

The Ice Age, Precession, and the Year 1250

Summary

In a lecture in 1910 Rudolf Steiner describes how climate changes and natural catastrophes at the end of the Ice Age were caused by planetary movements, specifically by precession. He vividly describes the upheavals, including a complete redistribution of water and land, which he said brought about the destruction of Atlantis between six and eight thousand years BCE.

Evidence that astronomical events effect Earth's climate goes back as far as 1842, when Joseph Adhémar published 'Révolutions de la mer'.

Adhémar looked for events in the solar system to explain ice ages, and proposed that the different lengths of winter and summer, brought about by a combination of axial and apsidal precession are the cause.

In 1879 Steiner read an essay summarizing Adhémar's work, written by Professor Kofler, one of his teachers. Kofler explains the origin of a 21000 year precessional cycle, which he believed was the cause of a regular global redistribution of the world's oceans.

Kofler located the middle of this cycle as occurring in the year 1248 CE, a time known to historians as the Medieval Renaissance. Steiner describes the work of the Spirits of Form around this time bringing about a gradual change in human consciousness.

The contribution of the Scottish climatologist James Croll provides further evidence that long term climatic changes are brought about by astronomical events.

More recent investigations into deep ocean sediments and Antarctic ice cores have shown that cosmic cycles in our solar system are the driving forces of Earth's long term changes in climate.

Introduction

On several occasions Rudolf Steiner made statements about a global catastrophe at the end of the most recent Ice Age ¹(approximately 10000 years ago, 8000 BCE), and its relation specifically to the year 1250 CE, (more broadly, to the 13th and 14th Centuries), which he described as being of great importance for the evolution of human consciousness. He relates the end of the Ice Age and changes in human consciousness during the 13th Century to astronomical events, namely to the precession of the equinoxes. It is not at all clear what he meant by this. Precession is a continuous process, and one aspect which needs clarification is how a continuous process can determine a fixed period in Earth's history. Although Steiner often associates the end of the most recent Ice Age with the destruction of Atlantis, this is a subject in its own right, and will not be considered here.

The present article places Steiner's statements in the context of past and present knowledge about the most recent Ice Age, and explains how axial and apsidal precession contribute to a 21000 year cosmic cycle. It looks for geological and climatological evidence of a global catastrophe, whether the cause of such a disaster (dys-aster) may to be sought in the 'stars', or, as Steiner indicated, in the "precession of the equinoxes", and explains the alignment of astronomical events around 8000 BCE and 1250 CE with events on taking place on Earth during these times, as described by Steiner.

¹ In this essay I use 'Ice Age' to refer to the most recent period of widespread glaciation, and 'ice age' to refer to any prior periods of extensive glaciation.

Steiner's interest in the Ice Age was kindled by an essay written in 1879 by one of his high school teachers,² The essay not only summarized the state of knowledge at the time, but also made predictions about the future. As is only to be expected, much of it is outdated. But the main point of the essay, namely the causal link between astronomical events and changes in long term climate - which Steiner indicated, but did not explain - remains valid today; indeed, is fully supported by subsequent climatological and astronomical research.

Numerical calculations are kept to a minimum, and may be safely ignored without losing the thread of the argument.

With two exceptions, English translations from Steiner's lectures are from 'rsarchive.org', as indicated in the footnotes.

Rudolf Steiner's 'Occult History'

There are several occasions when Rudolf Steiner describes the end of the most recent Ice Age as a global catastrophe – he referred to it as the “Atlantean catastrophe” - an event which he links to the precession of the equinoxes. In lecture 5 of the cycle 'Occult History' for example, he said the following³:

“Between the old influences in the Atlantean epoch and those in the Post-Atlantean, there was a boundary-period filled by the Atlantean catastrophe — by those events whereby the face of the Earth was totally changed in regard to the distribution of water and land. Such periods and changes consequent upon them are connected with mighty processes in the constellation, position and movement of the cosmic bodies connected with the Sun. In fact, such periods in the Earth's evolution are determined and directed from macrocosmic space. It would lead too far if I were to attempt to describe to you how these successive periods are directed and regulated by what is called in modern astronomy the precession of the equinoxes. This is connected with the position of the Earth's axis in relation to the axis of the ecliptic, with mighty processes in the constellation of neighbouring celestial bodies; and there are definite times when, on account of the particular position of the Earth's axis in relation to these other bodies of the cosmic system, the distribution of warmth and cold on our Earth is radically changed. This position of the Earth's axis in relation to the neighbouring stars causes the climatic conditions to change. In the course of something over 25,000 years, the axis of the Earth describes a kind of conical or spherical movement, so that conditions undergone by the Earth at a certain time are undergone again, in a different form and indeed at a higher stage, after 25,000 to 26,000 years.

And here, because it is of essential significance in the whole historical development of Earthly humanity, we may point particularly to the fact that in the seventh millennium before Christ there was an especially important astronomical epoch - important because, on account of the constellation brought about by the relative position of the Earth's axis to the neighbouring stars, the climatic conditions on Earth culminated in the Atlantean cataclysm. This happened six to eight thousand years before our era, and the effects of it continued for long ages.

During this period the macrocosmic conditions worked into the physical in such a way as to bring about the mighty physical upheavals of the Atlantean cataclysm, which completely changed the face of the Earth. This was the greatest physical transformation of all, the most drastic action of the macrocosm upon the physical Earth.” (GA 126, 92-93)

² 'The Ice Age during the Diluvial Period and its Causes', by Professor Franz Kofler.

³ Lecture given in Stuttgart on 31/12/1910. <https://wn.rsarchive.org/Lectures/GA/GA0126/19101231p01.html>

Is there any geological evidence for these startling assertions? Given that the phenomena Steiner describes took place in the physical world as recently as 10000 years ago, has any evidence of their occurrence been discovered by geologists?

Although there is no geological evidence *globally* for “mighty physical upheavals completely changing the face of the Earth” at the end of the most recent Ice Age, nor for a *global* change “in regard to the distribution of water and land” during this time, there are however, well documented cases of *local* catastrophes as the Ice Age glaciers slowly melted about 10000 years ago.

Local Catastrophes

One example is the Missoula Floods which occurred in the Columbia River basin in North America. These were the result of the breaching of an enormous ice dam more than 600 metres high. It was created by the retreating glaciers of the North American ice sheet, but repeatedly gave way, thereby again and again draining the huge glacial lake behind it. The immense floods scoured the Columbia Plateau as the water roared toward the Pacific Ocean, resulting in the so-called channelled Scablands in Washington State.

Another example of the collapse of an ice dam is the sudden draining of Lake Agassiz, the largest glacial lake in North America. Analysis of ocean floor sediments have shown that Lake Agassiz, more voluminous than the Great Lakes combined, emptied catastrophically about 12000 years ago. A torrent of fresh water rushed into the Atlantic Ocean in an unimaginable cascade, creating a fresh water cap on the surface which noticeably slowed down the Gulf Stream. Temperatures in the Northern hemisphere dropped sufficiently to bring back Arctic conditions for about 1000 years, a period known to climatologists as the Younger Dryas Cold Event.

An example of a ‘catastrophe’ moving at an imperceptibly glacial pace, is the gradual flooding of Doggerland.⁴ A large area of what today is the North Sea was not only dry land connecting Britain to Europe, but was inhabited by Mesolithic people between approximately 7000 and 5500 BCE. Rising sea levels caused by melting ice slowly drowned the land; first the low lying plains, eventually the Dogger Hills were swallowed up by the inexorably encroaching North Sea. Today the Dogger Hills are known as the Dogger bank, 15 to 35 metres below sea level. Successive generations of ‘Doggerlanders’ were forced to move to ever higher ground, until eventually, when the ice had stopped melting, they found themselves in what is today England and the Netherlands.

⁴ The Guardian, 8 May 2019: ‘Scientists to create 3D map of submerged Mesolithic landscape of Doggerland’

More recently, in June 1818, a sudden local cataclysm occurred in the Val de Bagnes in the Swiss Alps. A lake more than a mile long had filled the valley behind an ice barrier formed by the Gietroz glacier. See Figure 1. Attempts were made to drain the lake by digging a trench through the ice, but the ice dam gave way before the work could be completed, and 18 million cubic metres of flood waters cascaded into the valley below. Fortunately, the local people downstream had been aware of the danger because a similar torrent had destroyed their village in 1595. Many were able to evacuate, but the flood waters still claimed 47 lives. The disaster motivated the engineer who had been in charge of the attempted diversion, Ignace Venetz (1788 – 1859), to make a careful study of local glaciers. His work would eventually lead to new ideas about the recent history of the Earth.⁵



Figure 1

<http://www.glaciers-climat.com/naissance-de-la-glaciologie.html>

The Spirits of Form and the Year 1250

Steiner continues his lecture by explaining how “six to eight thousand years before our era”, certain spiritual forces (the Spirits of Form) were able to work most strongly on the changing physical (climatic) conditions on Earth, thereby bringing about the Atlantean cataclysms. Their effect on the development of human consciousness at that time was at a minimum, so that other, lesser, spiritual forces were able to exert their influence, with the result that the human spirit had to partially withdraw from the Earth for a time.

“Hence the influence from the macrocosm upon the spirit of man at that time was at its lowest; this epoch therefore provided an opportunity for Hierarchical Beings less powerful [than the Spirits of Form] to begin to exercise on man a potent influence, which then ebbed gradually away.” (GA 126, 94)

As was explained earlier in the lecture, these less powerful beings were the Angels, Archangels, and Archai. Steiner follows this with a suggestion that it is possible to imagine a time when the opposite situation comes about:

“. . . when those who are cognisant of such a matter experience the reverse of these conditions - namely, the least influence upon the physical and the greatest influence, precisely of the Spirits of Form, upon the human spirit. Hypothetically you can conceive that there may be a point in history where the reverse of the great Atlantean catastrophe applies. Of course, it will not be so easily noticeable, for the Atlantean catastrophe, when parts of the very Earth were blotted out, is bound to be a very striking event for people of our Post-Atlantean epoch, with their strong leanings to the physical. When the Spirits of Form are exercising a powerful influence on the human personality and have only a little influence upon what is taking place in the external world, the impression will be less vivid. The point of time when this condition - in the nature of things, less perceptible to men - set in, was the year A.D. 1250. The year 1250 is of momentous importance in history.”

⁵ Woodward (2014), p. 41.

Spiritual forces or beings have an effect not only on Earth's climate, but also on human consciousness. In 1250 CE the influence of the Spirits of Form on climate was at a minimum, but the effect of their activity on human souls was at a maximum.

Steiner puts aside for the moment the link between precession and the activity of the Spirits of Form, and goes on to present historical evidence illustrating just how important the Middle Ages were. The year 1250 CE was the

“. . . point of time especially adapted for conveying to mankind the mysteries which come to direct expression in the connection of the Spiritual with the working of Nature. Hence we see that this year 1250 was the starting-point of great and detailed elaborations of what was formerly only believed, only divined: it was the starting-point of Scholasticism, which is greatly undervalued to-day. It was also the starting-point of revelations which found expression in spirits such as Agrippa of Nettesheim [1486 - 1535], and which took effect most deeply in Rosicrucianism. This shows that if we want to search for the deeper forces of historical development, we must take into account conditions quite other than those outwardly in evidence. In point of fact, behind the things of which I have just been speaking there are also hidden the forces working, for example, in the rise and subsequent ebbing of the Crusades. The whole of European history, especially the flow of happenings between East and West is attributable solely to the fact that forces are at work behind the events, as I have now elucidated.”

What had been perceived during earlier times as

“! . . . spiritual reality behind the manifestations of Nature was forgotten, and attention began to be paid only to the manifestations of Nature. That is the modern mentality. Tycho Brahe [1546 – 1601] is one of the last of those who still grasped the reality of the spiritual behind the data constituting the sciences of external Nature. Tycho Brahe was a truly wonderful personality, because with his supreme mastery of external astronomy he discovered thousands of stars, and at the same time he had such deep inner knowledge of the sway of the spiritual Powers that he could astonish all Europe by boldly predicting the death of the Sultan Soliman. We see how out of the spiritual nature-knowledge, which begins to appear in 1250 and is exemplified in individualities such as Agrippa of Nettesheim, there gradually emerges what later on amounts merely to perception of the manifestations of external Nature; while the inner, the spiritual, remains in that mysterious stream known to us as Rosicrucianism. Then the two streams flow on.” (GA 126, 95-96)

The changes in human consciousness during the Middle Ages were unprecedented. Human souls gradually turned away from the spiritual realities manifest in Nature. No longer able to experience the divine directly through Nature, they saw only the outer garment, the physical world in which we live today.

The Medieval Renaissance

The late Middle Ages of European history have often been characterised as the Medieval Renaissance. Politically (the founding of free cities), economically (the establishment of craft and merchant guilds), and intellectually (the growth of free universities), the development of Western Europe during this time prepared the way for the later achievements of the Italian Renaissance, and the age of scientific discovery during the 17th Century. Contact with the Islamic and the Byzantine empires during the Middle Ages gave scholars access to the work of Greek and Islamic philosophers and scientists, especially the works of Aristotle (384-322 BCE), and later of his teacher Plato (428-348 BCE). Learning moved out of the monasteries and into newly established universities such as Bologna, Paris, Oxford, Padua, Vienna and

Heidelberg, to name but a few. These provided the infrastructure on which the intellectual progress of Europe would be based.

The climate too was different. The research of climatologists has shown that Northern Europe and the North Atlantic experienced a small but significant increase in average temperatures between the 9th and the 14th centuries, a period known as the Medieval Warm Period. Reductions in both sea ice and land ice in the Arctic allowed the Vikings to travel further North than had been possible during earlier times.

Greenland was settled by the Vikings in the 10th century, beginning with the voyage of Erik the Red from Iceland in 985. Ancient tax records show that grapes were grown in Britain in the 11th century.

The Middle Ages marked the beginning of an important development in the evolution of human consciousness, and it took place in a somewhat milder climate (at least in Northern Europe), contrasting with the Ice Age ten thousand years ago, and the 'Little Ice Age' which followed the Medieval Warm Period.⁶

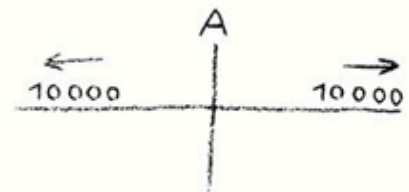
The subtle changes in climate, and the not so subtle changes in consciousness, took place gradually over several centuries. Why then does Steiner specifically mention 1250 CE as the “point in history where the reverse of the great Atlantean catastrophe applies”? Why were the Spirits of Form able to redirect their attention from bringing about changes in global climate to changes in human consciousness just at this time? And what role does precession of the equinoxes play?

Steiner leaves his listeners in no doubt that precession of the equinoxes, the “*mighty processes in the constellation of neighbouring celestial bodies*”, the global changes in the “distribution of water and land” and the “distribution of warmth and cold on our Earth”, are all related to the end of the most recent Ice Age. To emphasize the importance Steiner attached to these processes, here are two more passages from his lectures.

Changes in Human Consciousness during the Middle Ages

First, in Lecture 6 of the Astronomy Course⁷ Steiner explains the “*connection between what is going on in the life of mankind and the phenomena in the Heavens beyond the Earth*”; specifically, how the “*inner experiences which man on Earth was undergoing at that time*,”⁸ connected with the evolution of the Earth-planet altogether”. (GA 323, 118)

As explained in detail in ‘Occult History’ (see above) significant changes were taking place in human consciousness, a deeply felt “*moving and stirring of humanity*” was taking place, during the Middle Ages. Moreover, these changes lay “*in the very midst between two end-points in the scale of time*”. In Europe these end-points represent times during which human life was (and will be) barely possible at all. For if we go back 10,000 years, and forward 10,000 years from the Middle Ages (at A, on Steiner’s sketch) we reach the “*maximum development of the Ice Ages*” in Europe.



“*Surveying therefore the evolution of these European regions we find an Ice Age — a laying-waste of civilization — 10,000 years before the Christian era, and we should find the same again 10,000 years after this time. The deep stirring of human life, of which we have been speaking, happened midway between two such barren epochs.*” (GA 323, 119)

⁶ The Little Ice Age refers to a deterioration in the climate after the Medieval Warm Period between 1645 and 1715.

⁷ Lecture given in Stuttgart on 6/1/1921. <https://wn.rsarchive.org/Lectures/GA/GA0323/19210106v01.html>

⁸ i.e during the 13th Century.

Steiner then describes the precession of the spring equinox through the ecliptic in the course of a Cosmic Year, and predicts another ice age about 10000 years from now, when the vernal point is in the constellation of Scorpio.

“At the time we spoke of,⁹ when there was that deep stirring of the spiritual life in mankind, the spring equinox was in the constellation of Pisces. In the Graeco-Latin Age it had been in the constellation of Aries, previous to that in Taurus, and so on. We get back to Leo or Virgo, more or less, during the time when glacial conditions prevailed over the greater part of Europe and in America too. Looking into the future there will be another Ice Age in these regions when the vernal point reaches the constellation of Scorpio. This rhythm is contained within what takes its course in 25,920 years. Although admittedly of vast extent, it is a true rhythm none the less.” (GA 323, 125)

Clairvoyance and Initiation

Second, an extract from Lecture II of Steiner’s book “The Spiritual Guidance of Man”.¹⁰ Here details of a more esoteric nature relating to the year 1250 are revealed. After 1250 CE it is no longer sufficient to be merely clairvoyant. In order for a clairvoyant person to draw correct conclusions from their spiritual experiences they must be initiated. Only initiation enables such a person to distinguish between the various kinds of super-sensible beings and events.

“In modern times the powers guiding humanity are faced by the special task of bringing about a balance between the two principles of clairvoyance and initiation. Leaders of spiritual training had necessarily to pay attention to this at the beginning of the modern era. Therefore the esoteric spiritual movement, which is adapted to present conditions, always makes a point of maintaining the right proportion between clairvoyance and initiation. This became necessary at the time when mankind was passing through a crisis with regard to its higher knowledge. That time was the thirteenth century. About the year 1250 was the point of time when mankind felt itself most shut out from the spiritual world. A clairvoyant looking back upon that period sees the following: The most eminent minds of that time who were striving after some kind of higher knowledge could only say to themselves: ‘What our reason, our intellect, our spiritual knowledge is able to find out is limited to the physical world around us. With all our human endeavour and power of perception, we cannot reach a spiritual world. We only know of it by accepting the information concerning it which our forefathers bequeathed us.’ This was the time when a direct view of the higher worlds was obscured. That this can be said of the era in which scholasticism flourished, is not without significance.

About the year 1250 was the time when men were compelled to fix a boundary between what they were able to apprehend for themselves, and what they had to believe from the impression made upon them by the traditions which had been handed down. What they could find out for themselves then became limited to the physical world of sense. Afterwards, however, came the time when there was more and more possibility of again winning a view of the spiritual world. But the new clairvoyance was of a different kind from the old, which virtually became extinct just about the year 1250. In the new form of clairvoyance, western esotericism was obliged strictly to uphold the principle that initiation must be the guide of spiritual sight and hearing. This was the special task assigned to an esoteric current which then entered the stream of European civilization. As the year 1250 drew near there arose a new kind of guidance into the super-sensible worlds.

⁹ i.e. 1250 CE.

¹⁰ Based on lectures given in 1911. https://wn.rsarchive.org/Books/GA015/English/ASGB1921/GA015_c02.html

This guidance was prepared by the spirits then guiding outer historical events, who centuries before had prepared for the kind of esoteric training which would become necessary by the conditions prevailing in 1250. If the term 'modern esotericism' be not misused, it may be applied to the spiritual work of those very highly evolved personalities. External history knows nothing of them, but what they did is apparent in every form of civilization which has developed since the thirteenth century.” (GA 15, 57-58)

And so the question may well be asked: was there an event in 1250 CE which stood out for Rudolf Steiner as of crucial importance in human evolution? The answer is yes. It turns out that a significant astronomical event took place in 1248 CE. This event is described in an essay written by one of Steiner's high school teachers in 1879, to whom we now turn.

Professor Franz Kofler and the Ice Age

In the second chapter of his autobiography Rudolf Steiner mentioned an essay written by his geography and history teacher Professor Franz Kofler, entitled 'The Ice Age during the Diluvial Period and its Causes'.¹¹ He wrote that he had read the essay eagerly and "had retained a lively interest in the problem of the Ice Age". (GA 28, 47)¹²

The Ice Age problem was a relative newcomer to 19th Century natural philosophers and to the 'savants' (scientists) studying the natural world. Goethe had been one of the first to speculate on the origin of the huge blocks of Scandinavian granite (so-called erratics) dotted about on the North German plain, suggesting that they might have been carried there by large sheets of floating ice. He followed the ideas of Venetz and other Swiss glaciologists with great interest, and devoted a chapter (Book 2, Chapter 9) to a discussion of the possibility of an ice age in his novel 'Wilhelm Meisters Wanderjahre', first published in 1821.¹³

The term 'Ice Age' (Eiszeit) was introduced into the discussions of natural scientists in the course of a ground-breaking lecture by the palaeontologist Louis Agassiz (1807-1873) in 1837. The members of the Swiss Academy of the Natural Sciences had come to their annual symposium in Neuchâtel in July of that year prepared to hear a lecture on fossil fish, a subject on which Agassiz was a recognised expert. They were more than a bit surprised to hear him enthuse about a vast ice-sheet which had once covered most of Europe.

Although Agassiz gave credit to Goethe, "Goethe alone unified all the indications into a definite theory",¹⁴ and in spite of a hastily organised field trip into the nearby Jura hills to see the evidence first hand, he was unable to overcome their scepticism. Later in the year a letter from his mentor, the renowned German naturalist Alexander von Humboldt (1769 -1859) strongly advised him to return to his research on fossil fish. But Agassiz would not be dissuaded, and became one of the leading proponents of the Ice Age during the 19th Century. He closed his Neuchâtel lecture with the words:

¹¹ 'Die Eiszeit während der Diluvialperiode und ihre Ursachen' by Dr. Franz Kofler, published in the *Vierzehnter Jahres-Bericht der Nied.-Österr. Landes-Oberrealschule*, Wiener Neustadt, 1879; reprinted privately by C. S. Picht, Stuttgart in 1927.

¹² English translation from 'Rudolf Steiner, an Autobiography', page 50.

¹³ See for example Dorothy Cameron (1964) *Goethe - Discoverer of the Ice Age*, https://www.igsoc.org/journal/5/41/igs_journal_vol05_issue041_pg751-754.pdf

and W. Engelhardt (1999) *Did Goethe discover the Ice Age?*

https://www.researchgate.net/publication/291794935_Did_Goethe_discover_the_ice_age

¹⁴ W. Engelhardt (1999) *Did Goethe discover the Ice Age?* Ibid.

“I conclude, that at a certain epoch the whole of Europe was covered with ice . . . Death enveloped nature in its burial shroud.”¹⁵ - a remarkable premonition of Steiner’s description of the desolation 10000 years ago.

Steiner’s Interest in Geology

Kofler's essay was written in 1879 when Rudolf Steiner was 18 years old. That same year he enrolled at the Vienna Institute of Technology (‘Technische Hochschule’), where he studied both philosophy and the natural sciences for four years. One of his teachers was Karl Julius Schröer, who was working on a new edition of Goethe’s dramas for Joseph Kürschner, publisher of a new collection of German National Literature. On Schröer’s recommendation Steiner was employed by Kürschner as editor of Goethe’s scientific writings between 1883 and 1897. During this time, he wrote a series of four articles on geology for ‘Pierer’s Konversations-Lexikon’, a household encyclopaedia also published by Kürschner. One of these was entitled ‘Ice Age’ (Eiszeit), written in 1889.¹⁶ ‘Ice Age’ is a standard reference article outlining what was known about the Ice Age towards the end of the 19th Century. It presents the evidence for an extended period of glaciation covering all of Europe North of the Alps (in particular the erratics) and considers the two most likely causes under discussion at the time:

- periodic changes in the inclination of Earth’s axis of rotation (precession), and
- changes in the distribution of continents and oceans.

Both of these had first been suggested by the French mathematician Adh mar in 1842, and are described in detail in Kofler’s essay. Steiner did not cite Kofler in his encyclopaedia article, using instead more scholarly sources. Many years later he said that his contribution to ‘Pierer’s Konversations-Lexikon’ would probably have been edited.

Professor Kofler’s Essay

Kofler’s essay is made up of three sections. The first summarises the evidence indicating that vast ice sheets had covered Northern Europe and North America in the not too distant past; for example, erratics, U-shaped valleys, terminal moraines, and striations. During the 19th Century it was commonly believed that Earth’s crust had gradually cooled from a molten state to its present condition. The indisputable evidence of vast ice sheets covering Europe and North America in the recent past contradicted this belief; some unknown factor must have warmed the Earth’s surface again, causing the ice to melt. The second section looks to the cosmos for possible answers, and the third lends support to the conclusions of the second by examining a theory current during the 19th Century, namely the global redistribution of land and sea.

Many theories had been advanced to explain the onset of the Ice Age, and the subsequent anomalous warming; a decrease in the strength of the Sun’s radiation (insolation), an increase in interstellar dust in that part of the universe through which our solar system was passing at the time, or a decrease in atmospheric carbon dioxide, or enormous volcanic eruptions blocking the Sun’s energy. Charles Lyell (1797 – 1875) considered by many (in England) to be the father of geology, even considered the possibility of the Northern continents uplifting to a higher altitude, thereby causing temperatures to drop. But none of these theories stood up to closer scrutiny. And so,

¹⁵ See for example: <http://shipseducation.net/glaciers/Agassiz.htm>

¹⁶ The others were entitled ‘Alluvium’ (1888), ‘Basalt’ (1889), and ‘Geologic Formations’ (1890).

Kofler tells us, geologists began to consider 'cosmic laws' ("kosmische Gesetze") to explain the Ice Age.

Based on the observations of Tycho Brahe (1546-1601), Kepler (1571-1630) had shown that the Earth's orbit round the Sun is an ellipse, with the Sun at one of the foci.¹⁷ As the Earth travels along her orbit she is sometimes closer and sometimes further away from the Sun. She reaches her closest point to the Sun (146 million km) on January 3 during the Northern winter. This is called the perihelion point. The Earth is furthest away from the Sun (151 million km) on about 4 July, the point of aphelion. The difference of 5 million km, or about 3.4%, may not seem like much, but turns out to be very significant, as we shall see. Perihelion and aphelion are called the apsidal points of the elliptical orbit, and the line joining them across Earth's orbit is called the apsidal line. Figure 2 illustrates the relationship between solstices and equinoxes and the apsidal line. Note that for the sake of clarity the eccentricity of the elliptical orbit has been greatly exaggerated. The ellipse shown in Figure 2 has an eccentricity of 0.6, which would place the foci considerably further apart. It is not possible to show the correct eccentricity (0.0167) on a sketch of this size.

What follows is an outline of the second section of Professor Kofler's essay in which he explains what he believed to be the cause of the Ice Age. I have included in this outline the names of the astronomer-mathematicians who did the necessary calculations and made the extra-ordinary discoveries which form the backdrop to Kofler's essay, and deserve a mention in the story. We are as indebted to them for explaining the physical laws of our universe, as we are to Rudolf Steiner for explaining its spiritual laws.

The first proposal for an astronomical, or cosmic, theory to explain the Ice Age was made in 1842 with the publication of 'Revolutions of the Sea' (Révolutions de la mer) written by the French mathematician Joseph Alphonse Adhémar (1797-1862). He believed that the Southern hemisphere is currently experiencing an ice age, and that ice ages occurred alternatively in each hemisphere with a cycle of 21000 years.

But before investigating Adhémar's reasoning, we need to be clear about solstices, equinoxes, and the two different kinds of precession (axial and apsidal precession). They play an essential role in his theory.

Solstices and Equinoxes

The rotation of the Earth about its axis gives rise to day and night. The axis of the Earth's rotation is tilted at an angle of 23.4° to a line drawn vertically to the plane of the orbit. The tilt of the axis (the obliquity) gives rise to our annual seasons. The Northern hemisphere experiences summer when the North Pole is inclined towards the Sun, and winter when the North Pole is inclined away from the Sun. In the Southern hemisphere the situation is reversed. The obliquity varies very slowly between 22.1° and 24.5° , over a period of 41000 years, but this will not concern us here.

Each of the four seasons begins at a specific point along Earth's orbit. These are called the cardinal points. In the Northern hemisphere December 21 marks the beginning of winter because on this day the Northern hemisphere is inclined furthest away from the Sun, making it the shortest day of the year North of the equator. This point is called the winter solstice for the Northern hemisphere (and the summer solstice for the Southern hemisphere). Six months later, 21 June marks the beginning of

¹⁷ In his 'Principia Mathematica' published in 1687, Newton used his universal law of gravitation to prove this mathematically.

summer. This is the summer solstice, the longest day of the Northern year, when the Northern hemisphere is most inclined towards the Sun. See Figure 2.

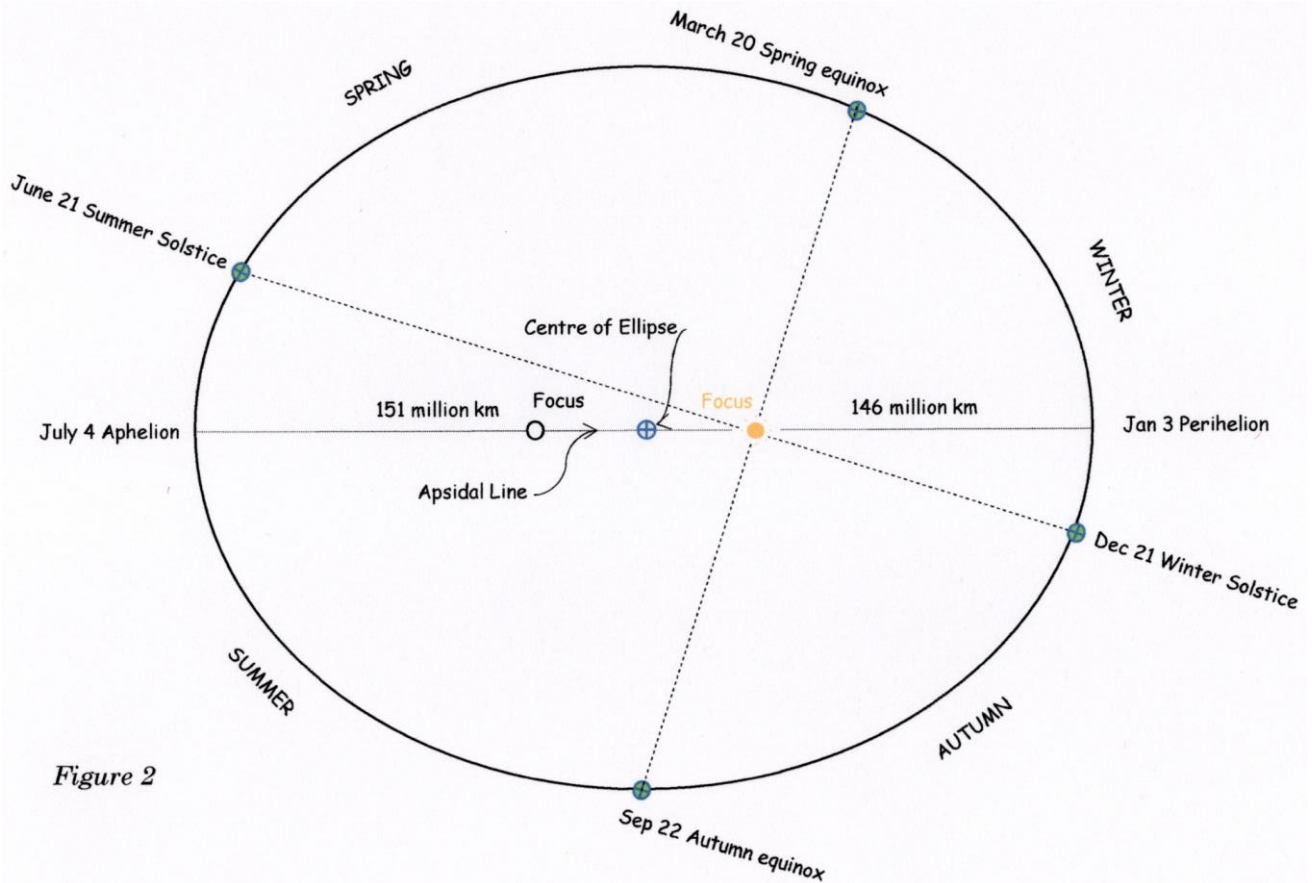


Figure 2

On two days of the year both the Northern and Southern hemispheres are equally inclined towards the Sun, on March 20 and on September 22. On these two days there are exactly 12 hours between sunrise and sunset everywhere on Earth. These two points are therefore called the equinoxes. Equinoxes occur when a line joining the centre of the Sun to the Earth is perpendicular to Earth's axis.

The four cardinal points mark a cross intersecting at the Sun. The short arm of the cross divides the orbit into two unequal parts. It can be seen from Figure 2 that the distance travelled by the Earth between the autumn and spring equinoxes is shorter than the distance travelled between the spring and autumn equinoxes. In addition, according to Kepler's second law, the Earth travels faster during this time. There are in fact 7 fewer days in the Northern winter than in the Northern summer. In the Southern hemisphere the situation is reversed. There the winters are 7 days longer than the summers.

Adhémar reasoned that because there are more hours of darkness in the Antarctic region ($7 \times 24 = 168$ hours) during the Southern winter, it must be cooling. He believed that the Antarctic ice sheet was evidence that the Southern hemisphere is currently experiencing an ice age.

From 22 September to 21 December = $8 + 31 + 30 + 21 = 90$ days.
From 21 December to 20 March = $10 + 31 + 28 + 20 = 89$ days.
Total = 179 days.
From 20 March to 21 June = $11 + 30 + 31 + 21 = 93$ days.
From 21 June to 22 September = $9 + 31 + 31 + 22 = 93$ days.
Total = 186 days. Difference = 7 days.

Having established to his satisfaction that the Antarctic is currently experiencing an ice age, Adhémar went on to explain how the most recent Ice Age in the Northern Hemisphere came about.

Adhémar knew that there are two kinds of precession. What Steiner referred to as the "mighty processes in the constellation of neighbouring celestial bodies" are actually a

combination of two precessional processes. This requires a somewhat longer explanation.

Precession of the Equinoxes (Axial Precession)

The equinoxes mark two special days, March 20 and September 22, on the Earth's annual journey round the Sun, when there are exactly 12 hours between sunrise and sunset all over the Earth. The term 'precession of the equinoxes' is used by astronomers to describe the gradual year-on-year change in the position of the Earth relative to the fixed stars of the zodiac on the day of the spring equinox. The equinoxes precess (from 'precede' = to go before) because as the Earth orbits round the Sun, the 20th of March arrives at a slightly earlier position each year, a phenomenon as old as the solar system itself. The full cycle is completed after approximately 25920 years, the so-called Platonic, or Cosmic, Year.

If we follow Earth's journey around the Sun from the winter solstice on December 21, past the spring equinox on March 20, past the summer solstice on 21 June, then past the autumn equinox on September 22, and back again to the winter solstice, one full orbit later, we find that the winter solstice has occurred slightly (about 20 minutes) earlier in the orbit. When the Earth has returned to the same apparent position relative to the zodiac, the point of maximum inclination away from the Sun has been passed. In fact, each of the four cardinal points, including the equinoxes, is reached about 20 minutes earlier on each subsequent orbit. This is the phenomenon known as precession of the equinoxes, or axial precession. Twenty minutes might seem a very small fraction of a year, but it turns out to be highly significant.

The phenomenon of precession was first noticed by the Greek astronomer and mathematician Hipparchus in about 120 BCE. By comparing his astronomical observations with those made by Timocharis 170 years earlier, as well as with even older observations made by the Babylonians, he noticed small but systematic variations in the direction in which the Earth's axis pointed relative to a fixed star in the zodiac. He concluded that the direction moved (precessed) through the zodiac, with the result that the position of the Earth in its orbit around the Sun at the equinoxes and solstices (or any other fixed calendar date) slowly changes, and that precession has the effect of rotating the cardinal points along Earth's orbital path in a direction opposite to the (apparent) movement of the Sun. See Figure 3.

That is why the tropical year, which measures the seasonal cycle (for example, from spring equinox to spring equinox, or from winter solstice to winter solstice), is 20.29 minutes shorter than the sidereal year, which is measured by the Sun's apparent position relative to the stars. After 25,920 years the difference amounts to a full year, and the positions of the seasons relative to the orbit are back where they started.¹⁸

¹⁸ $20.29 \times 25920 \div (60 \times 24 \times 365.25) = 1$

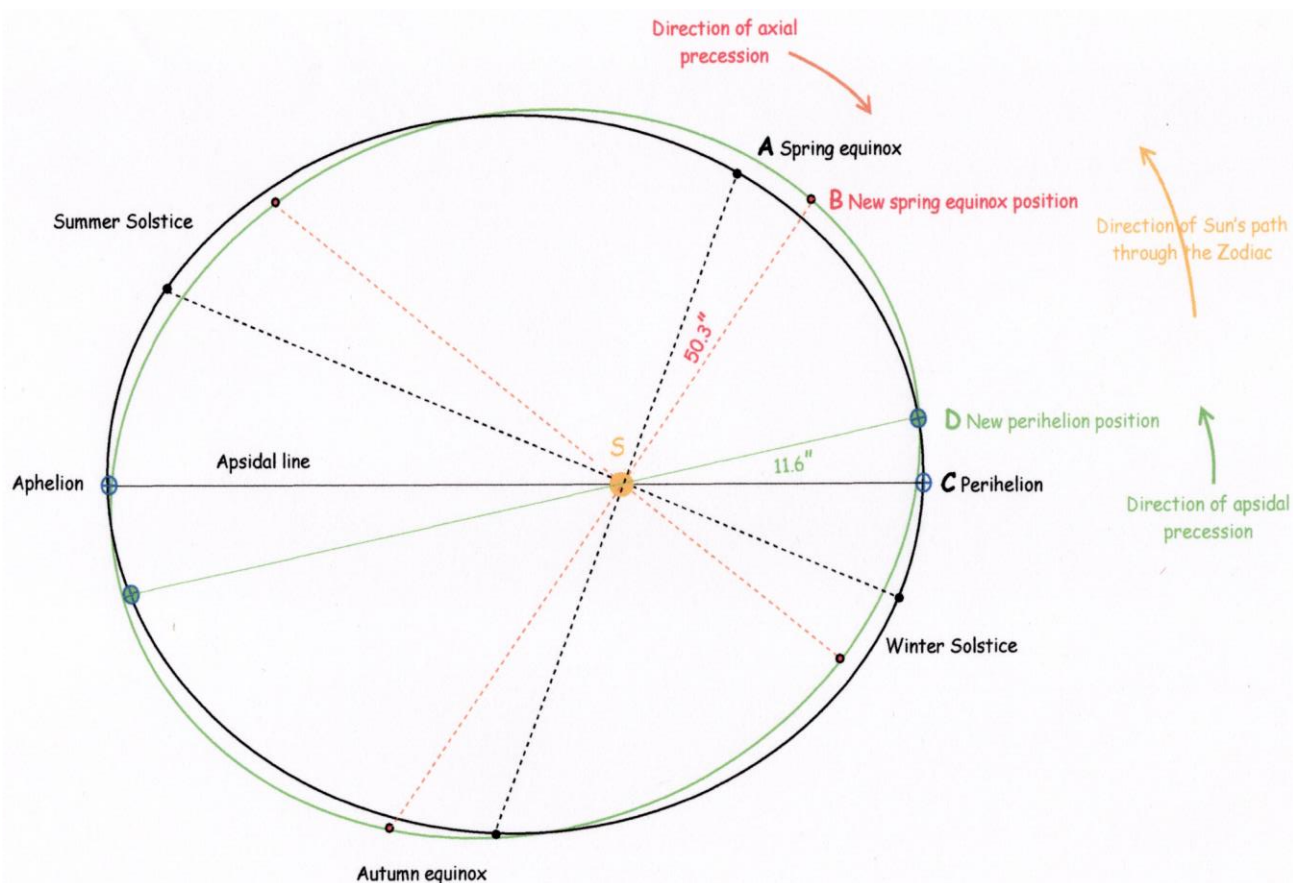


Figure 3

As a result, the apparent position of the Sun relative to a fixed point in the zodiac on some seasonally fixed day slowly precesses through all twelve constellations, at 1° every 72 years. Hipparchus calculated that the rate of precession was between 1 and 2 degrees per century.

The precession of the equinoxes is the third component of what Copernicus (1473 – 1543) referred to as the threefold movement of the Earth, i.e.

- a daily rotation on her axis,
- an annual orbit around the Sun,
- and the precession cycle once per Platonic Year.

Although it's not quite that simple. Because Copernicus assumed that the orbiting Earth always has the same side facing the Sun¹⁹, he had to correct for this by introducing a third movement, equivalent to a full precession cycle during a single year. He did this in such a way that his combined second and third movements correctly describe both Earth's annual revolution and her precession.²⁰

All plant and animal life is inextricably tied into the first two movements, but an awareness of the third is a key feature of human consciousness. Precession can only be discerned on the basis of observations made during the course of many generations.

The precession of Earth's axis may also be imagined as the 'wobble' of a spinning top with an extended Earth axis tracing a cone in space. Today Earth's axis points almost exactly to Polaris (the North star), but it will point to Vega in the constellation Lyra in about 13000 years. The rate of precession is not constant over time and various values are given. Using satellite technology and modern computers a value of 50.290966

¹⁹ As does the orbiting Moon around the Earth.

²⁰ Taking into account that it would be another 60 years before Kepler established Earth's elliptical orbit.

arcseconds per year has been calculated for the present time (giving a Platonic Year of 25770 years).²¹

Axial precession is caused by the gravitational pull of the Sun and the moon on Earth's equatorial bulge. The phenomenon was first explained in 1754 by the French mathematician Jean le Rond d'Alembert (1717 – 1783), who based his calculations on Newton's universal law of gravitation. During the eighteenth century other mathematicians set themselves the task of calculating an accurate trajectory of Earth's orbit - by hand! - a long and painstaking process! In 1784 the mathematician-astronomer Joseph-Louis Lagrange (1736 – 1813) discovered that Earth's elliptical orbit itself rotates (apsidal precession, see below), and Adh mar was able to make good use of his results. Another was Urbain Le Verrier, who published his work one year after that of Adh mar.

Urbain Jean Joseph Le Verrier (1811 – 1877) spent much of his life developing equations for the planetary orbits. In 1843 he published a set of results showing how the shape of the Earth's orbit had varied over the past 100,000 years. He based his calculations on the orbits and masses of the seven planets known at the time. This painstaking work enabled him to predict the existence of an unknown planet which was causing unexplained irregularities in the orbit of Uranus, which had been discovered by Sir William Herschel (1738 -1822) in 1781. The cause of these irregularities was the planet Neptune, discovered in 1846 within 1° of Herschel's calculated position. Even today, the discovery of Neptune is considered a triumph of Newtonian mechanics.²²

Being a continuous process, equinoctial precession by itself could not suddenly have altered the "face of the Earth" and the "distribution of warmth and cold" nine or ten thousand years ago. Other astronomical movements were involved, the most important of which is apsidal precession.

Apsidal Precession

Adh mar had studied the work of Lagrange, and so he knew that Earth's elliptical orbit rotates (together with the apsidal line) in the same direction as the (apparent) movement of the Sun, a phenomenon known as apsidal precession. This rotation is primarily due to the gravitational effects on the Earth of the giant planets Jupiter and Saturn on their orbits round the Sun. The result of these effects is that the date of perihelion slowly moves through the calendar, returning to the same date after 21000 years.²³ Currently perihelion falls on January 3.

It takes 112000 years for a complete rotation of Earth's elliptical orbit relative to the fixed stars,²⁴ equivalent to 11.571428 arcseconds per year. The actual value currently observed is 11.45 arcseconds, giving 113,188 years for a complete cycle.²⁵ See Figure 3.

We therefore have two cycles of precession, independent of each other, but both dependent on the force of gravity; axial precession with a period of 25920 years, and

²¹ An arcsecond is 1/3600th of a degree. A value of 50 arcseconds per year gives 25920 years for a complete cycle. Because the rate of precession is not perfectly constant, the length of a Platonic Year varies very slightly.

²² Le Verrier also discovered an irregularity in the apsidal precession of Mercury, and he spent much of the rest of his life trying to find the planet Vulcan, assumed to be responsible for this irregularity. Vulcan was never found, and Newtonian mechanics was (and still is) unable to account for the anomaly. In 1915 Einstein was finally able to solve the mystery using his general theory of relativity.

²³ Modern calculations give a long-term average of 23000 years, with values varying between 20800 and 29000 years.

²⁴ https://en.wikipedia.org/wiki/Milankovitch_cycles#Apsidal_precession

²⁵ <http://farside.ph.utexas.edu/teaching/336k/Newtonhtml/node115.html> ,Table 2.

apsidal precession with a period of 112000 years. Because they occur in opposite directions, apsidal precession shortens the period of axial precession. Figure 3 shows the annual precessions of the spring equinox and the apsidal line. Points B and D will coincide in 6500 CE. The eccentricity and the size of the annual precession angles are again greatly exaggerated.²⁶ From the diagram we can see that perihelion is approaching the spring equinox at $50.290966 + 11.571428 = 61.862394$ arcseconds per year.

In short, the two cycles of axial and apsidal precession combine to shorten the time it takes for the spring equinox and perihelion to coincide to 21000 years.²⁷

Kofler used 11.8 arcseconds of apsidal precession in his calculations, which is close to the modern theoretical value of 11.87 arcseconds.²⁸ His value implies an apsidal period of $360 \times 60 \times 60 \div 11.8 = 109,830$ years.

Kofler then stated (without proof) that perihelion coincided with the winter solstice in 1248 CE, and that (in 1879, when perihelion fell on January 1st), they were 10.82° apart. Currently (2018) they are 13.2° apart. The date 1248 can easily be verified on the internet. One reliable source²⁹ gives 1246 as the year when perihelion coincided with the winter solstice, another³⁰ gives 1268, and also shows how to calculate it using standard trigonometric procedures.

Today the Northern hemisphere winter solstice occurs when the Earth is close to the Sun near perihelion. In the Southern hemisphere the winter solstice occurs near aphelion, when the Earth is further away from the Sun. That's why Adhémar thought the Southern hemisphere is currently experiencing an ice age.

The situation was reversed 10,500 years ago. The Northern hemisphere winter solstice occurred when the Earth was far from the Sun near aphelion, and so Adhémar concluded that an ice age occurred in the Northern hemisphere 10,500 years ago. His prediction was that ice ages would occur every 21000 years, alternately in one hemisphere and then in the other. Placing the most recent Ice Age 10500 years ago turned out to be a remarkably prescient conclusion, because in 1842 geologists were still completely in the dark about the timing of geologic and climatic events.

The Changing Distribution of Water and Land

But Adhémar went further. He theorised about the thickness of the Antarctic ice sheet by comparing the depths of the Arctic and circum-Antarctic Oceans, and found the latter to be considerably larger and deeper. At the time it was not yet known that Antarctica was a continent, and the assumption was that the ice sheet either floated or rested on the floor of the ocean. In either case there was believed to be an enormous amount of ice in the Antarctic. Adhémar speculated that this vast amount of ice displaced the centre of gravity of the Earth, and caused the water of the world's oceans to accumulate around the South Pole. This excess water would freeze and attract even more water. He speculated that the ice would eventually reach a thickness of 60 km. Then, as the Southern Ocean began to warm as the Southern hemisphere summers approached perihelion during the 21000-year cycle, it would gradually melt the base of the ice cap, leaving an enormous mushroom of ice, which would eventually collapse

²⁶ An angle of 50 arcseconds would be just over 20 cm wide 1 km away.

²⁷ $360 \times 60 \times 60 \div 61.862394 = 20950$ i.e. approximately 21000 years.

²⁸ Ibid, Table 2.

²⁹ <https://Earthsky.org/astronomy-essentials/are-the-december-solstice-and-the-january-perihelion-related>

³⁰ <http://adsbit.harvard.edu/full/1895PA.....2..219H/0000219.000.html>

into the sea, creating a 'tidal wave' that would sweep Northward, engulfing the Northern hemisphere, where the cycle of freezing would start again. Could this be the "mighty physical upheaval of the Atlantean cataclysm" Steiner described in lecture 5 of 'Occult History'?

Adhémar's contemporaries were quick to dismiss his oceanic revolutions as mere fancy, and the drastic changes in climate he proposed were also criticised. In 1852 Alexander von Humboldt pointed out that Adhémar's basic idea of one hemisphere warming up while the other cools down was wrong. Any decrease in solar energy (insolation) received by one hemisphere during an aphelion winter would be compensated by an increase during the perihelion summer. Total annual insolation does not vary, only its seasonal distribution. The British astronomer Sir John Herschel (1792 – 1871, son of Sir William) pointed out that any extra warmth the Northern hemisphere received during the longer aphelion summers we are currently experiencing in the Northern hemisphere, would be decreased by Earth's greater distance from the Sun.

Today the reasons why the Southern polar regions are colder than the Northern ones are well known. The Antarctic continent is isolated from the other continents by the Antarctic Circum-Polar Current, which prevents the moderating influence of warmer ocean currents, such as the Brazil Current off South America and the Mozambique Current off Southern Africa. In the Northern hemisphere the warm Gulf Stream flows unimpeded into the Arctic Ocean. Secondly, the ice sheet itself prevents warming even during the summer by reflecting much of the Sun's energy back into space.

Although Adhémar's theory turned out to be incorrect, his fundamental idea that astronomical phenomena have a significant effect on Earth's climate was correct. It was taken up by the self-taught Scottish polymath James Croll (1821 – 1890). He was able to provide a crucial correction to Adhémar's theory by taking into account the additional fact that the eccentricity of Earth's orbit gradually changes. Kofler refers to Croll's work several times in his essay, but only insofar as it supported Adhémar's catastrophic theories, thereby ignoring an important aspect of Croll's calculations.

The Work of James Croll

James Croll grew up in a small village in Scotland. Although he had to leave school at the young age of 13 to help on the family farm, he managed to continue his studies at home. He became fascinated by the "beauty and simplicity of the concepts of the physical sciences, which filled him with delight and astonishment". His interest became a passion, and he later recalled:

'In order to understand a given law, I was generally obliged to make myself acquainted with the preceding law or condition on which it depended. I remember well that, before I could make headway in physical astronomy, I had to go back and study the laws of motion and the fundamental principles of mechanics. In like manner I studied pneumatics, hydrostatics, light, heat, electricity, and magnetism.'³¹

His family was unable to afford university, and he took a number of jobs before he found a position as janitor at the Andersonian College and Museum in Glasgow, where he had access to an excellent library.

Croll realised that Adhémar had been incorrect in concluding that that the difference between the lengths of winter and summer could cause an ice age, but he was

³¹ Quoted in Imbrie and Imbrie (1979), p.77.

convinced that some astronomical mechanism, “some great, fixed, and continuously operating cosmical law”, must be responsible.

Croll was familiar with the work of Le Verrier who had demonstrated that the eccentricity of Earth’s elliptical orbit gradually changes, from as little as 0.005 to a maximum of 0.06. A full cycle takes approximately 100,000 years. Eccentricity is a measure of the roundness or flatness of an ellipse. A perfectly round circle has an eccentricity of zero, whereas an ellipse only 1% longer than it is wide has an eccentricity of 0.14. At present the eccentricity of Earth’s orbit is 0.0167, i.e the ellipse is only 0.014% longer than it is wide. Even on a very large scale drawing such an ellipse would be indistinguishable from a circle.

Orbital eccentricity plays a key role in summer and winter temperatures because it determines Earth’s distance from the Sun at perihelion and aphelion. An elongated orbit decreases the distance at perihelion and increases it at aphelion. As noted above even with Earth’s current very small eccentricity, the difference between perihelion and aphelion still amounts to 5 million km.

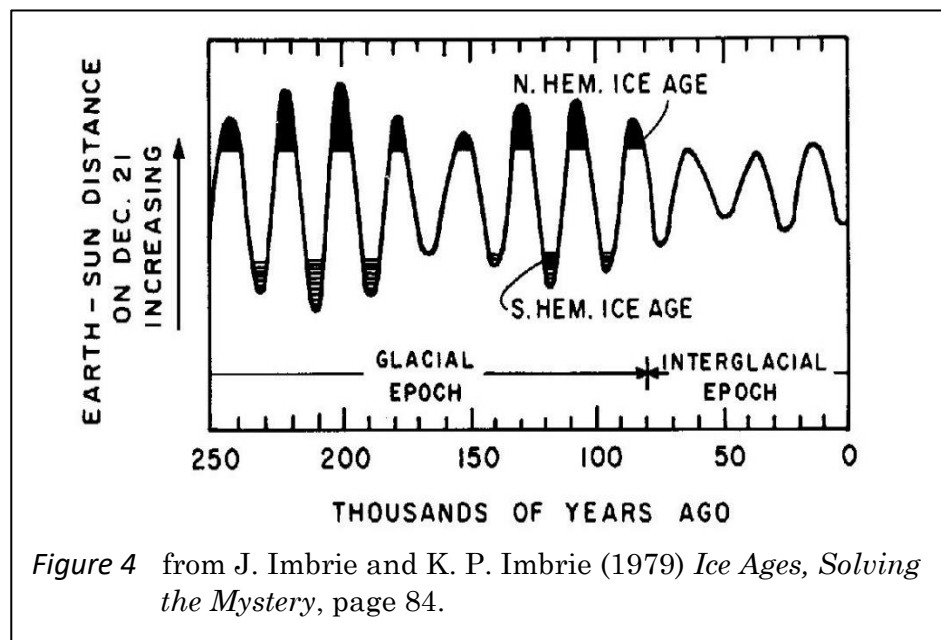
It occurred to Croll that the gradual change in orbital eccentricity might be responsible for climatic changes in the Northern and Southern hemispheres sufficient to bring about an ice age. His first paper, published in 1864,³² evoked a great deal of discussion, and he was encouraged to develop his ideas further. He later wrote: “. . . as the path appeared to me a new and interesting one, I resolved to follow it out. But little did I suspect, at the time when I made this resolution, that it would become a path so entangled that fully twenty years would elapse before I could get out of it.”³³

Using the formulas developed by Le Verrier, Croll calculated the orbital eccentricity for a selection of dates over the past 250 thousand years, and illustrated these on a graph. See Figure 4.

From his astronomical calculations Croll came to conclusions very similar to those of Adhémar. If winter occurs when the Earth is far from the Sun, as it was in the Northern hemisphere 10500 years ago, temperatures drop. If winter occurs when the Earth is close to the Sun, as it is in the Northern

hemisphere today, temperatures are higher than usual. However, a drop in winter temperatures does not automatically result in an ice age, as Adhémar had assumed. Glacial epochs only occur during periods of high eccentricity.

Croll showed that during periods of low eccentricity winters are not cold enough to induce an ice age. He called such periods interglacial epochs. During periods of high



³² ‘On the Physical Cause of the Changes of Climate during Geological Epochs’ was published in the ‘Philosophical Magazine’.

³³ Quoted in Imbrie and Imbrie (1979), p.80.

eccentricity, exceptionally mild winters result when the winter solstice occurs at perihelion, and exceptionally cold winters occur when the winter solstice occurs far from the Sun at aphelion. See Figure 4, on which Adhémar's 21000-year cycles are also clearly shown.

Croll also supported Adhémar's wilder speculations, namely that a vast ice cap at one pole of the Earth would "so derange the Earth's centre of gravity as to draw the ocean towards that pole, and cause the submergence of part of the land."³⁴ In the third and final section of Kofler's essay this is discussed in detail.

Croll's pioneering approach to ice ages was decades ahead of his time. He was the first to recognise that small changes in insolation arising from orbital variations are amplified by positive feedback mechanisms in the climate system:

- Increased snow and ice cover would increase reflection of the Sun's energy (albedo), thereby lowering temperatures even further.
- A temperature decrease in the Arctic would have the effect of displacing the Trade Winds and the North Atlantic Equatorial Current Southwards across the equator. These warm waters would be deflected further South by the East coast of Brazil, thereby decreasing the volume of the Gulf Stream and the North Atlantic Drift, and causing further cooling in the Arctic.

Lyell's Reaction to Croll's Theory

By 1864 there was no longer any doubt that an Ice Age had existed across much of Europe and North America, but all theories attempting to explain it had proved wanting. Included were those of Charles Lyell, who held fast to the possibility of major continental upheavals, and the changing global distribution of land and sea. He described one possible scenario in the first edition of his classic work 'Principles of Geology', first published in 1830-32.

"When land is massed in equatorial and tropical latitudes, polar climates are mild. The land, heated to an excess under the equatorial Sun, gives rise to warm currents of air that sweep North. On the other hand, land massed around the poles produces the reverse effect. There is no land at the equator to soak up heat, and no warm winds coming into polar regions."³⁵

To illustrate his point, Lyell included two maps in all eleven editions of 'Principles of Geology' published in his lifetime. One shows the seven continents we recognize today spread over the tropical latitudes, the other shows the same seven continents spread over the polar regions. He gives no indication of how the continents could have moved to the positions shown, but his maps are an uncanny premonition of Wegener's continental drift theory (today's plate tectonics). Could this have been the source of Steiner's (and Kofler's) claim that "*the face of the Earth was totally changed in regard to the distribution of water and land*"?

If Steiner had not read Lyell's 'Principles of Geology', he was certainly aware of it. In Chapter XXII of his autobiography he wrote ³⁶.

"On the other hand, despite the incomplete form in which they presented their ideas, I recognized in Lyell, Darwin and Haeckel a trend of thinking that could become fruitful when carried further.

³⁴ Quoted in Fleming J.R. (1998), 167.

³⁵ Ibid., 163.

³⁶ English translation from 'Rudolf Steiner, an Autobiography', page 288.

For example, Lyell's principle, that those phenomena of the Earth's evolution which are not accessible to sense observation – because they belong to the past – can be explained through ideas derived from observation of present phenomena, seemed fruitful to me when carried further in the direction indicated; and similarly to seek understanding of man's physical structure by deriving its form from animal forms, as Haeckel does in such a comprehensive way in his 'Anthropogenie', [Evolution of Man], appeared to me an excellent foundation for the further development of knowledge.” (GA 28, 330)

Lyell was eventually, but reluctantly, persuaded to grant recognition to Croll's work by the two highly regarded astronomers³⁷ he had approached for advice on how Croll's theories might affect Earth's climate. In 1866 he added a long chapter on the astronomical influences on climate to the tenth, and subsequent, editions of 'Principles of Geology', but insisted that these were subordinate to geographical causes such as “the relative positions of land and sea”.

Charles Darwin was more impressed. He thanked Croll for sending him his papers, and wrote: ‘I have never, I think, in my life, been so deeply interested in any geological discussion. I now first begin to see what a million means . . . I thank you cordially for clearing so much mist before my eyes.’³⁸

Croll wrote up the results of his meticulous research in his book ‘Climate and Time’ in 1875. Unfortunately for his theory, the timing of his ice ages turned out to be wrong. His calculations implied that the most recent ice age ended 80000 years ago, rather than 10000 years ago (See Figure 4). At the time it was not possible to test his theory because the ages of the glacial deposits (moraines) had not yet been determined, and there was as yet no independent time scale against which his ideas could be tested. Nevertheless, Croll's painstaking work remains a milestone in our understanding of how interactions between astronomical and terrestrial factors such as albedo and ocean circulation, determine the climatic conditions of our planet.

Professor Kofler again

In his essay Kofler explains the effects of the gradually changing eccentricity of Earth's orbit, and quotes values of eccentricity from the 12th edition of Lyell's ‘Principles of Geology’. See Table 1. But he does not explain how this modified Adhémar's theories, except that greater differences between summer and winter would undoubtedly increase the severity of the ice ages, which would continue with their 21000-year cycle. The greater the difference between the lengths of summer and winter, the more severe the ice age. Neither does he mention Croll's discovery that eccentricity has to have a certain critical value before an ice age can occur.

Eccentricity	Difference between perihelion and aphelion	How long ago	Difference in length of summer and winter.
0.0167	5 million km	200 years	8 days
0.0458	13.6 million km	100000 years	23 days
0.0566	16.8 million km	200000 years	28 days

Table 1 Earth's Eccentricity and its Effect on the Length of Summer and Winter

Kofler also discusses the effect of Earth's changing axial tilt (obliquity) on long term climate. He points out that the smaller the axial tilt the less the effect on our seasons. If the axial tilt was zero, we would have no seasons, the noonday Sun would always be directly overhead at the equator, and continuously skim the horizon at the poles. The

³⁷ Sir John Herschel and the Astronomer Royal Sir George Biddell Airy.

³⁸ Letter from Darwin to Croll, 19 September 1868. Quoted in Fleming (2006), 49.

greater the axial tilt the greater the severity of an ice age, because winter snowfall and summer melting are determined by seasonal temperature changes.

The remaining 10 pages of Kofler's 25-page essay comprise a detailed discussion of the theories of Dr Heinrich Schmick, as described in his book 'The Displacement of the Oceans, and the Ice Ages of Earth's Hemispheres, their Causes and Periodicity.'³⁹

Schmick attempted to support Adhémar's theory by finding an alternate explanation for the (supposed) present-day massing of the world oceans near the Antarctic. His explanation is based on the fact that the Earth is closer to the Sun during the 4 months (currently November to February) on either side of perihelion. Accordingly, the crest of the twice-daily tidal wave passing through the world ocean from East to West would be slightly higher, and a small amount of this excess water would (for complicated reasons) be drawn to the South Pole, where it would freeze and accumulate over the many thousands of years remaining until perihelion coincides with the spring equinox (in 6500 CE approx.). In this way changing sea levels would gradually submerge the Southern and expose the Northern continents, leading to a redistribution of water and land as championed by Lyell. But the objections of von Humboldt and Herschel concerning the seasonal compensation of global temperatures are addressed by neither Kofler nor Schmick.

Conclusions

It seems reasonable to conclude therefore that, provided Steiner was referring to 'physical' astronomical processes, the "*mighty processes in the constellation of neighbouring celestial bodies*" in 1250 CE refer to the alignment of the winter solstice with the apsidal line, i.e. the shortest day in the Northern hemisphere coincided with perihelion. The "*neighbouring celestial bodies*" are the planets in our solar system, whose orbits and mutual gravitational attraction bring about the alignment. It is perhaps not too far-fetched to imagine (for how else can we conceive of the effects of their spiritual work in a physical universe?⁴⁰) that the Spirits of Form made use of the solar system's ever-changing gravitational field to bring about the alignment and the resulting changes in global climate at the end of the Ice Age.

The previous alignment which brought about short mild winters as in 1250, thereby enabling the Spirits of Form to be active in the evolution of human consciousness, would have occurred about 19750 BCE, as the Palaeolithic period was drawing to a close⁴¹, and at the dawning of a human (Mesolithic) consciousness we would probably recognise today, as demonstrated by the Magdalanian style of cave art at Lascaux in France and Altamira in Spain.⁴² That transition too was undoubtedly important from a spiritual point of view; perhaps this was a time when a veil first began to be drawn over a direct consciousness of spiritual worlds, a process fully completed 21000 years later, in 1250.⁴³

Ten thousand years from now perihelion will align with the summer solstice in the Northern Hemisphere. Summers will be warmer and shorter, winters colder and longer, but beyond that climatologists are hesitant to predict whether there will be

³⁹ 'Die Umsetzungen der Meere, und die Eiszeiten der Halbkugeln der Erde, ihre Ursachen und Perioden'. First published in 1869, the book has been reprinted (in German) in 2017.

⁴⁰ Even the Large Hadron Collider hasn't provided a definitive answer on the 'real' nature of gravity.

⁴¹ 1250 CE – 21000 = 19750 BCE. There is a great deal of variation in the boundary between the Palaeolithic and the Mesolithic periods as determined by palaeontologists.

⁴² The Magdalanian culture dates from about 17000 BCE, and is named after the overhanging rock shelter first excavated in the 1870's in Dordogne, France.

⁴³ As described by Steiner in 'The Spiritual Guidance of Man'.

another ice age as extensive as the one 10000 years ago. The consensus is that ice ages are initiated at the critical point when summer insolation reduces sufficiently so that it fails to melt back the previous winter's snow. Ice slowly accumulates, more of the Sun's energy is reflected back into space (there is an increase in albedo), and the feedback loop ensures that the ice sheets continue to grow. But even today, the many variables (both astronomical and terrestrial) which determine this critical point are only partially understood.

It seems reasonable to conclude therefore that Steiner's dating of the most recent and the next ice age (in the Astronomy Course and elsewhere) was based on the state of knowledge towards the end of the 19th Century, as presented by Kofler in his essay.

A second reasonable conclusion would be that Franz Kofler's essay was the source of Steiner's descriptions of the drastic changes in Earth's climate, in the global distribution of water and land, and how these were brought about by a combination of axial and apsidal precession. The essay gives an excellent overview of what was known of the most recent Ice Age at the time, discusses the astronomical theories of Joseph Adhémar and James Croll, as well as the terrestrial theories of Heinrich Schmick and Charles Lyell, all of which had sparked the interest of the young Rudolf Steiner.

By the time Steiner gave his lectures (in 1910, 1911, and 1921) the cosmic-astronomical causes of the Ice Age had been established beyond reasonable doubt. Although Adhémar's suggestion of a complete redistribution of water and land every 10500 years had not been taken further, and although the terrestrial causes of the Ice Age advocated by Schmick and Lyell had been proved wrong, Steiner used their ideas as graphic imaginations to support his case for a period of drastic upheavals in the spiritual evolution of humanity, a period when human souls felt abandoned, when "the influence from the macrocosm upon the spirit of man was at its lowest". (GA 126,94) He made use of physical events which were believed to have taken place globally, and which did in fact occur locally, to describe what he saw in his spiritual vision; the storms and tempests experienced by human souls at a critical stage of their spiritual evolution.

Postscript

Croll's astronomical theory was taken further by the Serbian civil engineer Milutin Milanković (1879 – 1958). By making various assumptions about the formation and retention of snow and ice, and for the first time including the effects of axial tilt into his calculations (a greater tilt makes the seasons more extreme), he produced graphs which appeared to correlate well with the 21000-year precessional cycle. He devoted most of his life to the Ice Age problem, and was the last climatologist to do all the necessary calculations by hand. His conclusions, like those of Croll before him, were questioned, and for many years believed to be inaccurate.

Questions which remained unanswered were for example, the problem of warm interglacial periods.⁴⁴ There were still too many unknown terrestrial factors, such as the role played by carbon dioxide and water vapour in the atmosphere in determining global temperatures. To what extent precession, eccentricity and axial tilt influenced the onset of an ice age remained topics of lively discussions among geologists and climatologists. The breakthrough came 100 years after the publication of Croll's book.

By the 1970's powerful computers were able to calculate planetary orbits with meticulous precision. International teams of geoscientists had learned to trace Earth's

⁴⁴ There is mounting evidence that the Earth is presently in such a warm interglacial period.

changing atmospheric and oceanic temperatures by measuring the ratio of oxygen isotopes in air bubbles trapped in the Antarctic and Greenland ice sheets, as well as in deep ocean sediments. Complicated statistical methods had been devised to eliminate random errors in the measurements.

The results of all this work were put together in a ground-breaking paper published in the magazine 'Science' in 1976. Entitled 'Variation in the Earth's Orbit, Pacemaker of the Ice Ages', it showed conclusively that the onset of an ice age is determined by the gradual variations in Earth's orbit as she revolves around the Sun⁴⁵; changes which are in turn determined by the mutual gravitational attraction which the planets in our solar system exert upon each other; by the "mighty processes in the constellation, position and movement of the cosmic bodies connected with the Sun".

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List of Illustrations

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Figure 2. The relationship between solstices and equinoxes and the apsidal line.

Figure 3. The opposing movements of axial and apsidal precession.

Figure 4. Earth's orbital eccentricities over the past 250,000 years. From J. Imbrie, J. and Imbrie, K. P. (1979) Ice Ages: Solving the Mystery.

⁴⁵ Hays, Imbrie, and Shackleton, (1976), 1121-1132.

