=5{,}971$. At equator the Earth's radius is 6,378 km, so that gives the remaining distance towards Earth's surface: *6,378–5,971=407 km*. A discontinuity is found at 410 km depth (Allen, 1983), and given that match it is found reasonable to keep on with the analysis. According to Francis (1993), a tectonic plate is 120 km thick, as convection takes place below that depth. The dimensions of rolls of a pair of layers within the remaining void between 120 and 410 km depth are then calculated according to same preconditions in every way, including intersection and proportion:

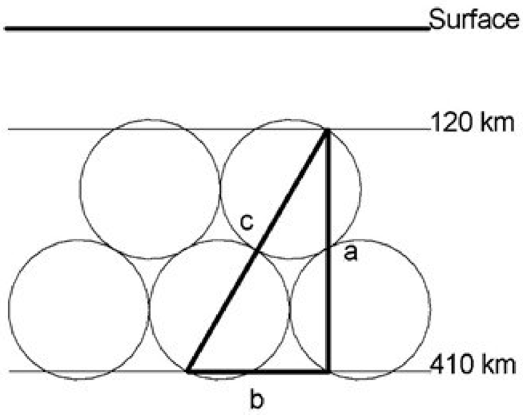

Figure 2: A mathematical model used to find the number of convection rolls of equal height and breadth with the Earth's layers, extending from tectonic plate bottom down to top of the large scale mantle convection rolls. Intersection proportions always remain the same. The same properties of intersection are found within the Gutenberg layer, as shown in figure 1.

The radius of a circle of the model can then be calculated according to the sides, *a, b* and *c* of the triangle where $c=2b$; $(2b)^2=b^2+a^2$; $b=167.4$; The number of convection rolls is found by dividing the circumference of the Earth with the horizontal diameter of a circle within the mathematical model, which is: $(40{,}075/(167.4*(3.12/\pi))\approx 240$. Thereby the globe should have 240 convection rolls side by side within the upper most layer. The main conclusion of this calculation is that each roll spans $360°/240 = 1.5°$, measured directly from east to west along every latitude of the globe. The centrifugal force affects the cells everywhere in a comparable way as within the equatorial plane, and a vertical section of a convection roll always maintains the said proportions perpendicular to Earth's rotation axis.

The transition layers, for example the Gutenberg discontinuity, are functionally important for heat exchange from the lower set of convection rolls to the one above. The mathematical match with the Gutenberg layer provides the proportion of intersection of convection activity between different layers used throughout this model. The proportion between convection rolls and intersection layer is thereby revealed by the measured thickness of the Gutenberg layer, and supposed to be the same for the other layers above. Therefore, the resulting mathematical model becomes very accurate. The two layers of figure 2 are seen as necessary to ensure the relevant circulation. The result is also perfectly in accordance with the measured thickness of the well-known asthenosphere layer, found in between the bottom of the tectonic plates and the depth of 200 km. Another fundamental discontinuity is found at the depth of 670 km (Allen, 1983). Extrapolation, with exact trigonometry of the system of 240 parallel convection rolls, also fits to that discontinuity. It leads to the conclusion that within the large convection rolls of the lower mantle, a secondary set of convection rolls is found in between 410 and 670 km depth.

Thereby a wholistic picture of the equatorial plane does emerge. The convection rolls should be arranged one upon another there as suggested by Walzer (1971). The Gutenberg discontinuity, found between approximately at 2,700-2,900 km depth (Allen, 1983), is seen as a transition layer, with the two layers of outer core and lower mantle convection rolls intersecting each other. The resulting equatorial plane can thereby be drawn schematically:

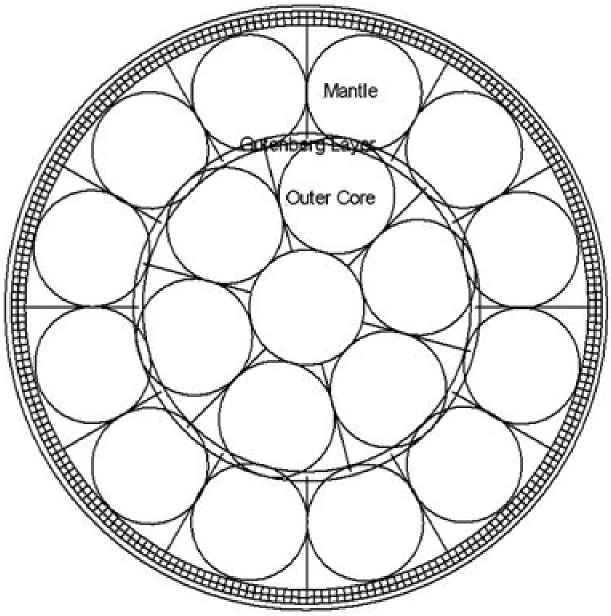

Figure 3: The equator section of the convection rolls model. Inner core, outer core, lower mantle large cells, the two layers between 120 and 410 km are shown. The layers between 410 and 670 km depth are omitted. The section is drawn to scale and indicates that the large convection rolls intersect within the Gutenberg layer.

By adhering to a single precondition of convection, all the discontinuities fall into the resulting pattern. A similar model of convection rolls sections was suggested by Hess (1962). The next step will be tracing the sections of convection rolls out from the equatorial plane. The result should then be a three-dimensional model of the convection rolls system of the Earth. As the secondary convection rolls within the large lower mantle have little direct impact on the surface, they will be omitted in the rest of this article. Even though the plane of equator is the most easily understood part, sections of different latitudes are affected by the same kind of centrifugal force and convection. The path of a convecting particle, within a vertical section of a convection roll of this mathematical model, maintains the proportion of equal height and width compared with the rotation axis of the Earth at all latitudes. This is a heat flow system, based on material flow. However, radioactive material is the primary heating source, so radiation must reach the core of the Earth and heat it. The radioactive elements are mostly distributed within the top layers of the Earth , but heat is constantly dispersing from the core with convection (McBirney, 1993). The radiation from the upper layers through the mantle and to the core seems to have been neglected in the literature of geology, but my father, Thorbjörn A. Fridriksson, did point out that according to the graph of heat conductivity within the mantle, presented by McBirney (1993), the mantle must become transparent to heat radiation, and therefore the core is constantly being heated by the radiation from the uppermost layers of the Earth. Fridriksson also points out that Munroe effect can then occur when two symmetric sources of energy flow combine, in this case causing flow of magma into the ductile tectonic plate above, as explained theoretically with the statement that ‘force is concentrated to become a jet’ by Torrey (1945).

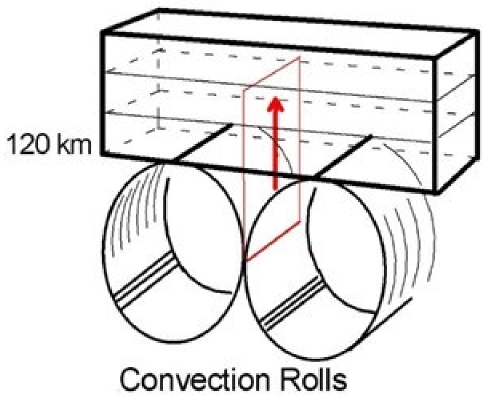

Figure 4: A pair of convection rolls underneath a tectonic plate. The ductile part of the tectonic plate is then divided by long term Munroe Effect. In this way, the tectonic plates are divided into distinct polygons by the grid of convection rolls division lines.

3. THE HORIZONTAL ALIGNMENT OF THE CONVECTION ROLLS

The section of equator is the starting point for analysis of the whole system of convection rolls. If we follow the path of an infinitely small particle within a convection roll, we will find out that it will not keep on rotating endlessly within the equatorial plane, but spiral away either north or south. This spiral path of the particle represents the total shape of the convection roll. Therefore, we can follow this horizontal aspect of the convection roll. Various examples of such horizontal paths were calculated by Paldor and Killworth (1988), and they suggested that the basic length unit is the Earth's radius. By referring to their calculations, the Coriolis Effect and the geoid form of the Earth, an equation for the alignment of the convection rolls was derived.

On a sphere, we find that the total length along each latitude is diminished by $\cos\varphi$, where φ is latitude, and therefore we can find the latitude where the diameter of horizontal circle is the same as Earth's radius, and the relevant circular path also crosses equator 30° apart. We first replace φ with y, for the mathematical grid of squares used for calculations. Then we solve the equation of a triangle: $x^2 + y^2 = ((1/\cos(y))*30)^2$. The solution, as $x=15$, is $y=32$, which then represents the axis for mathematical centers of the horizontal alignment of each convection roll. The effect of the geoid form has to be taken into account, as curvature of the Earth differs slightly at different latitudes. Thereby the horizontal path of a convection roll can be drawn within the mathematical grid:

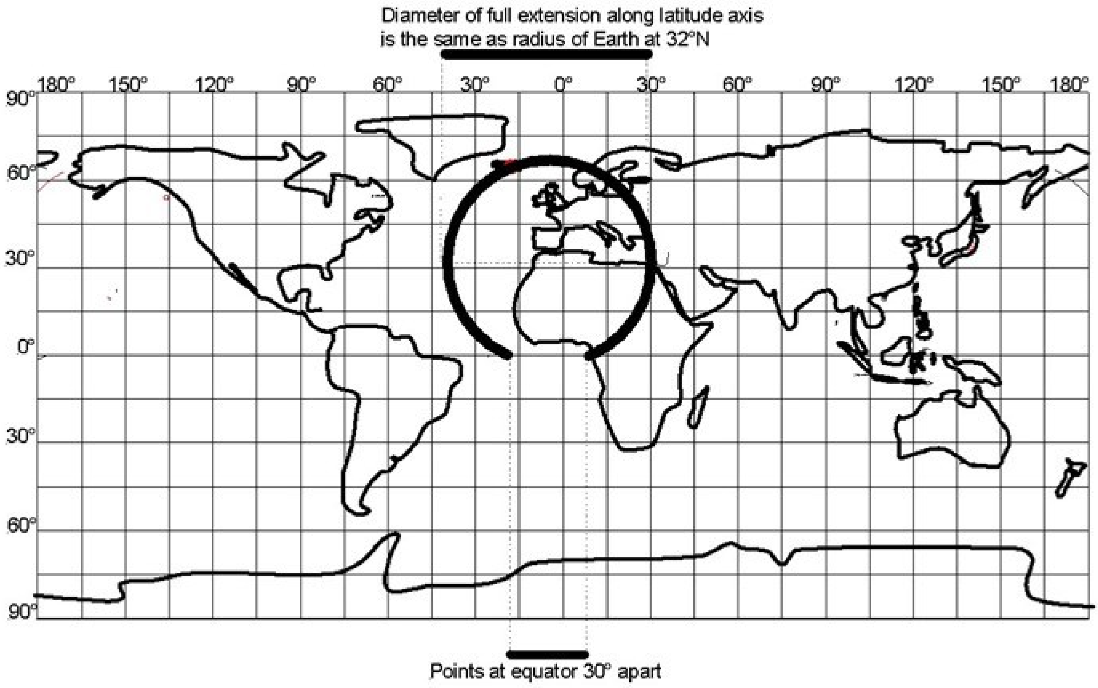

Figure 5: The calculated horizontal alignment of convection rolls. The arch consists of division lines between rolls of two different layers found within 120-410 km depth, connected end to end at the northernmost point.

A convection roll extends from equator towards either north or south according to the equation of a circle:

$$(x - C_n)^2 + (y - 32)^2 = 35.341^2$$

Here x, y and C_n stand for latitude, longitude, and each central point of the circular path on the x-axis, found along the 32^{nd} latitude, respectively. The values are: $C_n = \{-178.7, -177.2, -175.7, \ldots, -0.2, 1.3, 2.8, \ldots, 179.8\}$ for n from 1 to 240. The points of C_n are found 1.5 degrees apart around the globe. The radius of 35.341 corresponds to half of the Earth's radius along a straight line between two points on the 32nd parallel. This is the basic equation of the Convection Rolls System of the Earth. The same equation is applied for both hemispheres. The only difference is the fact that a flowing particle turns to the right in the Northern Hemisphere compared to the flowing direction, and to the left in the Southern Hemisphere.

The same equation applies for the polar areas, with the mathematical x-axis is found where y=96:

$$(x - C_n)^2 + (y - 96)^2 = 35.341^2$$

The convection rolls system in polar areas follows the equation, where $C_n = \{-178.7, -177.2, -175.7, \ldots, -0.2, 1.3, 2.8, \ldots, 179.8\}$ for n from 1 to 120. It follows from those equations, that an intersection zone is found between 60.7°N and 67.3°N, and in the same way between 60.7°S and 67.3°S.

An essential factor of understanding how the convection cell system works is recognizing that it circulates constantly in the same way, without any hindrance, regardless whether vertical or horizontal flow vectors are traced within the convection rolls system. It turns out that intersection is an integral part of the convection rolls system. The tangential points, between equatorial and polar parts of the convection rolls system is found at $y=64$, as central diameter is found along $y=32$. The model has thereby been almost fully described, showing how inner heat is carried to the surface by a convection rolls system.

Adhering to the two versions of the equation for convection rolls alignment, we can trace the resulting intersection zone. Mathematically the 64th parallel is the central axis of the zone. Again, a vertical segment should be drawn:

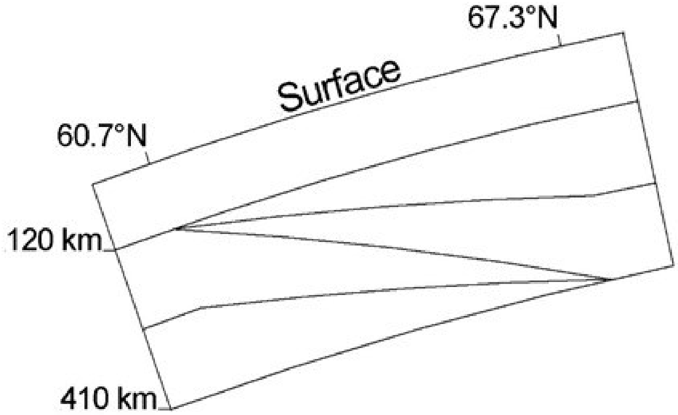

Figure 6: A schematic drawing of the intersection zone of convection rolls between 60.7°N and 67.3°N. Iceland is found within these latitudes.

Then we are ready to investigate the geology of Iceland, resulting from the effect of those four convection rolls layers found underneath the country. The convection rolls extending from pole are dominating as being found above the others, but they thin out to nothing at 60.7°N. The combination of pulling effect of the large-scale tectonic drift with the complex implications of the horizontal intersection zone can then be analyzed accordingly.

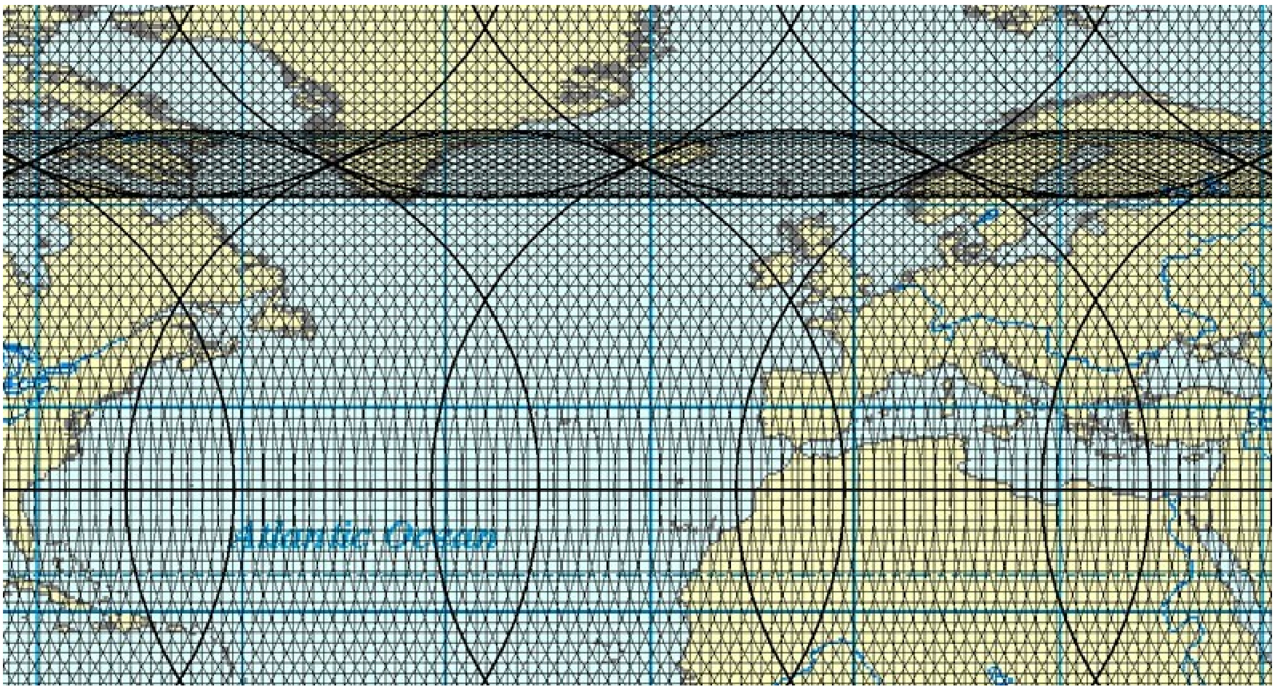

Figure 7: The location of convection rolls. The division lines between rolls of two different layers form a grid of polygons. On the map, degrees of longitude and latitude appear as of the same length. As rotation velocity difference between latitudes is a factor shaping the curvature of convection rolls, the difference of rotation velocity is in this way mathematically eliminated, and the horizontal curvature appears to be always the same at different latitudes. The result is a map showing the convection rolls aligned in a circular pattern. Drawn on GIS map.

3. THE GEOLOGY OF ICELAND EXPLAINED ACCORDING TO THE CONVECTION ROLLS SYSTEM

The geology of Iceland can be used to describe how this convection rolls system works. Here it is shown how it resembles the distribution of various geological features, from volcanic zones to tectonics, and of course, the distribution of geothermal areas.

3.1 The grid formed by division lines between the rolls of all four layers within the intersection zone found under Iceland

First of all, we should consider Iceland's position within the convection rolls system. The mathematical consistency allows us to zoom in on specific locations, for instance Iceland, and analyze its geological features by referring to the grid of division lines between convection rolls found within 120-410 km depth. Volcanic zones of Iceland and distribution of geothermal heat can then be directly compared with the convection rolls system. The story begins where the Reykjanes Ridge ends, as the convection rolls responsible for the rifting process along it, are subducted by other convection rolls extending from the north.

Figure 8: The grid of division lines between convection rolls underneath Iceland. The grid is the mathematical result of drawing circular lines according to equations $(x - C_n)^2 + (y - 32)^2 = 35.341^2$ and $(x - C_n)^2 + (y - 96)^2 = 35.341^2$ respectively, where C_n represent fixed numbers of longitude with *1.5°* interval, as explained in the text. The lines are drawn on a map from the National Land Survey of Iceland.

This grid allows us to check whether coherence is found between the geology of Iceland and the derived system of convection rolls. The result is surprising, as the volcanic zones, volcanoes and geothermal areas show resemblance to the grid of division lines between the convection rolls of the layers below Iceland. The examples are many.

However, the first line of reference is the division between the large cells of the lower mantle from 410-2,900 km depth. According to the model, this line extends towards NE as shown here:

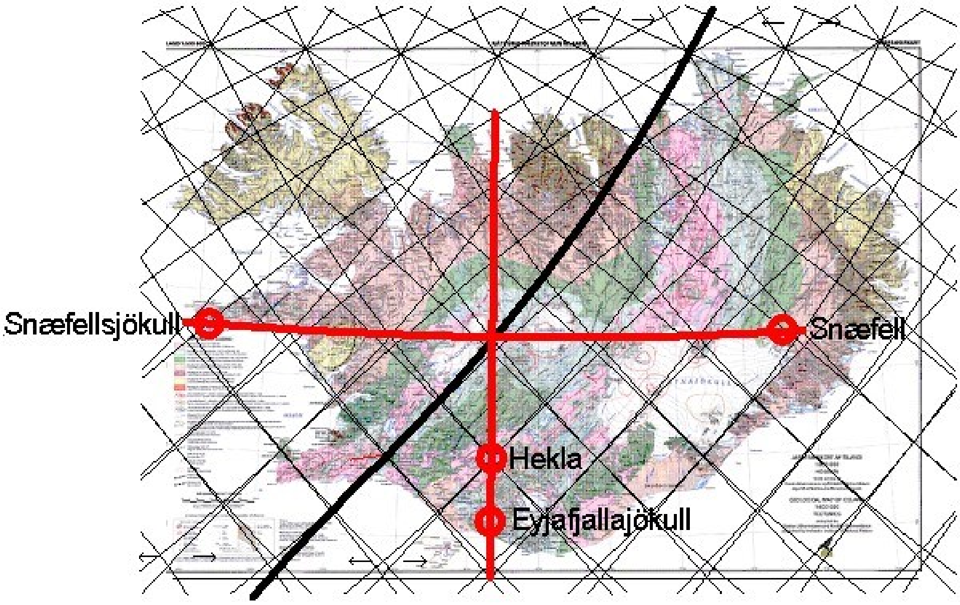

Figure 9 The wide black line shows the division between large convection rolls of lower mantle under Iceland. At the latitude 64°48′N, the peaks of the two outposts of Icelandic volcanoes are found, Snæfellsjökull and Snæfell, exactly the same distance from the central line at that latitude, shown with horizontal red line. The N-S axis through the same point, intersects the volcanoes Hekla and Eyjafjalljökull. The northern end of the axis extends through the extinct rift zone of Skagafjörður. Map is based on data from The Icelandic Institute of Natural History.

The fact that the distance from Hekla volcano to the peaks of the two outposts of Icelandic volcanoes, Snæfellsjökull and Snæfell is exactly the same, is intriguing. But the coherence between the mathematical model of the convection rolls also provides an explanation why it is so. The extinct volcanic zone, which is still seismically active, of Skagafjörður, as described by Hjartarson (2003), is found at the northern end of the N-S axis through Hekla. The volcanic zones are immediately found to resemble the derived pattern resulting from the convection rolls. Also, it can be explained why there are two distinct volcanic zones in the southern half of Iceland.

3.2 The effect of tectonic drift of the two tectonic plates of North America and Eurasia

The outer borders of volcanic zones coincide accurately with divison lines between convection rolls. Also, the earthquake zones show clear resemblance with the model. But comparing the details of geological knowledge with the model is always most convincing. This grid shows upwelling lines with red color, and downwelling lines with blue color. The division lines of the four layers between 120-410 km below the surface are all drawn on one map:

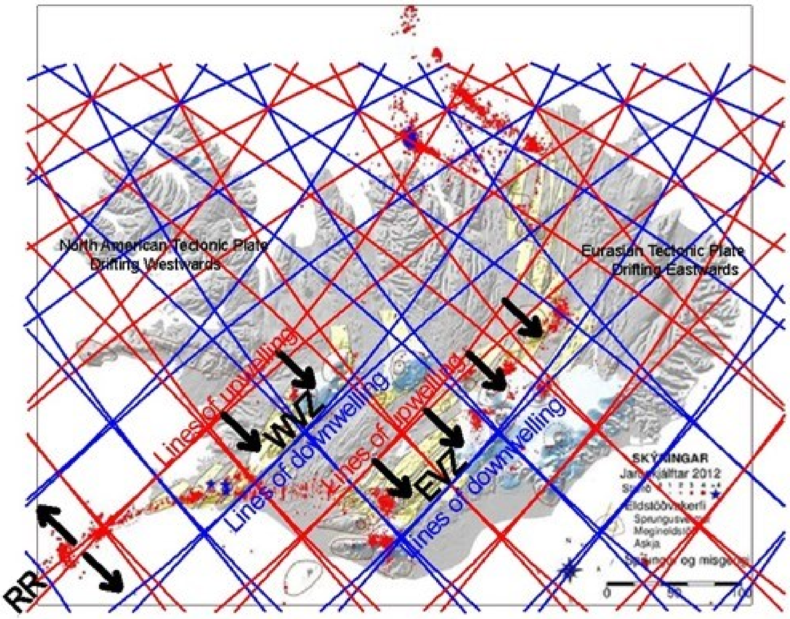

Figure 10: The effect of convection rolls shaping the volcanic zones of Iceland. The arrows show how the flow of certain convection rolls is opposite to the large-scale tectonic drift of the North American Tectonic Plate, resulting in the rifting process. Volcanic systems and active faults are from Einarsson and Sæmundsson (1987).

The South Iceland Seismic Zone (SISZ) fits into this framework, and shows different caracteristics than other areas in Iceland because it is subject to pressure on the SW and NE sides, as explained by Einarsson and Björnsson (1979). The seismic zone is oriented E-W, along the 64th parallel with N-S oriented faults according to the so-called bookshelf arrangement.

Figure 11: The South Iceland Seismic Zone along 64°N, compared to the convection rolls model shown with red lines. N-S oriented earthquake faults pattern is schematically shown. Drawn on map from the National Land Survey of Iceland.

The origin of pressure on the SW and NE sides due to opposite tectonic drift of the surrounding plates is well-known. The additional explanation provided here is that the division lines between convection rolls also divide the ductile lower part of the tectonic plate above into distinct polygons. This symmetric polygon is thereby a prerequisite to form the regular pattern of earthquake faults. The symmetry of the diamond-shaped polygon around N-S axis causes the stress axis to be aligned exactly E-W, and the relevant end points of the model are the same as observed end points of the SISZ according to Einarsson and Björnsson (1979). The regularity of the interval of the faults within the zone is shown by Einarsson et al. (2002).

The faults of the brittle part of the tectonic plate also provide deep pathways for flowing water, deep enough so that the water can become heated. This provides abundant geothermal resources within the SISZ and throughout Southern Lowlands. The pattern of divisions due to shear stress within the ductile part of the plates can then be calculated exactly, making the prediction of fault location within the brittle part above much easier.

3.3 How the areas of low and high temperature are distributed

To explore geothermal activity, the distribution of main low temperature areas of Iceland can first be examined, as shown here:

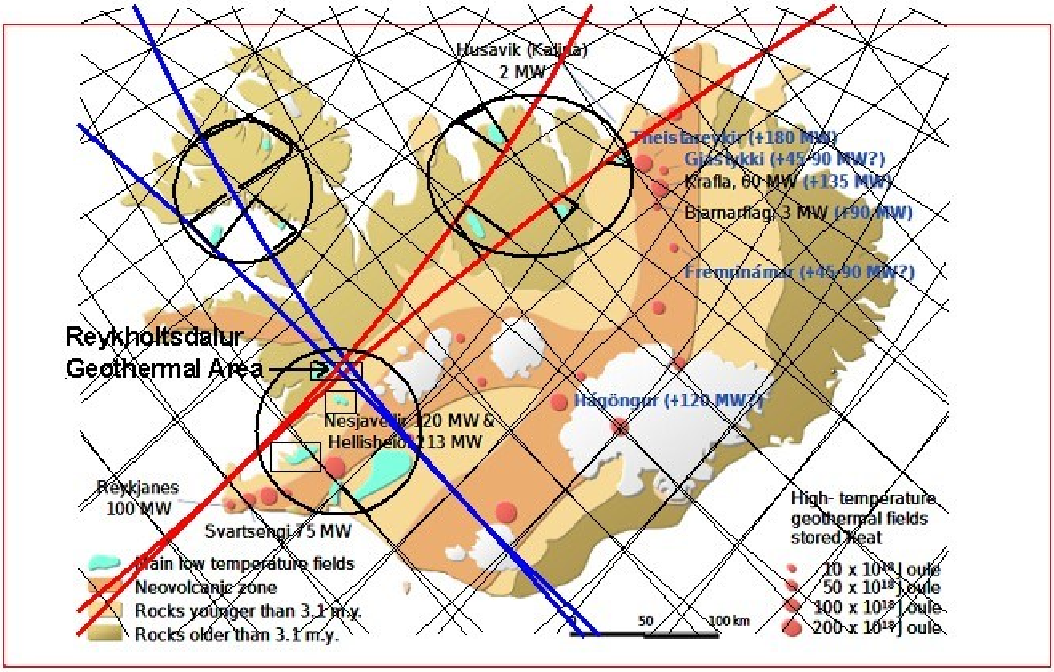

Figure 12: The distribution of main low temperature fields in Iceland. All of them are found within polygons attached to either the Reykjanes Ridge convection rolls towards N-E or the Hekla convection rolls towards N-W. At the center, where these lines are all combined, the most powerful low temperature area in Iceland is found, within the Reykholtsdalur area. Based on map from the National Power Company of Iceland.

The valley of Reykholtsdalur and its surroundings is the strongest low temperature area in Iceland (Kristmannsdóttir et al. 2005), including Deildartunguhver hotspring, by many considered to have the largest flow of boiling hot water in the world. The area is therefore of special interest, and on the map above it is shown how the Reykjanes Ridge upwelling convection division lines cross the downwelling convection division lines, extending from Hekla, exactly where the geothermal area is found. Besides seeing how the lines cross each other, the geology of the Reykholtsdalur area is intriguing. The E-W axis of Reykholtsdalur and the Borgarfjörður fault zone in many ways resembles the E-W axis of the SISZ. The similarities of the two areas of the SISZ and Borgarfjörður have been studied by Khodayar and Einarsson (2002). The low temperature area of Reykholtsdalur appears in association with crossings of lines, but can thereby also be compared with the large area of the SISZ. The resemblance between the valley of Reykholtsdalur geothermal area and the convection rolls division lines can be studied more closely on this map:

Figure 13: The Reykholtsdalur Geothermal Area and the Convection Rolls Division Lines Framework. The area is also pointed out in Figure 12. The E-W alignment is obvious. Drawn on a map base from National Land Survey of Iceland.

Both vertical impact of the convection rolls below, and the horizontal effect of tectonic drift on each polygon, have to be considered when explaining the existence of geothermal heat. The vertical impact is mostly apparent within a relatively small area at crossings, whereas the horizontal aspect can be noticed throughout the relevant polygon area.

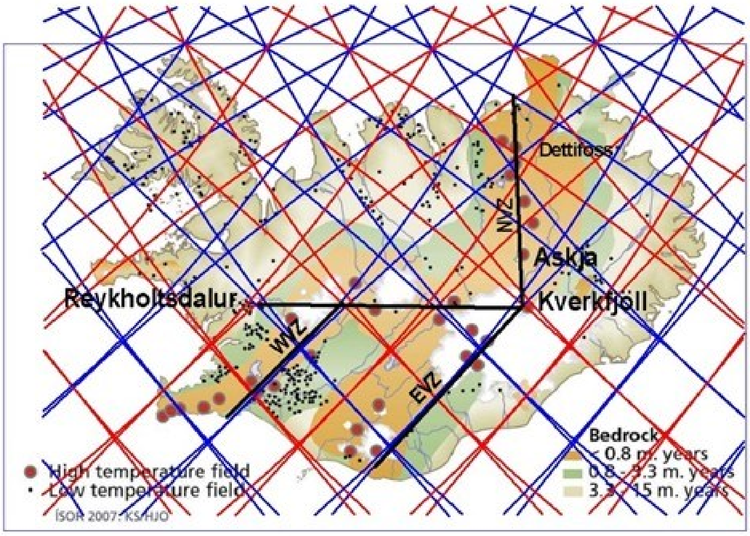

Figure 14: The distribution of main high temperature fields in Iceland. Correlation between high temperature areas and polygons can be functionally explained. Each high temperature area has the function to fill up voids due to rifting process within certain polygons. Askja is a clear example. Here it is also pointed out that the largest low temperature area of Reykholtsdalur has a counterpart at the high temperature are in Kverkfjöll at the same latitude. Based on a geological map from ISOR.

Looking at the map above, we get a bird's eye view of how the high temperature areas are distributed. The main rule appears to be that each polygon of the rift zones has at least one high temperature area accompanied with it. This grid also provides an explanation why the East Volcanic Zone and the North Volcanic Zone (NVZ) have a different orientation. The polygon of Askja is small and surrounded by other small polygons interacting closely with it, and therefore tends to break up in a different way than the large polygons of the EVZ. Therefore we find the sharp turn of distribution of high temperature areas at Kverkfjöll and the relevant latitude. The NVZ is then divided directly north to south along the central axis of each polygon, forming en echelon pattern of volcanic systems within the brittle part of the tectonic plate, as observable on the surface. The function of each volcanic system, with caldera, rifts and high temperature areas, can then be understood in more detail, considering the relationship with the relevant polygon on which it is located, and the adjacent polygons.

The rifting process within the area of the NVZ is due to the same convection rolls system as the WVZ and EVZ. An example can be taken from the waterfall Dettifoss, within the NVZ area, as its alignment can be calculated to be the same as of the convection rolls:

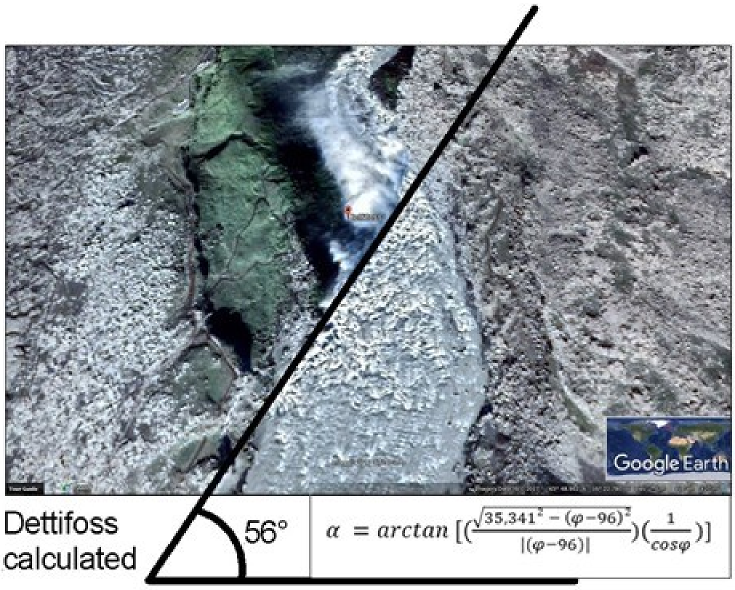

Figure 15: When the direction is calculated it fits to the most powerful waterfall of Europe, Dettifoss. The equation is derived from the formula for the convection system of the world (with polar section coefficient 96), *$(x - C_n)^2 + (y - 96)^2 = 35.341^2$, with C_n=-34.7*, shows deviation from west (*W56°N*) of the upper most convection cells. That particular line extends from Hekla volcano. This example shows how tectonics in general can be calculated, which is extremely important. Picture from Google Earth.

The example of Dettifoss is shown, because it is extremely important to be able to calculate tectonic alignment vectors. Dettifoss is located at the latitude *φ=65.8°N*, and the upper most convection rolls are oriented *W56°N*, exactly as the alignment of the waterfall. Countless examples of identical direct calculations can be shown all over the world. It is not always as simple as using the formula for alignment directly, but the ductile nature of the lower part of the tectonic plates makes the calculations easier than one should think in the beginning. Detailed analysis can then be made for each polygon and the relationship between them. The abundance of low temperature geothemal areas in the western half of the country and the distribution of high temperature areas along the rift zones can be studied according to the settings within the convection rolls system.The convection rolls directly affect the ductile bottom of the tectonic plates. When the framework of polygons is known, tectonic features, also of the brittle part of the tectonic plates, become explainable and predictable by applying the formula of the basically circular horizontal alignment of convection rolls.

4. CONCLUSIONS

The results of this analysis open up possibilities to comprehend the processes of Earth's interior and how they affect the surface in detail. According to the model presented here, the tectonic plates, about 120 km thick, are underlain by layers of convection rolls. The division lines between the convection rolls can be drawn accurately, and division lines of different layers form a network of gridlines. The resulting grid shows a pattern of polygons which can then be compared with different types of maps, immediately showing resemblance to various geological features.

With the calculated grid at hand, the tectonic framework of Iceland can be analyzed accordingly. For instance, the West and East Volcanic Zones are then seen to be the result of a pulling effect between the westward drift of the N-American tectonic plate and the convection rolls underneath with eastward flowing mantle material. The crust is thereby pulled apart, forming the rift zones. The South Iceland Seismic Zone connects the said volcanic zones, and is found within a polygon with westward flowing mantel material immediately underneath the tectonic plate. Each convection roll spans 1.5° from east to west, which is exactly the distance between the region of Hveragerði and Hekla, marking the western and eastern points of the SISZ. The polygon breaks up in a predictable way due to the regularity of the division lines surrounding it. Geothermal heat can then be exploited by drilling into the faults where water flows along them at appropriate depth.

Every part of the Earth can be analyzed in the same way. By systematically measuring pressure and tension within each polygon, location of deeper faults providing geothermal activity can be anticipated by calculations. Explanations are provided according to this model how low geothermal heat emerges within a large area like the SISZ due to tectonic drift. On the other hand, the much smaller Reykholtsdalur geothermal area in West Iceland is the strongest in Iceland, apparently due to combined effect of convection rolls extending from the Reykjanes Ridge and Hekla crossing each other at that location. The same kind of distinction emerges between high temperature areas, resulting from crossings of convection lines, such as Kverkfjöll, and the function of a high temperature area within a rifting polygon as in Askja. The convection rolls border lines match with the outlines of volcanic zones in Iceland, and every other aspect of the geology of Iceland is here found to be in harmony with the comprehensive model of mantle convection rolls.

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