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QUALIFICATION

Mini-Thesis submitted in partial fulfilment of the requirements for the degree of

Master of Theology

THESIS SUPERVISOR

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MINI-THESIS TITLE

A Critique of the Scientific Dating Methods Used by Young Earth Creationism to Prove a Global Cataclysmic Deluge: A Case Study of the Grand Canyon's Geology.

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DECLARATION

By submitting this work to the South African Theological Seminary (SATS), I hereby declare that it is my own work, that no one did it for me, and that I did not plagiarise any other person's work. I have cited all the sources such as books, journals and websites that I used. I understand and accept that should this declaration be proven false, I will automatically fail the course and be subject to disciplinary action by SATS.

Please note that unless expressly indicated otherwise, all scriptural quotations are from the "The Holy Bible, New King James Version" (1995), Thomas Nelson Publishers, Nashville.

ACKNOWLEDGEMENTS

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CONTENTS

GENERAL INTRODUCTION AND OVERVIEW OF THE PROBLEM.

Science is always performed from one perspective or another, because prejudice, bias or inclination is inherent in our human nature. Arie Leegwater (2009) believes that for Christians, science is done from within the perspective of a relationship with God. This is particularly relevant in the discussion over the age of the Earth to the Young Earth Creationist (YEC)[1] movement whose literal interpretation of the Bible guides their science.

Young Earth Creationism believes, as is indicated by its name, that the earth is much younger than the billions of years accepted by natural science, holding that God created the earth between 6 000 to 12 000 years ago, with most opting for the younger date (Mcgee 2012). Furthermore, YEC believes that mankind's moral decay so distressed God that He elected to purge the earth by means of a worldwide deluge which was then recorded in Genesis 6-8 in what is known as Noah's Flood.

Recent Creationism argues that the prime evidence for this worldwide flood, and hence for a young earth, is recorded in the stratigraphy of the Colorado River's Grand Canyon, (abbreviated hereafter to GC), which extends almost 250 km from Lake Powel in Arizona's north-east down to Lake Mead in the north-west (Beus and Morales 2003:1). In substantiation of their position, YEC has adopted a number of dating methods and arguments to prove a young earth, the scientific accuracy of which has not been satisfactorily established.

It is the contention of scholars from both the natural sciences and OEC communities, that YEC has at times been guilty of poor scientific practices. Creationist Kurt Wise has been openly critical of some of the ideas and practices that have emerged from fellow creationists (Gundry, Moreland and Reynolds 1999:50), stating that there was a "need for a board of evaluators" to oversee the creationist materials being taught in

[1] Young Earth Creationism (or Recent Creationism) will be abbreviated as YEC, and Old Earth Creationism as OEC, except in headings and at the beginning of paragraphs.

Sunday Schools, Christian Schools and Home Schools because, “The poor kids are being taught garbage” (Witham 2002:52).

This questionable scientific methodology has also been seen in the way in which YEC has challenged the reliability of the current dating methods that are accepted as being accurate by many scholars within the natural sciences, while YEC omits applying rigorous scientific critique to its own dating methods. It is failures such as these that impede the consideration of YEC models, (whether relating to the formation and age of either the GC, or the Earth), as serious options by the general scientific world.

This thesis will investigate the soundness of some of the YEC claims, with the main body of this work being divided into four chapters.

The first major section in the body of the thesis, Chapter 1, “A Critique of Young Earth Creationist dating methods with respect to modern natural science dating methods”, will focus on the scientific principles and practices of both natural science and YEC.

Because the debate over the earth’s age does not exist in a vacuum, this chapter will introduce the subject by:

- Giving a synopsis and historical overview of the debate, which will commence with Bishop Ussher’s dates for creation and the Deluge, and his influence on the early geological thinking that led to the School of Catastrophism. The rise of modern science would replace Catastrophism with the modern School of Uniformitarianism, which grew in influence despite being challenged by the re-emergence of creationist thought in the latter half of the 19th century and which became the modern creationist movement of today.
- Introducing and evaluating some current dating methods. Here the evidence for an old earth as supplied by the study of fossils, tree-rings, ice layers, annual lake deposits (varves), magnetic mineral orientation, coral growth rates, and radioisotopes will be examined.

The Radioisotope dating section will look at the nature of radio-active decay, and how this nucleo-physical-chemical characteristic of an element is used to determine the age of a rock or archaeological artefact. The science and mathematics of radio-dating procedures will be studied, and the Uranium-Lead, Potassium-Argon, Argon-Argon and Rubidium-Strontium methods will serve as examples of the procedures and some of the problems inherent in radioisotope dating. This section will serve as the introduction into an in-depth study of Radiocarbon dating.

- The Radiocarbon[2] dating procedures study is of special importance as disproving the reliability of 14C dating to gauge the age of organic materials would greatly strengthen the YEC claims for a young earth. This section will visit the historical development of 14C science, as well as examining the modern technologies, procedures and problems that are inherent to this dating method. It must be stressed that this will not be a "straw-man" situation, created to support either the YEC position, or the OEC and natural scientific positions.

The next major section, Chapter 2 "Theological and Biblical Examination of the Young Earth Creationist Position" will examine the theological and biblical issues found in this debate. This chapter will:

- Introduce the YEC perspective on the absolute authority and inviolability of the Scriptures, and hermeneutical position.
- Give an overview of two important debates relating to the book of Genesis, namely the supposed influence on the content of Genesis by pre-historical middle-eastern literature, and the authorship-redaction problem. The reason for the inclusion of this material is that the YEC position appears to have areas of overlap with some of the pre-historical epics and myths from the Sumerian and Babylonian eras, which could indicate that YEC theology has

[2] The term Radiocarbon will be used interchangeably with Carbon-14, or the abbreviation 14C.

been unknowingly influenced by the reworking of that material by Moses or later redactionists.

The following sectional sub-divisions will discuss the evidence for and against the cataclysmic event of the global Deluge as this is a special focus of YEC science. Accordingly these sections will cover:

- An overview of aspects relating to flood narratives from around the world, and how theology views the Noah's flood story as God's Judgment on sin.
- The influence of the J and P sources contributions to the Noah flood story as they provide a basis for some off the YEC Deluge postulations which will be discussed later.
- The historical understandings of the Deluge by the Septuagint reading Jewish communities, the Protestant Reformers, and the founder of the Methodist Church, John Wesley.

A short theological study of selected scripture passages relating to the flood recorded in Genesis 6-8 will then follow. The YEC perspective on these passages will be examined so as to understand how they are able to interpret them to validate their dating of the earth, and their claims of a universal deluge which formed the GC.

The Biblical study will be used to seek to understand the basis for the YEC challenge to the accuracy of the dating methods currently being used by the natural sciences. This will include an examination of the YEC assertions that the dating methods of the natural sciences provide greatly inflated ages for rocks and fossils, and thus "mislead" people over its true young age.

Chapter 3 "The Young Earth Creationist Perspective", will examine the YEC models relating to the Deluge, and the GC's formation and geology. In doing so this chapter will:

- Introduce the basic YEC creation model of a single low continent that was riven during the Deluge event into the continents and oceans known today.

- Reveal that there are a number of competing YEC postulations for the internal processes of the Deluge's Biblically recorded duration.
- Take cognisance of Uniformitarian geological responses to some of the YEC postulations.
- Introduce some of the YEC erosional and depositional models, and examine some case studies, such as the Mount St. Helen's event, which are cited as proof for the precedence of catastrophic events as agents of change, over the gradual processes of Uniformitarian geology.
- Discuss the merits of the early YEC Breached Dam model, as opposed to the newer Deluge Drainage model, as an explanation for the GC's formation.
- Evaluate the YEC arguments against the igneous rock formations in the GC being ancient as revealed by the inconsistently applied radioisotope dating methods of modern geologists.
- Examine the arguments for the explanation of the contact zone between the Precambrian and the sedimentary formations of the Phanerozoic Aeons.
- Weigh the evidence for a catastrophic Deluge; and
- Appraise the YEC case for recent marine deposition of selected rock strata within the GC geological column as opposed to modern geology that indicates that the evidence points to multi depositional environments for the sedimentary rocks of the GC.

Chapter 4, "The Future of Young Earth Creationism: Science or Dogma?" will examine the current state of YEC science, and seek to predict its future. This entails evaluating flaws within the YEC scientific method, in order to enable that YEC will be able to contribute to the general store of scientific knowledge, and not be side lined and relegated to the category of religiously biased pseudo-science.

The General Conclusion chapter will weigh all evidence presented to determine whether the contention by both natural scientists and OEC is correct in asserting that the data obtained from the natural and earth sciences does not support the YEC claim that:

(1) The GC originated from a world-wide flood and,

(2) The earth is younger than 12 000 years.

1. A CRITIQUE OF YOUNG EARTH CREATIONISM DATING METHODS WITH RESPECT TO MODERN NATURAL SCIENCE DATING METHODS.

1.1. A Synopsis and Historical Introduction to the dating of the Earth Debate.

For most of the Church's history, neither the earth's age, nor how to determine that age, were issues of concern to the average believer, and certainly not problems on which faith stumbled or fell. When people did think about it, the general consensus reached was that the earth was young (Gundry, Moreland and Reynolds 1999:49). Indeed, Luther (1483-1546) advocated a creation date of 4000 B.C (Portman 1997). From the middle of the seventeenth century however, these issues would become matters for serious discussion which would continue right up to the present. For that reason a short excursion into the history of the debate will be undertaken so as to better understand the current state of the debate.

In 1650 Archbishop James Ussher (1581 – 1656) of Ireland announced in "The Annals of the Old Testament", that his research of biblical and secular sources dated the earth's creation to October 22, 4004 B.C. (Grudem 1994: 273; Mathez 2000; Linder 2004). Ussher then dated Noah's flood to 2348 B.C. (Linder 2004). These and other dates in his chronology of Biblical events would be included in many editions of the KJV Bible for almost a century and a half[3], and hence throw a long shadow over the emerging science of geology.

Prior to the nineteenth century, geological studies in Europe and America had been largely the domain of interested amateur enthusiasts from other disciplines, among whom were numerous Christian laymen and clerics. Influenced by their faith, and writings like those of Ussher, they interpreted their findings in terms of their primary faith document, the Bible, which in Genesis 6-8 highlights the cataclysmic worldwide deluge. This led to geological structures being interpreted in terms of great accidents

[3] YEC still considers Ussher's scholarship of value, contending (i) that the earth is younger than 12 000 years old, and (ii) that Noah's flood was a God directed universal deluge that shaped the earth's geology (Portman 1997).

or catastrophes, giving rise to what became called the 'Catastrophism'[4] school of geological thought (Whitten 1972:74).

'Catastrophism', linked as it was to the Genesis creation stories, taught that most geological structures such as mountains resulted from extremely violent short term processes. Certainly this was the position adopted by Oxford's first Reader in Geology, Anglican Cleric and scientist, William Buckland (1784-1856)[5]. Although not a young earth supporter, Buckland was a 'catastrophist' for most of his life, and was for many years committed to finding proof to support Noah's flood. He was later persuaded by Louis Agassiz (1807-1873) that glaciation, rather than a global flood, offered a better explanation for many sedimentary deposits (California, University of, Museum of Paleontology 2015).

For the most part natural scientists have however, always believed that where possible, supernatural explanations should be excluded, and the answers to any problem sought for in the realm of science (California, University of, Museum of Paleontology 2015). This idea was bolstered by the many new discoveries being made in the geological diggings around the world with the result that 'Catastrophism' began to lose its influence and be discarded in favour of empirical science.

One of the new breed of empirical scientists was Scottish physician and chemist, James Hutton (1726-1797), the Father of modern Geology. Hutton's geological observations, had led him to conclude that natural processes operating over vast passages of time were the primary agents of change. His ideas laid the foundations to the modern understanding of Geology, which has as one of its central guidelines the concept of 'Uniformitarianism'[6] (Fleming 1938: 99; Whitten 1972: 229; Mathez 2000).

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[4] "The hypothesis, … that changes in the Earth occur as a result of isolated giant catastrophes of relatively short duration" (Whitten 1972: 74)

[5] Buckland, called the Father of Palaeontology, is chiefly remembered for, (i) the first scientific dinosaur description of *Megalosaurus bucklandii* in 1824; (ii) his seminal work in the paleontological field of coprology (fossilised dung); and (iii) his work on Britain's geological column (Scott 2015) (Oxford University of Natural History n.d.).

[6] The term uniformitarian geology and modern geology, are interchangeable terms.

Developed further by Charles Lyell (1797-1875)[7], 'Uniformitarianism' replaced 'catastrophism' as the main school of geological thought from then onwards[8] . Lyell believed that while catastrophic events contributed somewhat to the earth's geomorphology, the vast majority of structures and changes to the earth resulted from extremely slow, if not imperceptible, actions by natural processes (California, University of, Museum of Paleontology 2015). He argued that the same geological processes that are observable today, had been acting time immemorial, and that they had shaped and continued to shape, the earth. From the observations of current processes, Lyell declared that is was possible to interpret what had most probably happened in the past. This is known as the Principle of Uniformitarianism, and according to Read and Watson (1977:2) is "the first fundamental doctrine of geology".

By the mid-nineteenth century, many Christians were open to the arguments from natural science that the earth was millions, if not billions of years old. As Anglican clergyman and botanical scientist George Henslow [9] (1835-1925) noted c.1860 that "Geology had revealed the fact that the world had been peopled over and over again by old forms dying out and new forms coming in", (Francis 2010).

The emergence of the Adventist Church in the early 1860's would introduce a new dynamic to this debate, albeit only later in the twentieth century through Adventist inspired writings. Co-founded by Joseph Bates (1792-1872), John N. Andrews (1829-1883), James White (1821-1881), and mystic Ellen G. White (1827-1915), the church would make 'special six literal 24 hour day' creationism one of its "fundamental beliefs". The modern Seventh-day Adventist (SDA) Church still holds[10] this position with respect to the creation of the universe (Damsteegt, P.G. and Committee 1988: 69, 71, 76; Beliefs: The Official Site of the SDA World Church

[7] A former student of Buckland.
[8] Uniformitarian theory predated Charles Darwin's theory of evolution, which was revealed in "On the origin of Species" in 1859.
[9] Henslow's "South African Flowering Plants" (1903), contributed to the foundation of the Kirstenbosch National Botanical Gardens in 1913 (Francis 2010).
[10] These beliefs should "not be viewed as an unchangeable creed" and "constitute the church's *(current)* understanding and expression of the teachings of Scripture" (Damsteegt, P.G. and Committee 1988: iv).

2015). In addition, it would also restress the centrality of Noah's catastrophic flood in the geological history of the world (Gibberson 2009:1).

In the early 1900's George McCready Price (1870-1963), dedicated his life to the defence and advocacy of the doctrines of the SDA. In 1923 he published "The New Geology", a 723 page volume that denied many of the geological tenets being taught in universities, with special attention to discrediting the geological column (Gibberson 2009:3). In 1935 he published a follow up book, "The Modern Flood Theory of Geology". Together these works safeguarded the SDA's position on creation among its followers, although writers note that Price' influence on the wider scientific community was minimal in America, and all but non-existent in Britain (Hayward 1985:77; Boyd and Snelling 2014: 87).[11]

Throughout the mid twentieth century, books such as Alfred M. Rehwinkel's, "The Flood" (1951), continued to challenge the accepted scientific position of an ancient earth, but none would seriously reopen the debate until Henry M. Morris (1918-2006) and John C. Whitcomb (b.1924) released "The Genesis Flood" in 1961[12].

As a result of Whitcomb and Morris' book, recent creationism received widespread coverage and conservative Christians in America and elsewhere thronged to the banner of a young earth. Today, there are numerous organizations that support and advocate that the earth is less than 10 000 years old, most of which are to be found in the USA.[13]

As might be expected, YEC rejects 'Uniformitarianism' in favour of the discredited 'Catastrophism' model. This rejection probably arises from misunderstanding the concept behind the principle, which does not teach, as some YEC members believe, that "the rate at which things are happening has been constant from the beginning" (D.B. Gower, quoted in Hayward 1985: 120). But rather that the same processes,

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[11] Ronald Numbers contends that Price was the pre-eminent voice for special creationism in America for most of the early 20th century in, "George MCready Price and 'Flood Geology'" www.counterbalance.org/history/floodgeo-frame.html , accessed 21-09-2015.
[12] Giberson (2009:3) identifies this book as a scientifically more robust version of Price's work.
[13] Many are listed at http://creation.com/creationist-organizations-in-the-usa.

such as erosion and deposition, uplift and subsidence, have been constantly at work since the dawn of earth's history.

Similarly, YEC return to the ideas of 'Catastrophism' is based on a misunderstanding relating to deposition rates. As Jonathan Sarfati (1999) argues, "Great (sedimentary beds or rock) thicknesses could conceivably be produced either by a little water over long periods, or a lot of water over short periods". As evidence in support of this position, he refers to the Mount St. Helen's volcanic event where some places recorded the rapid deposition of more than 7 ½ meters of pyroclastic material on June 12, 1980 (Sarfati 1999) (see section 4.5 below).

1.2. An Introduction to Current Modern Dating Methods

In the search for answers to the earth's age, science has continually sought to upgrade its old techniques, and to develop new technologies and tools to cross check its results and test its postulates and theories. Indeed it is almost axiomatic that more than one dating procedure will be utilised when seeking to date a geological structure or artefact. One of the oldest and most respected dating tools relates to Palaeontology, the study of fossils.

1.2.1. Fossil Remains.

Even before Darwin, geologists speculated that fossils indicated that the earth was much older than Ussher's calculation. Dating fossils is however, no easy matter. Specific fossils have long been known to occur within certain rock strata, and their occurrence elsewhere is assumed to indicate rocks of similar age (White April 2007). Where more than one species of fossil is present, a more accurate relative age, ("not its absolute age"), for that rock in terms of the global geological sequence can be made (ibid). This is known as William Smith's Second Geological law (Read and Watson 1977: 5). Flipse (2012:126) notes however, that as far back as the late 1920's the YEC accused this law of being guilty of circular reasoning.

Fossilization occurs through three main processes:

- The complete replacement of the artifact's original organic material by minerals (Read and Watson 1977: 297).
- The conversion of organic matter under reducing conditions, over extremely long periods of time, into fossil fuels (Ibid: 202, 278).
- A third kind of fossilization[14] occurs when an animal is preserved in a medium, such as amber, asphalt-tar, or even the arctic permafrost.

YEC claims that all fossils resulted from sedimentation laid down during the Genesis flood (Cave Formations 2008), a position rejected by mainline science which demands great periods of time for these processes. As far back as 1990 however, creationists argued that oil was still being formed today under suitable conditions such as were found in the Gulf of California's Guaymas Basin (Snelling 1990). Subsequently, the production of fuels from waste cooking oils, often within days, under laboratory conditions, has lent support to the position that crude oil need not take millennia to form (see Wang 2007; Demirbas 2009). But where fossils are absent, as in older pre Cambrian rocks, any one of a number of radiometric isotope dating procedures may be the dating "tool" of choice. (See below).

1.2.2. Dendrochronology.

Dendrochronology (tree-ring dating), was developed by astronomer A.E. Douglass (1867-1962), in the mid 1890's after noting the varying tree-ring widths in stumps. Douglass correctly postulated, (i) that annual rainfall determined tree-ring thickness, and, (ii) that the rings might also record sun-spot activity, thereby making them accurate recording tools to help with archeological scientific dating. Douglass' research led him to found the University of Arizona's, "The Laboratory of Tree-Ring Research" (LTRR), in 1937. Today the LTRR is a leader in carbon-14 dendrochronological dating (Kaib 1999).

[14] Armitage (2015) argues that this should only be considered as preservation, not fossilization as no mineral replacement occurred.

Dendrology has proven that tree-cells accurately record natural disasters like fires and volcanic eruptions, as well as environmental changes caused by global weather systems or air pollution (Kaib 1999; Baillie 2010; Harley 2013).

Dendrochronology operates by overlapping sample pieces of wood whose ring-ages are precisely known with matching rings from other older pieces of wood, and so on (White April 2007). Richard Dawkins (2009: 89-90) enthuses that dendrochronology has been able to verify and date events as far back as 9500 B.C. with considerable accuracy, and postulates that tree-ring chains could even be extended further back if ancient petrified forests could be tied into the currently determined chain.

M.G.L. Baillie (2010) however, raises a caveat in the use of tree-ring chronologies, citing cases in England and Germany, where wrong assumptions about (i) the origin of, and (ii) the harvesting dates of the wood being examined, led to inaccurate matching of tree-rings, and hence false results.

Recent Creationists such as Chaffey and Lisle (2008: 137), argue against the accuracy of tree-ring dating claiming that under the disturbed climatic conditions that occurred after Noah's flood, which would have increased the atmospheric moisture content, thereby causing cooler summers and warmer winters, (in effect blurring the sharp distinctions between seasons), multiple rings could have been produced within the same year. I find this argument unconvincing, as such conditions would probably have produced wood similar to tropical tree growth, which are notoriously difficult to date because the consistent growing conditions produce uniform growth without clearly discernable rings. Harley (2013) indicates that new developments in the study of tropical woods show promise in resolving the problem of blurred ring development, thus expanding the field of dendrochronology.

Harley (2013) reports that research into the newest branch of dendrochronology, isotope dendrochronology, (which examines the prevalence of hydrogen, carbon and oxygen isotopes within the tree-rings), has begun to draw interest. These studies are anticipated to throw light on ecological relationships within micro and macro-ecosystems in the period being studied. In fact, the overall developments in the dendrochronological sciences have the capability of making dendrochronology ever

more important to dating techniques of the future, especially when linked in a mutual cross-check to another scientific chronology tool, ice-core dating.

1.2.3. Ice-Core Chronology.

The scientific process of ice-core dating emerged from studies of the Greenland ice-fields. Because Greenland's annual snowfalls seldom melt, each season's snowfall is covered and compacted by the following season's precipitation, and so on in perpetuity. The resulting annual ice-layers are believed to have been relatively constantly deposited over the last 100 millennia or so (Baillie 2010).

These annual ice-layers have preserved in neat succession the dust and pollutants, including lead from the Greco-Roman era (Ancient Lead Emissions Polluted Arctic 1994), that were present in the air at the time of precipitation.

While we note that the Greenland ice-layers have preserved a remarkably good record of the earth's atmospheric conditions over the millennia, this record is by no means perfect or complete. As Baillie (2010) has indicated, there are numerous instances within the ice-column, (almost 3000m thick in some places), that fail to show clear demarcations between successive ice-layers. Where such uncertain layers are noted, melting or folding is assumed, and an uncertainty figure of plus or minus one half-year is added to the estimated age of the disputed layer. This means that the estimated age for a particular ice-layer is acknowledged as being less certain the older it is. Where no independent corroboration exists, ice-core dating should only be taken to indicate an approximate age. Baillie (2010) and White (April 2007) believe that such uncertainties could be minimized where definite global marker events, such as major volcanic eruptions, can be cross referenced to corresponding dendrochronological records. Meese et al. (Geophys. Res. 102, 26,411, 1997), as cited in Wiens (2002:17), suggest that while ages less than 40 000 years may only have an error factor of about 2%, that this uncertainty rapidly rises to

10% for ages dated at 60 000 years and even 20% for ages dated to 110 000 years[15].

A recent development in dating the age of ice has emerged from the discovery that most ice contains minute pockets of air which have traces of Krypton (Kr) gas. Liptrot (1971:170) indicates that under normal atmospheric conditions, Krypton is found as a trace gas in the amount of about 1 part per million (ppm). Like many elements, Krypton is poly-isotopic[16], with one isotope, Krypton-81 (81Kr), having a half-life of about 210 000 years (Winter and Sheffield 2016). 81Kr has been recorded in ice-air pockets. Chowdhury (2014) reports that the calculation of the ratio of the non-radioactive Krypton isotopes to the residual amount of 81Kr found in a sample offers a promising new dating method.

1.2.4. Varves.

Varves, as presented by Read and Watson (1977: 185f), Wiens (2002:18) and White (April 2007), are the definite layers of deposition produced by seasonal flooding in many small, deep freshwater bodies[17], usually in the mid to high latitudes, where very little disturbance of the bottom sediment deposits occurs. These varve depositions, when cross referenced to methods such as ice-core sampling have proved to be useful in archeological studies, and according to Wiens (2002:19) some have been dated accurately to 35 000 years.

1.2.5. Magnetic Mineral Orientation and Mineral-core Dating.

Read and Watson (1977: 13), point out that many minerals have magnetic

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[15] Seely, (2003) views the GIST2 ice-core, the lowest layers of which has been dated by different methods to about 110 000 years, and throughout its length shows no signs of being interrupted by layers which would indicate inundation, as definitive proof that no major deluge, such as Noah's flood, covered this region during this period.

[16] Isotopes are variations of specific elements with extra or fewer neutrons within their nuclei, some being stable, others unstable (Marion 1976: 23). Their discovery emerged from Bertram Boltman's research in 1907 on Thorium (Young 2007b). Note that the convention adopted throughout this paper places an isotope's atomic mass number after the name when written in full, but before the scientific abbreviation such as Krypton-81, and 81Kr.

[17] Whitten (1972: 470) says that in practice "the term is almost always confined to sediments deposited in glacial melt-water lakes".

properties, and that at the time of a rock's solidification, these minerals record the earth's magnetic field within their alignment, which may help determine that rock's age. White (April 2007) notes that this method was used extensively in assigning ages in the mapping of sea-floor spreading.

Mineral-core dating examines the age of layers within mineral cores such as calcite. This procedure measures uranium traces present at points along the core's length, and has produced encouraging results, allowing researchers to date the different layers. Monastersky (1992) raises the caveat that because it is not possible to determine the rate at which groundwater movement through rock strata has occurred prior to the deposition of its dissolved mineral load, (which could be thousands of years), and which would influence the age ascribed to deposits, this indeterminate time must be factored into the final reckoning of a deposit's age.

Akin to this has been the argument that the formation of speleothems in underground cave systems indicates great age. YEC scientists validly challenge this arguing that there is no way to determine whether the groundwater chemistries presently determining mineral deposition have remained constant, and contend that deposition could have occurred much faster in the past, which would give the appearance of greater age (Bottle Stalagmite 1995; Cave Formations 2008). Science has not only looked to date the age of rocks formed by the natural processes of physics and chemistry, but also those formed by biological life, such as the vast ancient chalk deposits in south-east England, dated to the Cretaceous, (Bloodworth, et al. 2002), whose remnants are represented by Dover's White Cliffs, and of course coral reefs.

1.2.6. Coral Reef Dating.

Corals have been proven to show annual growth rings which can be used in dating a reef's age (Plight 1999; White April 2007). We note however, that sea level changes over the ages would influence the calculation of the ages of ancient fossil reefs (Chen 1990). The tools accepted almost universally by natural science as being the most accurate in dating rocks, mentioned thus far only in passing, deal with the decay of naturally occurring radio-metric isotopes found in rocks.

1.3. An Overview of Radio-metric Dating, with Reference to its use in Geology.

Radio-metric dating emerged from Antoine Henri Becquerel's discovery of radio-active decay in 1896 (Marshall Cavendish 2003; Young 2007b), and utilizes the constancy of radio-active half-life decay of the unstable isotopes of numerous elements to determine a sample's age. Half-life decay is the time during which half of the "unstable", i.e. radio-active, isotope will have been converted by either alpha *(α)* or beta (*β)* decay to form a "daughter" element that is entirely different from its parent. In the case of alpha decay, where the nucleus loses a Helium nucleus of two protons and two neutrons, the "daughter" element is four atomic units lighter than its parent, and two places to the left on the periodic table; while beta decay occurs when a nucleus loses an electron, (thus converting a neutron to a proton), producing an element with the same atomic mass[18] one element to the right on the table.

White (April 2007) states that, "the rate of decay is independent of physical and chemical conditions such as pressure, temperature and chemical binding forces"[19]. In his assessment, Roger Wiens (2002:5) states that half-lives "have been observed to not change at all over hundreds of thousands of years". It is this predictability, says White (April 2007), that makes radio-isotope decay the ideal tool in chronological studies. As both the isotopic decay rate and the percentage of the radio-active isotopes within elements have been accurately calculated, a determination of the percentage of the isotope present in a sample allows a calculation of its age, assuming that there is any isotope left to measure. As Wiens (2002:13) points out, all naturally occurring radio-isotopes with half-lives longer than about a billion years or so, are present in the geological record, while those with shorter half-lives are absent, having all long since decayed below any detectable threshold. This argues strongly for the creation of an old, rather than for a young earth.

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[18] Electrons are considered to have no measurable mass.

[19] The artificial isotope Beryllium-7 was shown to have fluctuations of up to 3% in its half-life of 54 days depending on the prevailing chemical environment in one set of experiments, and when subjected to pressures in excess of 270 000 atmospheres in another, as reported by Wiens (2002:21) citing articles from Earth Planet. Sci. Lett. 171, 325-328, 1999; and Science 181, 1163-1164, 1973.

Both White (April 2007) and Dawkins (2009:95), concur that because radioactive half-lives vary from milliseconds in some elements to billions of years in others, the elements most suitable for the particular study must be chosen to fit the time span being studied. For geological studies, where ancient igneous rocks are being dated, a longer more stable element such as Potassium-40, which has a half-life of 1,28 billion years (Marion 1976: 483; Moran 2009), is often used, although as Wiens (2002:1) indicates, there are more than 40 other elements from which to choose. Both Wiens (2002:6) and White (April 2007), recommend that where more than one radio-isotope is found in the same sample, that they be used to cross check each other. (See examples and problems relating to this in Section 4.4.2. below).

Wiens (2002:3) notes that rock dating is not just a simple matter of taking any rock sample haphazardly, testing it and assigning an age to it. To be eligible for reliable dating, the rock must be in as pristine a radio-isotopic condition as possible. This means that the sample undergoing dating must be the product of a closed system that (a) prevented radio-active contamination from outside sources, and (b) have captured all daughter products of the decay method being employed in the dating process. Wiens (2002:3) comments that where evidence indicates that there has been the addition or loss of any radio-active materials “the date is thrown out (and so is the rock!)”.

As noted above, there are a number of options for dating the ages of rocks. Only some of which have come under direct attack by YEC as being misleading. In all cases the calculations of age either employs the same exponential formula, or an adaption of it, and no deviations have been noted in the radioactive decay equation (Wiens 2002:3). The equation formula is as follows:

$$t = h \times \ln (m+1) / \ln (2)$$

Where: t is time in years; h is the half-life of the element; m is the amount of the element in the sample; ‘ln’( ) is the natural logarithm. (Wiens 2002:8).

Historically, the oldest radio-dating method examines the breakdown of uranium (U) to Lead (Pb). Uranium's natural isotopes, 238U and 235U both decay to two different Lead isotopes by two different decay pathways to 207Pb and 206Pb respectively. As Lead has other isotopes, 208Pb being the final decay product of Thorium-232, as well as the non-radiogenic 204Pb, it is easily understood that determining the amount of end product lead from a particular parent isotope is a complex process, and as a result, this dating system is regarded as being less reliable than others. On the other hand, the U-Pb dating process once properly and carefully completed often results in three dating calculations that are used to cross check each other. Wiens (2002:11) records that another dating system that was derived from the U-Pb dating system, examines the Lead isotope daughter products, and has been found to be useful in dating metamorphic events.

The Potassium-Argon dating system uses the decay of a radio-isotope of the abundant alkali-metal Potassium (K), that results in two daughter products Calcium (Ca) and Argon (Ar). Potassium-40 decays by beta decay to form Calcium-40 (40Ca), and by gamma decay with electron capture to form Argon-40 (40Ar) (Mougeot, X.; Helmer, R.G. 2012). As the ratio of daughter elements is precisely known, (with 11, 2 % becoming 40Ar, and the rest 40Ca), a determination of the amount of 40Ar present in an igneous rock with respect to 40K, reveals the amount of decay, and hence the age of the rock when it hardened. The equation for calculating the age is:

$$t = h \times \ln (1 + (40Ar) / (0.112 \times (40K))) / \ln (2)$$

Where: t is the time in years; h is the half-life in years; ‘ln’( ) is the natural logarithm (Wiens 2002:5).

Argon[20] is used because as a gas, most free Argon in the molten magma or lava would quickly migrate out before hardening, thus any 40Ar found in the rock would have been formed after the hardening event. Where a suspicion exists that atmospheric Argon may have been incorporated into the hardening rock, a determination of the amount of 36Ar present may be made, and thus eliminated with its trace 40Ar ratio, from the equation. It was the failure to perform this action that led to YEC tests that showed known age igneous rocks of only a few decades, to have ages measured in millions of years (Wiens 2002:6). I believe that in this instance YEC has inadvertently rendered dating science a service, for it forced natural scientists to adopt stricter 40K - 40Ar protocols, thereby producing more accurate and reliable results.

Derived from the K-Ar method, the Argon-Argon method examines the direct relationship between the amounts of Potassium and Argon in a rock. The process involves nuclear bombardment of the rock sample to convert 39K to the short life 39Ar isotope. The sample is then heated in a furnace at an ever increasing temperature to release the Argon. The decay produced 40Ar and new 39Ar will be released in constant proportions, reflecting the relative proportions of the 39K to 40Ar in the rock sample. Where pre-existing 40Ar occurs, its release will distort the ratio at one or more points, thus enabling the amount of pre-existing 40Ar to be calculated, and subtracted from the final computations. Unlike the K-Ar process, the Ar-Ar dating system, although in use for half a century has not been discounted as being unreliable by the YEC (Wiens 2002: 6).

The Rubidium (Rb)-Strontium (Sr) decay method[21] examines the breakdown of 87Rb by beta decay to 87Sr within the mica minerals such as Lepidolite and Biotite, which are common components of igneous rocks (Read & Watson 1977: 49). This method measures the amount of the radio-isotope 87Sr in a sample and compares it to stable isotopes of Strontium such as 86Sr. The premise behind this method assumes

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[20] Calcium was rejected because as an abundant element, there is no way of determining how much calcium was present in the original magma (Wiens 2002:5).

[21] I have personal experience with the Rb-Sr decay method as it was the radioactive source used to teach the undergraduate geology students like myself, about radioactive decay in the “Physics 1 Terminal” course of the Physics Department of the University of Natal (Durban) in 1979.

that all Strontium present in the molten magma will be in the naturally occurring isotopic ratios right up until the rock hardens, but that the amount of 87Sr will increase as 87Rb decays according to its half-life of 48,8 million years. This increase in 87Sr can be measured and calculated.

Wiens (2002:8,9) notes that there have been instances where the results of Rb-Sr dating have been challenged. A few problem areas that have been identified and addressed are as follows:

- Where there are indications that the parent magma of a rock was not thoroughly mixed with respect to its rubidium and strontium elements, or
- That partial post-formation metamorphism occurred,

Cross checking via another method is the usual practice to determine the age of the sample. Furthermore:

- Where xenoliths[22] were incorporated into the magma before cooling, the decay of radio-active isotopes within the xenoliths will throw the age calculations of the sample out. Competent geologists however, are able to identify these inclusions, and hence exclude them from the younger solidified crystal matrix to produce a representative sample of the rock under investigation.

As a practical example of the application of two of the above mentioned dating methods, Read and Watson (1977:50) record that in the 1970's the Rb-Sr method was used in conjunction with the K-Ar method to date the Shap granites in the English Lake District in the range of 380-395 million years old.

While there are numerous other dating methods being applied today, this thesis does not have the scope to examine them, and so those discussed will suffice as a general introduction to the methods of rock and mineral dating, and focus more closely on the well-known, but largely mysterious world of carbon dating.

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[22] "Xenolith – An inclusion of pre-existing rock in igneous rock" (Whitten 1972: 489)

Read and Watson (1977:49) write that where articles are known to contain carbon, and are believed to be younger than 70 000[23] years, Radiocarbon dating has become the isotope of choice in dating samples from “recent geological history”.

1.4. Radiocarbon Dating.

The impact of 14C dating on a number of modern sciences, such as archaeology, forensics, geology and medicine, cannot be over-estimated. Scholars have recognised the revolution in dating methods that 14C dating heralded, and Desmond Clark (1979), as quoted in Higham et al. (2002), noted that it had put an end to "inspired guesswork" and "imaginative speculation".

When correctly applied, 14C dating has contributed significantly to the growing corpus of knowledge in a number of scientific fields, and much of this data has had interdisciplinary applications thereby bringing related scientific disciplines closer together. Reaching the end product of determining a date by 14C procedures is however, a lengthy and complex process that requires commitment to the highest standards of scientific procedures from the very onset of the sampling, and throughout the process, until the final product is achieved. Like all branches of science, 14C went through its own infancy of inaccuracy, but unlike other sciences, it retains one of those inaccurate elements in its final calculations, and thus an understanding of 14C dating would be incomplete without its historical background with respect to the instruments used in the dating process.

1.4.1. An Overview of Early and Current Radiocarbon Dating Instruments.

Radiocarbon dating emerged from the US Government's Manhattan Nuclear project. Following WW2, one of the physicists on the project, Willard F. Libby led a team of scientists in 1947 to apply some of the war time research to humanitarian ends. While working with radiocarbon, they discovered that 14C atoms decayed at a predictable rate to form the daughter product Nitrogen-14 (14N). Libby’s team’s

[23] Dawkins (2009:95) considers 50 000 years, about 10 half-lives more plausible.

research indicated that with the passing of about 5568 ± 30 years[24], half of the 14C would have decayed by beta decay, and reverted to 14N (Higham, et al. 2002).

Libby's 14C half-life decay rate premise was tested against an acacia wood sample from the Egyptian Pharaoh Zoser's tomb, dated by other means to ca. 2700-2600 BC. The test dated age was found to be sufficiently congruent with the previously accepted age to support the basic hypothesis, which was then further tested against other wood samples of known age. The results of these tests were plotted against a theoretical curve for 14C decay and published in "Science" in 1949. This work led to Libby being awarded the 1960 Nobel Prize in chemistry (Higham, et al. 2002), and opened a new frontier in dating methods, the barriers of which have continued to be pushed back ever since.

Once the premise of the reliability of 14C decay had been established as verifiable and repeatable, fellow scientists sought to develop and expand the science. This led to an adjustment of the 14C half-life value to the currently accepted Cambridge half-life value of 5730 years (Marion 1976: 483; Higham et al. 2002; Regina, University accessed 17-12-2015).

Libby's original method of measuring the by *β*-decay in solid samples by modified Geiger counters was subsequently discarded in the early 1950's in favour of two new and more accurate techniques: Gas Counting, and Liquid scintillation counting. These two technologies which have underdone refining over the decades, have however remained the main techniques utilised in radiocarbon laboratories around the world. Since the late 1970's, a new technique, Accelerator Mass Spectrometry (AMS), has produced faster and equally accurate results as the older methods, while utilising much smaller samples, although at a much greater cost (Beta Analytic Inc. 2016).

Gas Proportional Counting is aligned to the older conventional Geiger counter technology and records radioactive decay events. In order to determine the amount

[24] Known as the Libby half-life, this figure was later found to be 3% less than the actual half-life of 14C and replaced by the current Cambridge half-life figure (Higham, et al. 2002; Beta Analytic Inc. 2016).

of 14C in a sample, the sample is oxidised to Carbon di-oxide (CO_2) gas. The decay of 14C in the gas by *β*-decay, is then recorded by counters, and a determination of the number of decay events is used to calculate the percentage of 14C within the sample, and hence its age (Beta Analytic Inc. 2016).

Liquid Scintillation Counting (LSC) resulted from the discovery in the 1940's that some organic compounds, which were named scintillators, reacted to ionising radiation by fluorescing. Early in the 1950's researchers decided that the recording of these fluorescent events within a determined time period would be a more reliable way of determining the decay of 14C atoms, and hence the total 14C present in a sample, enabling a better calculated age of a sample being dated (Higham, et al. 2002).

The basic process of LSC as practised by modern laboratories is as follows. The samples are oxidised until all Carbon is only present in the form of Carbon di-oxide gas. Other waste gases present are then extracted by physical or chemical processes[25], leaving only pure Carbon di-oxide for further processing that removes the Oxygen by substituting it with Hydrogen to produce Acetylene gas (C_2H_2). The Acetylene is then tri-merised under catalytic conditions to produce Benzene, (C_6H_6), the scintillation solvent of choice[26]. All 14C *β*-decay events in the Benzene, (which cause a fluorescent reaction), are then recorded, and a determination of the amount of 14C present is made (Beta Analytic Inc. 2016; Higham, et al. 2002).

Accelerator Mass Spectrometry (AMS) laboratory analysis, was developed after work done by Rochester/Toronto and the General Ionex Corporation in 1977 (Higham et al. 2002), and has offered another way to perform radiocarbon dating. Although more costly than other 14C dating methods, AMS is faster, thereby producing results in a week or two, instead of months as is the case with other dating technologies (Young 2007c). Unlike older 14C dating methods which relied on recording the number of

[25] Individual laboratories have their own intermediate processes to remove unwanted waste and by-products in the process to achieve a pure Carbon end product (Higham, et al. 2002)
[26] Benzene has excellent light transmission properties, and produces a high chemical yield of Benzene from the Carbon of the original sample (Higham, et al. 2002).

14C β-decay events to determine the amount of 14C in a sample, AMS measures the total amount of 14C present in a sample, thereby eliminating the influence of background cosmic radiation. The Arizona University AMS program has claimed accuracies of 3 to 4 magnitudes greater than achieved with the older procedures, including an accuracy of $\pm$ 150 years with samples as small as 100 micrograms (Arizona, accessed 11-01-2016).

While the AMS process also commences with the combustion of the organic sample to Carbon di-oxide, and its subsequent purification, it differs from the other technologies after this point. Under Cobalt catalytic conditions ranging between temperatures of 820 – 920 Kelvins, the Carbon di-oxide is reacted with Hydrogen in a two stage reaction to produce solid Graphite with water as the by-product. The Graphite is then used as the cathode terminal of a sputter ion source in an accelerator. The graphite atoms are then stimulated into negatively charged ions which are separated into their isotopes along their track by magnetic and electric fields, to finally be recorded by particle detection equipment (Beta Analytic Inc. 2016).

The above instruments, and the results that they produce, were however, still a long way off in the 1950's when radiocarbon dating science began to be taken seriously. In fact the methodologies that are accepted as essential to unravelling the mystery of a sample's age developed slowly over the next few decades.

Early 14C experiments were conducted under the assumption that the 14C ratio present in a sample represented only the products derived from natural 14C decay. This notion was dispelled once, (a) the easy contamination of samples by outside 14C was understood, and (b) the reservoir effect concept postulated. Before either of the above two concepts can be investigated, it is necessary to understand the principles behind 14C dating.

1.4.2. A Simplified Explanation of the Principles behind Radiocarbon Dating.

Carbon is one of the few elements that is being continually produced through natural, human and nuclear processes, and it is produced constantly in its three naturally

occurring isotopes of Carbon-12 (12C), Carbon-13 (13C), and Carbon-14 (14C)[27] [28]. Two of these isotopes, 12C and 13C, constitute almost 100% of available Carbon, with the radio-isotope trace element 14C, only being formed at a rate of about one 14C atom in every trillion (10^{12}) Carbon atoms formed (Baumgardner, et al. August 4-8, 2003; Higham et al. 2002). In lay terms this means that in every million metric tons of Carbon, only 1 gram will be 14C.

Radiocarbon production in nature is determined by the rate of solar radiation which is considered to be relatively constant on an annual global scale (Marshall Cavendish 2003)[29]. The process which takes place in the upper atmosphere occurs when a cosmically bombarded 14N atom acquires a neutron and at the same time releases a proton, creating 14C. The simplified equation is as follows:

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{14}_{6}C + ^{1}_{1}p$$

The newly formed 14C atom, still in an "excited" state by the cosmic radiation, is rapidly oxidized first into the unstable Carbon-monoxide (CO), and then the stable Carbon-dioxide (CO_2)(Frair and Davis 1983: 69; Young 2007c; Beta Analytic Inc. 2016), which makes up about 0,0935% of the atmosphere's gases (Composition of the Atmosphere, accessed 11-01-2016). It is as CO_2 that it is taken up into the biosphere in plant material through photosynthesis, thus allowing all Carbon isotopes, and especially 14C, to become incorporated in all organic materials (Marshall Cavendish 2003; Young 2007c). These isotopes are also fixed inorganically in carbonate mineral deposits.

[27] Another 12 Carbon isotopes have been artificially produced under laboratory conditions.
[28] The full names for the isotopes will be used interchangeably with their chemo-isotopic abbreviations.
[29] Deviations from the natural dynamic balance are discussed below.

It is the reversal of this process, namely the decay of 14C back to 14N that is the focus of the Carbon dating process. The equation of the decay is as follows:

$$^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + \mathrm{e}^{-}$$

This decay, which commences on the formation of 14C, follows its half-life decay rate of 5730 years, and has led to its extensive use in archeology and other sciences. The final formula used in the calculation however, utilizes the Libby half-life and will be discussed below.

In order to determine the age of a sample, the amount of 14C present in the sample is measured against what it should have been at the time of formation in the case of inorganic minerals, or death in the case of an organic fossil specimen. Under ideal conditions, where no contamination of any kind has occurred, the following equation is then used to calculate the age of a sample:

$$t = (\ln (N/N_0) / -0.693) \times h$$

Where: t is the age of the specimen; h is the half-life of the isotope Carbon-14; 'ln'( ) is the natural logarithm function (adapted from Regina, University, Accessed 17-12-2015).

In terms of this calculation, using current technology, any sample older than 10 half-lives (about 60 000 years), would have less than 0,1% of the original 14C, rendering dating all but impossible. All that could be said was that the sample was at least 50 000 years old (Dawkins 2009: 95) (Regina, University, accessed 17-12-2015), and therefore not a specimen from the later part of the Quaternary which dates back

to about 2,6 million years ago, and is a component of the Phanerozoic Eon[30] which dates back from the present to about 530 million years ago.

Key to the use of the 14C process is the premise by natural science that the production rate of C14 in the atmosphere has been relatively uniform over the millennia, and that as a result, the ratio of 14C to the other two non-radioactive isotopes (12C and 13C) in the earth's environment, has remained roughly constant over the last part of the Quaternary. This premise was discounted when dendrochronological studies in the late 1950's and early 1960's indicated that there had been deviations in the ratio of 14C to the other isotopes by as much as 5% at certain times over the last 1500 years. This discovery demanded that 14C results be calibrated against other samples of known established age (Higham, et al. 2002). The necessity of carefully calibrating the amount of 14C present in samples was further underscored by the discovery of carbon reservoir effects.

1.4.3. Reservoir Effects.

Reservoir Effects are caused by environmental conditions which either hamper the absorption of 14C in its usual ratio, or cause extra 14C to be available for inclusion in an organic sample. As such, these effects pose serious challenges to the accuracy of dating some organic samples, as they cause aberrations in determining the age of the objects under investigation.

The effect relates to the problem where the 14C incorporation by living tissue did not occur by direct absorption from the atmosphere, but was derived from another source, i.e. reservoir, of radiocarbon. Any ‘reservoir’ could either be enriched or depleted with respect to the natural atmospheric ratio of 14C to 13C, and hence provide more or fewer 14C atoms for inclusion in organic processes. As has been noted from many diverse samples, any reservoir effect will lead to an inaccurate age, known as an apparent age, being recorded for the sample in question. In cases where extra carbon was present, a younger age is registered, while buffering from a

[30] This eon marks the appearance of the first exoskeletal fossils in the geological record (California, University of, Museum, accessed 12-01-2016).

14C poor or depleted reservoir source, results in an older age being allocated (Higham, et al. 2002).

Reservoir effects can be grouped under three main categories: natural; industrial and atomic. It must be noted that more than one of these effects may have acted on the sample under investigation, either sequentially or at the same time. For this reason strict scientific principles relating to the gathering and storing of samples must be applied at every individual archeological site, so as to exclude contamination, and to ensure that the appropriate reservoir correction figure be allocated to samples submitted for radiocarbon dating (Higham et al. 2002; Philippsen 2013).

The two natural sources that produce reservoir effects are water and volcanism. Due to the relative insignificance of volcanic reservoir effects, this effect will be discussed briefly before examining the far more complex issue of water's reservoir effect.

While volcanism may have played a far more important role in ages past when volcanic activity was far more widespread, its effects today are limited to the geothermal and volcanic zones around the earth. Research has indicated that volcanic gas emissions are usually 14C poor, resulting in apparent great age even in live plants within a small radius of the volcanic zone. This effect falls off rapidly, and at about 200m from the volcanic vents or fumaroles, plants register appropriate ages (Higham, et al. 2002).

The water reservoir effect was first noted in the 1980's, when scientists became aware that objects that had been in contact with water produced anomalous ages when dated by 14C methods. The response to these phenomena differed radically between the Creationist and natural science communities.

Creationist physicist and AMS researcher Gerald Aardsma (1989) short-sightedly dismissed these phenomena as being "not of very great practical importance for radiocarbon dating since most of the artifacts which are useful for radiocarbon dating purposes and are of interest to archaeology derive from terrestrial organisms which ultimately obtain their carbon atoms from air, not the water".

Natural scientists however, realised that because many archaeological objects are sourced from water impacted zones that this was an important aspect of radiocarbon procedures that could not be ignored if accurate results were desired.

Researchers such as Bente Philippsen (2013) showed that aquatically sourced artifacts, both freshwater and marine, can appear to be substantially "older" than their true age due to environmental factors that inhibited 14C absorption[31]. The Oceanic reservoir effect is especially significant, with marine samples usually registering an apparent age of about 400 years older than terrestrial samples taken from above the littoral zone only a few meters away (Higham, et al. 2002). This is due to the vast carbon reservoir capacity of the world's oceans which dilutes the 14C making it less likely to be incorporated into living tissue. In order to derive a true age this error requires a correction, known as the Marine Reservoir Correction.

World-wide testing however, has revealed that the oceanic reservoir figure differs regionally. To this end a global mean has been calculated as the point of reference, and every region must then have an individually calibrated weighted mean Carbon Reservoir Correction (ΔR) figure with reference to that mean (Higham, et al. 2002).

This ΔR figure is attained by measuring the 14C in known pre-atomic age marine samples, and comparing those readings to the 14C readings of 2004 and 2009 marine calibration datasets. For example the weighted mean ΔR for samples along the shallow marine zone (above 75 m depth), and littoral zones of the West Coast of South Africa has been calibrated at 146 $\pm$ 85 years (Higham, et al. 2002).

Terrestrial site samples are known to produce incorrect age results if a local groundwater source is contaminated. This is an acknowledged factor in age determination where organic humic[32] acids, (which readily swop carbon atoms with other organic materials), are present (Higham, et al. 2002).
Philippsen (2013) opines that individual site correction calculations are required, and must accompany all samples under investigation. This is however, a far from simple

[31] Philippsen cites numerous anomalous readings (2013).
[32] Any of a number of extremely long chain organic polymers that form as a result of bio-degradation.

matter. Gupta and Polach as reported in Higham et.al (2002), note that not only must the contaminant(s) be correctly identified, but also the extent and strength of said contamination; and “direction of change” be accurately determined and recorded.

Technological advances have also created reservoir effects as seen in industrial air pollution and nuclear fallout. The Industrial Air Pollution Reservoir (Suess) Effect, first came to notice through the work of Hans Seuss in the 1950’s when he postulated that global industrialization had introduced vast amounts of ancient 14C-free carbon into the atmosphere through fossil fuel combustion. This had effectively diluted the 14C in the atmosphere, giving much older apparent ages to modern post-industrial revolution organic materials as the 14C had not been incorporated into tissues in the standard ratios in which it should have been atmospherically present (Higham, et al. 2002).

In order to calibrate the correct 14C ratio, wood samples from 1890 which predated excessive fossil fuel combustion times, were used as the modern radiocarbon standard. These were then extrapolated for decay to 1950, a year which was chosen arbitrarily for convenience of calculation in honour of the first radiocarbon dates which were calculated in December 1949 (Higham, et al. 2002). Whereas marine and industrial air pollution effects skew radiocarbon dating results to older apparent ages, nuclear contamination operates in the other direction producing younger apparent ages.

Nuclear events have also been proven to affect the amount of 14C present in samples by adding to atmospheric 14C as a result of the many thermo-nuclear tests conducted by the major military powers in the 1950's and 1960's. This has resulted in a younger age being ascribed to articles dated by 14C techniques (Higham, et al. 2002; Philippsen 2013). First recorded in 1958, by Hessel De Vries, 14C levels were noted to increase to nearly double their normal atmospheric levels in from 1963-1965. These levels later fell again as the artificially produced 14C was absorbed by plants (Beta Analytic Inc. 2016; Higham, et al. 2002; Ubelaker 2006).

I suggest that the many nuclear non-proliferation treaties and strict control on nuclear testing procedures at play in the modern world would make it highly unlikely that radioactivity levels, and specifically14C levels, will reach the recorded levels of the early 1960's. The reality of nuclear reactors in both civil power production and military ships, and their spent waste dumps; as well as procedural and mechanical accidents, such as occurred at Three Mile Island (1979), Chernobyl (1986), and Tokaimura (1997), or natural disasters like Tohoku (2011); as well as any future nuclear accidents, will however mean that a nuclear reservoir effect calculation will always be a consideration in every dating process.

1.4.4. Poor Scientific Practices that Detract from Radiocarbon Dating's Reliability.

As is the case with most scientific investigative procedures, strict care must be taken at every level of the radiocarbon dating process to ensure the optimum result. This chain commences with the manner in sampling occurs, through that sample's storage, until its analysis occurs in a laboratory that is often separated both in time and distance, from its point of origin. Unfortunately, such is the sensitive nature of this science to sample contamination by modern 14C, that any break in the procedural chain may severely compromise the accuracy of the final age calculation. Good field work procedures do not necessarily guarantee a good final product. This must be accompanied by meticulous scientific laboratory techniques and thorough scholarship.

Higham et al. (2002), has noted with dismay that often published reports have omitted the most fundamental information relating to the protocols that governed sample gathering, storage and preparation. In other cases, reports neglected information relating to laboratory designations, test reference numbers and calculated reservoir effects. Higham lists as absolutely crucial the inclusion of the following in all reports: laboratory designation; sample number; Conventional Radiocarbon Age BP (CRA) (see below); the D14C figure (which includes the sample isotropic fractionation (d13C) figure, see below), and any reservoir calculation for the sample clearly identified as a *Reservoir Corrected Age.* Additional information to be included should identify the calibration curves being used in the dating process; and the hemisphere from which the sample originated, as cosmic

activity effects differ between the northern and southern hemispheres due to the earth's geomagnetic field[33].

1.4.5. Modern Radiocarbon Technologies and Procedures.

Radiocarbon dating science incorporates theoretical and practical methodologies, and both simple field tools, as well as highly sophisticated laboratory instruments, during the process of dating a sample. While technological advances have refined and improved the quality of the results derived from the recording instruments, the major advances in the science over the decades since Libby's early work relate to the methodology currently in use. It was for this reason, that the instrumentation was introduced earlier before discussing the methodologies that determine the accuracy of the final product – an age determination for a sample. A critical element of which, is the quality of the universal standard against which all samples are compared. Standardization is one of the rudimentary principles of science where any kind of scientific comparison is performed or required[34]. This applies especially to a science such as radiocarbon dating, which requires a standard against which all objects samples could be measured in order to be scientifically consistent and verifiable.

As noted earlier the first standard adopted was based on wood known to have been harvested in 1890. This was later replaced in 1955 by an Oxalic acid solution ($C_2H_2O_2$) standard prepared from sugar beet and designated Oxalic Acid 1 (HOx1) (N.I.S.T.[35] SRM 4990 B). The imminent depletion of HOx1 reserves in the mid 1970's resulted in another standard being synthesised from sugar beet molasses in 1977, and was designated Oxalic Acid 2, (HOx2) (N.I.S.T. SRM 4990C). Subsequently, laboratories around the world have instituted their own standards for their 14C tests, but all of these are considered to be secondary radiocarbon standards, and in most cases are cross referenced to the universal HOx2 standard (Higham, et al. 2002).

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[33] For an introduction to the study of the earth's geomagnetic field, which is outside the limits of this study, see "The Earth's Magnetic Field: On Overview" on the British Geological Survey site, http://www.geomag.bgs.ac.uk/education/earthmag.html.
[34] Discussion of Scientific standards, such as S.I. (International System of Units), and their origins is outside the parameters of this study. For an introduction see http://physics.nist.gov/cuu/Units/.
[35] National Institute of Standards and Technology, Gaitersburg, Maryland, USA.

Standardization in testing is essential to eliminate laboratory anomalies. As HOx2's 14C count is precisely known, it is used to calibrate and assess any local background contamination radiation in a testing laboratory. Where other radiation counts above that of the expected HOx2 are detected, these are subtracted from the test sample's final reading, thereby giving an accurate measurement as to the amount of 14C present in that sample[36] (Higham, et al. 2002). The amount of 14C present may however not be a true reflection of how much 14C should be present, as a factor known as isotopic fractionation must be taken into consideration.

The Carbon Isotopic Fractionation correction figure (d13C)[37], deals with the fact that while all carbon isotopes are deemed to be chemically identical, some reactions have been found to favour a particular isotope over others by preferentially selecting that isotope first. For example, 13C is the isotope most preferentially selected in photosynthesis, while being slightly excessively prevalent as dissolved carbon in the oceanic reservoir. This results in the isotope's "fraction" of the total number of free atoms being either higher or lower in a sample than should have been the case. A correction calculation must then be performed in order to adjust the isotope ratios within a sample to what they should have been under ideal atmospheric conditions. This entails subjecting the sample to mass spectrometer analysis to measure the deviation in the ratio of 13C to 12C, the result being recorded as mille (parts per thousand) difference from the VPDB[38] (carbonate) standard, and designated as that sample's d13C (Beta Analytic Inc. 2016: Higham et al. 2002).

Carbon isotope research has indicated that a strong correlation exists between the ratios of 13C and 14C to the more abundant 12C, with changes in the amount of 13C being approximately doubled for the 14C in the same sample. This means that once a sample's d13C value has been determined, further calculations involving the results attained from the scientific instruments recording decay events can be performed in order to determine the age of the sample (Higham et al. 2002).

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[36] Reservoir effects from the sample's site of origin must also be taken into consideration.
[37] In all cases d and D represent delta.
[38] Derived from the Cretaceous belemnite formation at Peedee in South Carolina, USA. (Coplan 1994 as quoted in Higham 2002).

The frequency of decay events are used to calculate the total depletion of the amount of 14C in a sample, and is expressed in mille to give the d14C figure which is calculated according to the following equation :

$$d14C = (Asn/Aon) - 1)\ 1000 \text{ per mille}$$

Where: Asn = is the recorded activity in counts per minute of the sample; Aon = is the recorded activity in counts per minute of the modern standard (Higham et al. 2002). The d14C figure is then scaled in relation to its d13C figure, to derive the 'normalised' [39] value of d14C, designated D14C. The equation now reads:

$$D14C = d14C - 2(dC13 + 25)\ (1 + d14C/1000) \text{ per mille}$$

The D14C figure is then inserted into the radiocarbon decay equation to give the Conventional Radio Carbon Age (CRA),

$$T = -8033 \ln (Asn/Aon)$$

Where: -8033 represents the mean half-life of 14C (Stuiver and Polach, 1977); 'ln'() represents the natural logarithm; Asn is the recorded activity in counts per minute of the sample; Aon is the recorded activity in counts per minute of the modern standard (Higham et al. 2002).

The CRA formula now reads as follows

$$CRA = -8033 \ln (1 + D14C/1000)$$

[39] Normalization is to the base value of -25.0 mille with respect to the VPDB carbonate standard. (Higham et al.2002).

In all cases, once the amount of residual 14C of a sample has been determined, a Conventional Radiocarbon Age BP (CRA), calculation can be performed, and an age ascribed to the sample under investigation.

The Conventional Radiocarbon Age BP[40] calculation is the final step to calculate the age of a sample. This calculation which is determined by a number of factors (see below), as established by Stuiver and Polach, and published in the journal "Radiocarbon" in 1977, (Higham 2002), has been universally accepted by the scientific community as the standard method of calculating the age of all samples being dated by 14C procedures. The CRA is however, not the actual age of the sample, and the CRA 'age' must first be 'scored' against a set calibration curve before the correct age of the sample is determined.

The reasons for the CRA being incorrect is that it deliberately uses the outdated Libby half-life age of 5568 years for 14C in its calculation, and not the scientifically accepted Cambridge age. This convention was decided on so as to avoid confusion over ages where artefacts had been dated prior to the adoption of the Cambridge half-life age. All dates are thus calculated according to the Libby figures, and designated as CRA ages, and then converted by the relevant calibration curve to their correct ages.

The factors that are incorporated into the calculation of the CRA as cited by Higham et al 2002, are:

- The use of HOx1 (now depleted), HOx2, or any acceptable secondary radiocarbon standards as the modern radiocarbon standard;
- A calculation of the isotopic fractionation (dC13) correction figure;
- The acceptance of 1950 as year 0, for all calculated dates;
- The assumption that natural carbon reservoirs have remained constant through time.

[40] BP represents 1950, see above.

Following from the above the CRA calculation equation is represented as:

$$t = - 8033 \ln (Asn/Aon)$$

Where: t is time in years; -8033 is the mean life-time of 14C (Stuiver and Polach, 1977); Aon is the activity in counts per minute (cpm) of the modern standard; Asn is the equivalent cpm for the sample; 'ln'() represents the natural logarithm.

1.5. Young Earth Creationist Challenges to Carbon-14 Dating.

Young Earth Creationist scientists have challenged the reliability of 14C dating on two points. In the first instance, Baumgardner, et al. (August 4-8, 2003) have questioned the assertion that 14C is absent from organic samples in the older Phanerozoic (see 2.4. above), claiming that 14C traces have been found in organic material from every part of the eon. This, they say, argues that the Phanerozoic is not hundreds of millions of years old, and that life on earth is younger than 90 000 years. They contend that their research supports the case for a global deluge as recorded in Genesis 6-8, which would indicate a recent creation.

Secondly, YEC science suggests that half-life rates may have been considerably faster before the deluge, but then slowed down. These faster half-life states could explain the 14C anomalies that they have identified where mainline scientists believe that none should exist (Baumgardner, et al. August 4-8, 2003; Frair and Davis 1983: 70).

Robert Rogland (2007), in response to the postulation of changes in radioactive half-life rates, wrote that verification of this would demand a severe re-evaluation of current quantum mechanical theory. Davis A. Young (2007b) reports that the constancy of the rate of decay of radioactive materials has been confirmed by "a variety of methods", and that the experimental evidence indicates that if there is any deviation in the constancy of decay rates, that at most it would be a deviation of a fraction of 1%. He also indicates that all evidence relating to known decay rates shows them to be all but impervious to the "effects of temperature, pressure, gamma radiation, x-rays, high energy particles, and electrical and magnetic fields".

Furthermore, Davis notes that this stability has been established with particular relevance to the radioisotopes commonly used in the archeological and geological sciences (2007b). Kirk Bersche (2008), flatly states that no scientific evidence exists to support the hypothesis that any radioactive half-life has ever differed from those known today.

1.6. Self-Correction in the Natural Sciences.

One of the most positive aspects of natural science has been its commitment to accurate and reliable scientific fact. This is seen in the way in that scientists have not hesitated to expose flaws in the science of others, even where scientific icons are concerned[41]. This trend is also seen in the commitment to accuracy in the work relating to 14C dating, where the faulty and poor science, and erroneous deductions and conclusions of others using 14C has been exposed on numerous occasions (van der Plight 1999; Blockley, Donahue and Pollard 2000; Cherubini, et al. 2014).

1.7. Assessment of Current Radiocarbon Dating Technologies.

At this point it can be stated with more than reasonable certainty that the reliability of radiocarbon dating has been adequately established by sufficient independent and cross checked tests for most scientists to assert that in the majority of cases the date derived for a sample is accurate to within a small error factor for ages less than 50 000 years.

I note however, that the above qualification on the limits of 14C dating is based on the inability of current technology to measure amounts of 14C below the threshold of 0,1% (10 half-lives). This is an important point, as the ever increasing sophistication and sensitivity of modern scientific apparatus and techniques will in all likelihood result in this barrier being pushed back, if not overcome. Davis Young (2007c) believes that AMS technology may extend 14C dating reliability further back than the current barrier of about 10 half-lives, and it is almost certain that the next major advance in this field will do so. The result will be that 14C dating will become an

[41] Dr Stanley Miller's work in the 1950's and 1960's, on the supposed primeval atmosphere, was publically refuted in his presence by his ex-students (Rana 2011b).

increasingly valuable tool, when in years to come its ever advanced procedures will provide greater accuracy and produce increasingly older yet reliable dates, than has hither to been possible.

2. THEOLOGICAL AND BIBLICAL EXAMINATION OF THE YOUNG EARTH CREATIONIST POSITION.

2.1. Overview of Young Earth Creationist Thought and Hermeneutical Approach.

In order to understand the YEC perspective on Noah's flood as being a Deluge which covered the whole earth to a depth of 15 cubits, Genesis 7:20, one must first be acquainted with the YEC theological position, which is influenced primarily by their hermeneutical stand point, and secondly by their physical model which is always subject to the YEC hermeneutic[42].

The YEC hermeneutical position is unapologetically that a Christian's highest duty must always be to accept the Bible at face value (Barrick 2014: Lecture 26). For them, Luther's position of *Sola Scriptura*[43] is as valid today as ever (Boyd and Snelling 2014: 12f). YEC Church historian Jim Owen (2016) describes their position as a simple historical-grammatical (literal) interpretation of the scriptures. As such YEC scholars acknowledge the:-

(i) Grammar, and literary techniques such as figurative speech and symbolic language of the autographs; and the (ii) Historical background and culture from which the texts derived; ("Got questions?. org", Accessed 16-02-2017).

For example, Geological Historian Terry Mortensen (nd) "New Answers DVD 3, Answers in Genesis, Accessed 16-02-2017" advocates that Genesis 1 must be viewed as history. He argues that because the New Testament passages indicate that Jesus and the early disciples all accepted the Mosaic books as literal history,

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[42] Footnote "Hermeneutics is the study of correct methods of interpretation", (Grudem 1994: 109), and as the "science that teaches the principles, laws and methods of interpretation", (Louis Berkhof as cited by R.Scott Clark, 2014)

[43] Also *Sola Fide, Sola Christus, Sola Gracia* and *Sola Deo Gloria* (Boyd and Snelling 2014:12f).

this can be the only position open to the church. Similarly Owen (2016) cites a host of early and later Church Fathers including among others Basil of Caesarea (329-379 AD), John Chryostom (347-407 AD), Theodore of Mopsuestia (350-428 AD), Augustine (354 – 430 AD), Luther and Calvin as being of the historical-grammatical school of hermeneutics. Furthermore, Owen makes a strong case that the first 11 chapters of Genesis need to be literal history if the incarnation of Jesus Christ, and His substitutionary death on the cross, is to have anything more than allegorical value.

In his reply to the YEC hermeneutical position, R. Scott Clark ("The Heidelblog", 05-02-2014), (although openly seeking to establish a Reformed Hermeneutic position on the debate), advocates that in addition to the above YEC hermeneutic principles, that both "the original intention of the human and divine authors", and "the narrower (immediate) and broader (canonical) context of a passage", must be included in the hermeneutic process. Just as importantly, in evaluating the YEC *sola Scriptura* position, he makes the point that it is quite possible to believe "in the unique and primary authority of scripture", and still interpret the scriptures incorrectly due to our innate human sinfulness.

The YEC physical model is built on Antonio Snider-Pellegrini's work (1859) (Austin et.al. 1994; Boyd and Snelling 2014: 22), and comprises postulations relating to the geology, geography, and atmosphere of the earth; prior to, during and after the Deluge event.

The ardent search by YEC scholars for physical proof to back up the global flood narrative of Genesis has at times produced dubious conclusions based more on wishful thinking than solid science. In some cases bad science has misinterpreted geological structures for the ark's remains in some localities, and in other cases deliberate falsification has occurred (Hill 2002: 176). John Baumgardner (Duff 2008: 167) decried this, writing that "If we as creationists are to make genuine progress in reconstructing the actual history of the Earth in light of God's revelation, we simply cannot afford such denial and misrepresentation of crucially important information". Barrick (2014, Lecture 28) indicates that YEC is continually seeking new models to explain the world around us. The problem with this position was made by Austin and

Wise (1994: 37) who pointed out that while creationist geology had produced many "broad theoretical models", it had "too few empirical studies to test the proposed theories".

2.2. Questions on the Authority and Reliability of Scripture as Underpinnings for Young Earth Creationist Theology

As noted above, the central tenet of YEC theology is the authority of Scripture. Most YEC scholars have accordingly adopted the Chicago Statement on the Inerrancy of Scripture as the basis from which they do their theology and science. This position therefore obliges us to investigate, (even if in only the most cursory fashion due to the constraints of the main focus of this thesis), two key problems relating to Genesis, namely its independence from outside influence and the issue of Man's origin.

2.2.1. The Arguments for the Independence of the Genesis 1-11 passages in the Light of other Ancient Near Eastern Writings.

When referring to the authorship of the Pentateuch, tradition has usually accepted that Moses was responsible for this collection of works within the Bible (NIVSB 1985). John Collins (2004: 48) however, writes that there is "no basis for this claim in Genesis or in the narrative portions of Exodus". Derek Kidner's assessment of Genesis is that it is an exceptional piece of writing in terms of its literary construction, dealing insightfully with spiritual and psychological concepts, and that "If its chief architect was not Moses, it was evidently a man of comparable stature" (1967: 16).

Be that as it may, when reading Genesis 1 -11 in the light of the Mesopotamian cosmogonical literature, one is struck by apparent similarities between these two sets of writings. This raises the important question as to whether any relationship exists between these writings, because if such a relationship can be proven, it would destroy the very foundation of the YEC position, which holds to the inerrancy of the scriptures.

In response to the problem Alexander Heidel (1951: 131) says that the textual similarities raise three possibilities:

(i) The Genesis account influenced the Mesopotamian myths;
(ii) The Mesopotamian writings influenced Genesis;
(iii) These and similar creation stories dated from a time when human beings had a more common belief system.

To these, Kenton L. Sparks (2007) adds two further options:

(iv) One text, (in this case the Hebrew), may have been influenced by another text, (the Mesopotamian), by means of a third intermediary unknown piece of literature;
(v) Similar, but unrelated events in each culture may have resulted in accidental parallel literature, which he calls “a phenomenological explanation”.

When all the arguments and debates about Genesis are evaluated, and among others they include:

- Early dates for Genesis having been written by Moses c. 1270 B.C., and whether or not he used earlier sources that may have been redacted, (Barker 1985:2; Hummel 1986); or much later authorship during the post-exilic period (Hummel 1986; Van Kooten 2005; Sparks 2007; Enns in Lioy 2012: 214);
- The supposed Akkadian roots of Hebrew, and the possible influence of Mesopotamian literature on scripture (Heidel 1951: 131; O'Leary 2003);
- That Genesis was written in sober non-mythological prose form to convey to the readers that its content was historical, and not as poetry as was the case of the Mesopotamian myths and epics (Boyd and Snelling 2014: 47), which as Heidel (1951:66), George (1999) and P. Enns (Lioy 2012:215) argued had purposes of teaching theological, political and life lessons;
- That Genesis teaches against polytheism while systematically discrediting and repudiating the Mesopotamian pantheon (Hyers 1984: 45,51); and
- That creation resulted *ex-nihilo* by God’s divine omnipotent fiat, (Heidel 1951: 89,97, 126,129; Hyers 1984:45; P. Enns in Lioy 2012: 215-6;), and was “very good”, but not in any way divine (Harlow 1984:182; Hyers 1984: 44),

we arrive at a position where the scholarly verdict, although not unanimous, is weighted in favour of Genesis being independent of the Babylonian writings.

Furthermore we note that C. J. Collins (Lioy 2012: 200) acknowledges that "a relationship" exists between the works, but contends that the truth about creation's origin is to be found in Genesis. Polkinghorne (2009: 164) recognises comparable "connections", but dismisses them as sufficiently dissimilar not to cause real concerns "for the modern reader". Heidel (1951: 139) however, flatly stated that the differences between the writings are so great that they negate any claims that the Genesis accounts were derived from the Mesopotamian texts.

The above leads to an assessment that the YEC model of creation:

(i) Cannot be said to be have been accidently influenced by the pre-historical myths and epics of the early Mesopotamian civilizations, as those writings are not related to the scriptural account of the creation as recorded in the opening chapters of Genesis, and

(ii) That the YEC model follows on directly from early Hebrew and Christian interpretations of the Genesis writings.

This assessment then allows us to examine the second problem of the origin of man.

2.2.2. Man's Origins in Young Earth Creationist Theology.

No discussion relating to the YEC theological position on creation, sin and the Flood, would be complete without a brief consideration of the origin of man. YEC theology ascribes to the classical viewpoint as expressed in the Westminster Confession and accepts as historical fact that in Genesis 2, the Bible introduces Adam and Eve, as real people who were the first human beings, and progenitors of all mankind (Harlow 2010: 181; Berry 2011: 42). The unfolding story reveals how through their willful disobedience, God's perfect created order of hierarchical relationships between Himself, man, woman and nature was forever disturbed. From this time forward, man and woman would be in conflict with each other, with nature, and most importantly, with God (Walsh 1977: 174; Och 2001a: 152,154; Och 2001b: 340; Berry 2011: 39).

As in the previous section, the disproving of the “reality” of Adam and Eve would strike at the heart of the YEC belief structure, but here again only the barest attention can be given to this debate.

Other positions on “Adam and Eve” that have been considered are that they were:

- Not the ancestors of all people, but only of the Hebrews (Berry 2011: 27);
- The tribal heads of the early clan of humans (Collins in Lioy 2012: 206).
- Generic names for the sum total of early human beings (Berry 2011: 21,48).
- The first spiritually aware people Berry (2007: 25; 2011:35);
- Real people formed for a priestly function in the world, while also being archetypes for all humanity (Walton 2012: Lecture 4);
- Not historical persons, because man is the product of evolutionary processes (Enns in Lioy 2012: 223);
- Literary figures whose story conveys moral truths applicable to all of humanity (Harlow 2010: 181; Hendel 2013: 183-4).

In assessing the arguments over the persons of Adam and Eve, Collins (Lioy 2012: 194) shows that wherever mention is made of them in the scriptures, the understanding was that they were real people. The early church, and even secular historians such as Josephus, held similar beliefs.

In his final analysis, Collins argues that there are good reasons to support a belief in a historical Adam and Eve:

(i) Man is so unique and so entirely of a different order to the rest of creation, that processes such as natural selection could not have accounted for his/her existence.
(ii) The commonality of man in every way, regardless of the level of culture, points to common ancestors best described in the persons of Adam and Eve (Lioy 2012: 206).

The conclusion that I have reached from the above is that while the case for the existence of Adam and Eve as the progenitors of the human race has not been

comprehensively proven, neither has it been disproven, and as such it can have a place in the theology of the church, and play a key role in YEC theology.

2.3. Perspectives on the Genesis Flood Narrative

2.3.1. Introduction.

In most studies in this field of science and theology, it is usual to find extensive coverage of the debate relating to whether or not ancient texts such as the Mesopotamian epics and myths influenced the Genesis flood. As this aspect was briefly covered above and dismissed as unconvincing, it will not be revisited.

On the other hand, the prevalence of flood stories from around the world requires a brief excursion into this topic, which will then be followed by a short overview of some of the current arguments pertinent to the debate of whether the Genesis flood was universal or localised.

2.3.2. The World Wide Culture of Deluge Narratives.

The dismissing of the Mesopotamian flood myths as irrelevant to the Genesis Deluge story does not however dismiss the topic of similar stories from further afield. Most scholars recognise that flood myths, poems and narratives have been reported from such widely separated cultures as early middle-eastern civilizations, the Orient, the Americas, and Polynesia (Rehwinkel 1951: 128; Kidner 1967: 95). Antony Milne (2000: 80-81) states that at least 72 languages contain a deluge story, while Richard Andree (Rehwinkel 1951: 129) claimed to have “collected 88 different flood traditions”.

In many of these stories the recurring theme is of a single family being warned by a deity to either seek refuge, or to prepare for the coming catastrophe, in order to survive and later repopulate the world. Three suggestions have been offered for this:

(i) That older cultures developed the myth, and then passed it on to their successors, (Neil 1962: 31);

(ii) That every culture/civilization has at some time or other suffered a flood of such devastation that it made its way into the folk records of the survivors' descendants, (Hill 2002: 180); or

(iii) That an actual physical world-wide catastrophe occurred in civilised man's history, which is recorded in different forms throughout the world, (Harris 2006).

The YEC have adopted the third option as the only one they believe to be in line with a literal interpretation of the Biblical record. This position will be examined more fully later through their interpretation of Hebrew autographs and science.

2.3.3. Some Current Perspectives on the Genesis Flood Narrative.

2.3.3.1. The Genesis Deluge: Universal or Localised?

Both Carol Hill and Dick Fischer believe that the Genesis account records a widespread devastating flood that was restricted to the Mesopotamian catchment area about 4900 years ago[44]. The relevance of this catastrophe was however, not universal to mankind, but only to the Semitic communities of the middle-east from which Abraham would emerge (Kidner 1967: 95; Fischer 2003: 230). Hill (2002: 171) believes that it was this flood, (which the Mesopotamians experienced as the destruction of their world), that was recorded as Noah's Deluge.

Similarly, Fischer (2003: 227) suggests that the idea of Noah's flood being a worldwide event originated in a misunderstanding of the Hebrew word commonly translated as earth. In Genesis 6:17, the word "*'erets*"[45] occurs and may be translated as 'earth', or 'land'. In the latter usage the word would indicate a geo-political area such as 'the land of Egypt, or Judah' etc. He indicates that where the whole earth is the focus, another word, *"tebel"*[46] is used. He thus contends, that the use of *" 'erets"* would indicate that the deluge judgement was local or regional, and not universal to the whole world. He also notes (2003: 228), that the word for

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[44] Derek Kidner believes that the Genesis 5 and 11 genealogies indicate an earlier date (1967: 95). Kent Hovind a later date (2003).
[45] Strong's (776), concurs but allows for *world* as a possible translation.
[46] Strong's (8398) by extension the *globe.*

mountain could be equally translated as hill, and believes that Genesis 7:19 refers to the hill ranges that surrounded the Mesopotamian catchment region, which could easily have been covered by an extra-ordinarily large regional flood.

In relation to the Biblical basis for a world-wide flood, Hill (2002: 171) opines that the best argument is found in the universal language of Genesis 6:6-8, where God repenting of mankind's creation because of the universality of human depravity, elected to destroy man.

Kidner (1967:91), does not see in the Genesis 7:19-24 passage "decisive" evidence to support either a universal or a localised flood, but affirms that the passage requires the reader acknowledge that the ark had cleared the mountains by fifteen cubits. He concedes however, that the evidence against a universal flood as presented by natural science has made the YEC position of a universal flood increasingly difficult to defend (ibid: 94).

We note that many Christian scholars accept the perspective of Noah's flood as a localised event in the Mesopotamian region, as the combined weight of the many scholarly works relating to biblical interpretation and translation, climate and weather patterns, and, geography and geology, on this topic, when taken together, present a formidable argument for a localised flood event. As the main focus of this thesis is elsewhere, the above brief overview is sufficient to introduce this aspect of the discussion to those interested in pursuing this subject further.

2.3.3.2. God's Grace towards Noah Amidst Judgment on Sin.

Central to the Flood narrative is the person and actions of Noah, who some scholars have identified as Ziusudra/Utnapishtim, the king of Shuruppak, from the Gilgamesh Epic. Some scholars contend that he was the only surviving righteous male descendent of Seth's godly line, the others having become enamoured by Cain's female line, Genesis 6:1-2, and which had led to them being drawn into practices of which God disapproved (Rehwinkel 1951: 52; Kidner 1967: 84; Hill 2001). As a consequence of the above, God then elected to save Noah along with his family, as they were to continue to teach the truth about Him in the world (Mallowan 1964: 63; Hill 2006: 125).

Kidner (1967: 86-87), notes that it is Noah's unique righteous relationship with God, amidst a totally corrupt world, that allows God to commune with him, and as a result to save him and his family (1967: 86-87). Neil (1962:31), further postulates that it is the presence of devout people of all religions amongst us, (whose hearts, like Noah's, are inclined to God), that stays God's hand from once again visiting His wrath on sinful humans before the final judgement.

Returning once again to the theme of judgement, we are obliged to ask who was being judged, and how extensive was that judgement.

2.3.3.3. The Deluge: Universal Judgement and death, or Specific only to Mesopotamia?

Mallowan (1964: 81) and Hill (2006: 127) concur that the deluge, although occurring through natural processes, was a divinely orchestrated judgement by God on sin in the Mesopotamian region that occurred about 2900 BC. A major point of discourse is whether or not this was a universal judgement on the entire human race, or a selective punishment aimed at only a specific portion of humanity.

Fischer (2003: 229) cites Donald Boardman as contending that God's focus was on the Mesopotamian society and culture to which Noah belonged, and that the punishment was restricted to them. In his turn, Fischer argues that the flood judgement was reserved for those who had been the inheritors, and violators, of the Adamic covenant, who lived in the Mesopotamian zone. Those outside the zone had been exempted from destruction as they had not known any teachings on sin, and were therefore not under the law in terms of Romans 5:13b. I find this argument to be disingenuous, as all but the very young and insane, know right from wrong.

Genesis 7: 22-23 records the death of every air breathing creature on earth as the result of the Deluge. This, Barrick (2014: lecture 26) declares, fulfilled God's plan to destroy all terrestrial life, and that the people and creatures saved in the ark were predestined to repopulate the earth.

Fischer (2003: 228), on the other hand, reminds us that Hebrew literature's rich usage of pictorial speech should also be applied to the news that "all" air breathing

life perished on earth. As such it should be interpreted as meaning that while a considerable percentage of animals died, it should not be literally understood as indicating that no life survived the flood.

Unpacking the story of Noah and the Flood is however not quite as straight forward as most readers perceive the story to be, as careful scholarship has revealed that Genesis 6-9 appears to have two distinct Hebrew narratives which have been skilfully intertwined by some unknown redactor.

2.3.3.4. An Overview of the J and P Flood Narratives Argument.

Neil (1962: 32), Kidner (1967: 98) and Edwin Good (2011: 69) identify two distinct, but well interwoven, narratives in Genesis 6-9, which are identified as the J and P traditions. The J source tale has a distinctly Hebrew religious slant and refers to God as Yahweh, and approaches the Deluge from a naturalist perspective which lasts 61 days. The P account calls God Elohim, and while it is less overtly religious, reveals the Deluge as a supernatural event lasting 375 days.

J's flood story's origin is traced by Good (2011: 77) back to Eden. Humanity's understanding of the "knowledge of good and evil" Genesis 3:5, had begun a pathway that led ever downwards from the murder of Abel, until Yahweh regretted creating mankind, and decided to undo His creation.

Without recording mention of the ark's construction, Noah was tasked with collecting seven pairs of "clean", and a single pair of "unclean" animals, of every kind to stock it. The implication is that the extra "clean" animals were required in terms of the Hebrew dietary laws for, (a) food during the voyage, and (b) afterwards for sacrifice[47], Genesis 8:20. The narrative then simply declares that a 40 day torrential rainstorm[48] followed, which Good (2011: 78) interprets as indicating that a long period of rainfall followed which was sufficient to flood the earth completely. After the flood was over, Noah then sacrificed some of the clean fauna as a burnt offering, the

[47] Henry (1873: 59), three pairs to breed and the seventh for sacrifice.
[48] By comparison, both Gilgamesh and the Sumerian flood story record a seven-day storm that drowned the flat Mesopotamian world (Good 2011: 79).

aroma of which was pleasing to Yahweh, who then promised never to destroy everything again, despite the fact that mankind had not changed.

The P flood story is seen by Good (2011: 80-81) as commencing at Genesis 6:9 with Elohim's repetitive refrain of man's universal corruption, and then commanding the ark's[49] construction, which would house the refugees during the coming Deluge. The fact that only single pairs of animals were taken into the ark argues for the perspective of antediluvian vegetarianism[50].

In this version, the Deluge viewpoint appears to be that of a hill dwelling people who thought that for the mountains to be submerged, prolonged inundation would be required, followed by an equally long time for the water to subside again. The waters for the Deluge were derived from two separate zones: (i) the subterranean "fountains" below the earth, and (ii) the "windows of heaven" above it. After having been open for 150 days, these great water sources closed, and the waters then retreated over the same period, until the ark grounded itself in the Ararat region. At the end of this voyage, no sacrifice occurred, as would be expected if there were only a single pair of every species on board, Genesis 8:19 (Good 2011: 82-83).

Good (2011: 79) sees this narrative as more than just the recording of a natural disaster, rather it is a radical reworking of the original creation, so that God can restart creation anew with the remnant of earth's life preserved in the ark.

Having examined the above, the questions that now emerge are whether the Hebrew scriptures support a worldwide, or a regional flood, and whether they have been correctly translated in terms of their original meaning and intention, or if ideas foreign to the original author(s) have been imposed upon the text? These questions will be addressed below in section 3.4.

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[49] "Floatable box" (Good 2011: 80-81), or "chest" (Kidner 1967: 87), or "coffin" (Kessler and Deurloo 2004).

[50] As this study's focus is on the Flood and its purported remodelling and restructuring of the earth's geomorphology, no further discussion relating to the Ark's size, construction duration, or its manifest will be conducted.

2.4. Interpreting the Ancient Scriptural Texts.

For YEC followers, as has been noted before, their foundational position is the belief in the infallibility of the Scriptures. As such, YEC science has the responsibility of substantiating the truth of scripture, or perhaps more correctly to say that YEC science is the tool with which they seek to prove *their* perspective of Biblical truth. This thesis therefore requires an understanding of the ancient texts from both the YEC and mainstream scholarly perspectives. The following section will cover the understanding of the Flood texts by scholars from various eras, as well as highlighting certain areas of debate

2.4.1. The Septuagint's Perspective on the Flood Narrative.

The earliest respected translation of the Hebrew Scriptures is the Greek Septuagint. For many years it had a place of honour within the Jewish communities of the Mediterranean world, and as such influenced the understanding of those who read it, especially with respect to the Flood narrative. According to Susan Ann Brayford (2007: 267), the Septuagint reveals that once the rains began, the storm conditions continued to worsen during the initial 40 days, she cites Wevers (1993:97) who argues that the imperfect Greek verbs in Genesis 7:17-24, '*ἐπληθυνθη*' 'multiplying', and '*ἐπεκρατει'* 'prevailing'*,* indicated that the floodwaters were "winning the battle with life on earth". After the 40 day tempest passed, the floodwaters continued to cover the earth for a further 150 days before 'giving up' '*ἐνεδιδου*' (Brayford 2007: 268), which I suggest is nature's proper and obedient response[51] to the might of God's power as excercised in the wind of Genesis 8:1.

2.4.2. Historical Protestant Understanding of the Flood.

When reading the Bible it is apparent that most people of faith held to a literal understanding of the flood as a universal event, as is seen in Isaiah 54:9, Matthew 24:37f, Luke 17:26f, Hebrews 11:7, First Peter 3:20 and Second Peter 2:5.

[51] See Psalm 93:3-4.

Calvin, in his commentary on Genesis, clearly held to the authorship of Moses[52], to whom he continually referred. With regard to the narrative of the chronology of the Flood, he believed the narrative to indicate that the flood commenced in the springtime with 40 days of continuous rain (Calvin 1948: 261, 271). The waters were supplemented by subteranean sources (Ibid: 270), which caused the flood-waters to rise continually until they floated the ark, covered the hills and then the high mountains to a depth of 15 cubits[53] (Ibid: 272). God then shut the waters off at their sources in the heavens and under the earth, so that they remained constant for 150 days, before subsiding and allowing the ark to finally come to rest in the Ararat range after about 10 months (Ibid: 277).

Scott Manetsch and Timothy George (2012: 263), note in their evaluation of the reformer age that while the high profile leaders such as Calvin, Luther, and Zwingli did not engage the debate as to the depth of the floodwaters or the universality thereof, with any real interest; some of their lesser known fellow reformers like Wolfgang Musculus (1497 – 1563), Johannes Brentz (1499 - 1570), and Peter Martyr Vermigly (1499 - 1562), embraced a flood that covered the highest mountains.

John Wesley (2016), clearly interpreted the scriptures in terms of a young earth and dated the flood as occuring 1656 years after the time of creation. He accepted that for 40 days and nights the rain was continous over the whole earth in a way “as were never known before or since”, and seems to imply, (although it is not clear), that the waters reached their zenith at the end of the 40 day inundation, at which point they covered the pre-flood mountains. After this a period of 150 days followed where the waters ebbed and flowed, all the time gradually subsiding until the ark finally ran aground in Armenia under God’s “wise providence”.

[52] The first recorded challenge to Moses’ authorship of the Pentateuch was by the twelfth century Jewish scholar Ibn Ezra (Collins 2004: 48).
[53] Hill (2001) notes that the ancient Sumerians also identified three other lengths of 30 cm, 52 cm and 72 cm as the cubit, and questions whether the 45 cm cubit, which is commonly adopted by scholars, can be positively accepted as the Biblical cubit of Genesis.

2.4.3. Genesis 7:11. “The Great Deep’s Fountains” and “The Windows of Heaven”.[54]

In examining the phrase "the fountains of the great deep" Gen 7:11, Fischer (2003: 227- 228) indicates that in Hebrew the phrase has multiple meanings that include sub-oceanic vents, the deep sea itself, and even riverine depths. He argues that within the wider Semitic language group usage, the phrase can refer to any inundation by water, regardless of how it occurred. Eugene Roep (1987: 69), interprets both these phrases as a reversal of the orderliness of creation and a return to the pre-creation chaos before God separated the waters, Genesis 1:2-7. John Barton and John Muddiman (2010: 64) concur, seeing both the phrases not in terms of water sources, but as the indication of God undoing His created order as “chaos has come again”, but make no comment on the duration of the flood’s inundation.

Good (2011: 78-82), believes that a careful separation of the two interwoven flood stories leads to two different conclusions. In the J narrative, he identifies exceptionally heavy natural rainfall which fell for a considerable duration and was recorded as “40 days and nights”. He concludes that the number “40” must not be interpreted literally, but merely represents a long time[55]. He does however, see a different perspective in the Y narrative. Although unsure as to whether Genesis 7:19f supports the waters rising by fifteen cubits, or covering the mountains to that depth, he grants that it is the writer’s intention to show that the rain that fell was unnatural or supernatural, and was about the task of “undoing of whatever restrained the cosmic waters from the creation” (Ibid: 82). Although unsure of the links between the “*tehom* / abyss-fountains”, and the “windows”, he interprets the passage as indicating that the waters continued to grow in magnitude until both sources were closed at the end of 150 days, after which the water swiftly receded over the next five months (Ibid: 82).

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[54] “Floodgates of the sky”, (NASB 1977).
[55] Similarly, Spence and Exell (1911: 117), interpret the ”40 days and nights” as “metaphorical and optical” language.

2.4.4. "*Mabbuwl"*, God's Divine Flood.

Young Earth Creationist scholars Chaffey and Lisle (2008: 89), and Barrick (2014: Lecture 26) indicate that the word *"mabbuwl"*[56], translated as flood, is only used in scripture in the context of Noah's Deluge, and that other words are used to describe local floods and flooding. Kidner (1967: 89) concurs, and both Strong's (n.d.) and Young's (1949) concordances confirm that *"mabbuwl"* only occurs once again after Genesis 11:10, in Psalm 29:10, supporting the assertion that this was not a natural flood, but a divinely orchestrated event.

2.4.5. The Depth of the Flood.

In Genesis 7:19-20, the mountaintops were reportedly submerged to a depth of 15 cubits, (about 6 ½ m). Carol Hill (2002: 173-174, 176- 177) argues that because the depth of flooding could be determined, this shows that the flooding referred to was restricted to the covering of the highest points in the Mesopotamian plains, which were local hills, or even ziggurat temples. She concedes however, that if the 5200 m high Ararat range, (which a straightforward reading of Genesis 7:19 and 8:4 indicates predated the flood), was indeed covered to this depth, then the flood was almost certainly worldwide in nature.

Having perused some of the perspectives on the Flood from sources outside the YEC movement, the focus now shifts exclusively to the YEC model, and the arguments from scripture and YEC science that they present as evidence to support their contention for a universal Deluge during the time of Noah.

3. THE YOUNG EARTH CREATIONIST PERSPECTIVE.

3.1. The Young Earth Creationist Model.

Although based on Snider-Pellegrini's work in the late 1850's, the modern YEC model is largely a fine tuning of Whitcomb and Morris' hypothesis as found in their book "The Genesis Flood (1961)".

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[56] Strong's (3999), a *deluge-flood*.

Working from the premise of a ‘literal 24 hour six-day week’, the model embraces a cool earth creation event. The crust, which rested on a subterranean band of water about 15 km below it, had a single, giant, relatively flat continent, Gondwanaland, that encompassed all the earth’s visible landmass (Barrick 2014: Lecture 27,30), and was surrounded by a “shallow” pre-deluge ocean.

At the time of the Deluge, the continent was ripped into several smaller continental plates along the fissure lines that resulted from the release of the subterranean waters below the earth in the form of super fountains which extended many kilometres into the upper atmosphere to return as torrential rain (Barrick 2014, Lecture 27), when the structure supporting the crust collapsed. The resulting floodwater was sufficient to submerge the low continent to the depth specified in Genesis 7:19-20.

The newly formed independent continental plates were then forced rapidly apart during the period of the Deluge to form the modern ocean basins and trenches in some zones. These new oceans would be the repository for the waters once the Deluge was over (Ham, Sarfati and Wieland 2000). Meanwhile, the water covered globe was being swept and scoured clean by currents in excess of 300 km/h, as proposed by Baumgardner and Barnette in their “Patterns of Oceanic Circulation” model. These currents then later deposited their sediments on top of the Pre-Cambrian (i.e. pre-flood) basement, to form the sedimentary rock strata found throughout the world (Boyd and Snelling 2014:89), in what is known as the geological column. The fossil remains within those layers reflecting the mobility of the creatures as they endeavoured to escape the rising flood waters before being drowned, i.e. the marine creatures would have died first and been deposited in the lowest Paleozoic strata, while superior strata would have preserved ever more mobile land animals the higher one went in the geological column, with the most mobile being found in the uppermost layers when they too finally succumbed to the flood (Boyd and Snelling 2014:89, 156f). It was these soft sediments riding on the fast moving continental plates, that were buckled, distorted and elevated while still pliable, (as the plates collided over the next few centuries), to form the world’s mountains, including the Himalayas, in accordance with Psalm 104:8-9, (Ham,

Sarfati and Wieland 2000; Barrick 2014: Lecture 27). The occurrence of the numerous marine deposits found in alpine zones is argued as evidence of this postulation.

The next phase in the earth's development occurred in the form of a single continental wide, ice-age event that followed the Deluge, which resulted as the earth established a new dynamic equilibrium geologically, geographically and atmospherically (Baumgardner 2005; Boyd and Snelling 2014: 89). This phase incorporated a warmer global ocean than is known today due to hydrothermal energy being released by the "fountains of the deep" Genesis 7:11, as vast amounts of vapour would have been released into the atmosphere for precipitation. This vapour would have caused almost complete cloud cover, thus reflecting most incoming solar radiation back into space, resulting in cooler land masses. The cooler land would have caused the cloud vapours to precipitate as a ceaseless cycle of snow storms lasting about a millennium. The snows from these storms were then compressed into the ice sheets of the earth's only ice-age (Morris 1993; Boyd and Snelling 2014: 89).

3.2. Contra Perspectives within Young Earth Creationism.

Although the Whitcomb and Morris' model is influential, and while many YEC scholars have agreed with their dates for the commencement and end of the Flood period, they often disagree with the events within that period. Whitcomb and Morris (Boyd and Snelling 2014:89), proposed that the flood waters rose to their maximum height at day 40, and then remained stable until day 150, at which time, the ark which had been afloat throughout the flood, grounded on Ararat. After day 150, the waters began receding for the next 221 days, until the ark's complement had disembarked. Whitcomb and Morris correlated this time event to be at the end of what natural science defines as the Tertiary Period's Pliocene epoch (Boyd and Snelling 2014: 92).

Harold G. Coffin believes that the rising flood waters took 40 days to float the ark, and then continued to rise until day 150, which reflects in the standard geological column as the end of the Permian period and Palaeozoic era. He hypothesised that the receding of the waters coincided with the rising of the new mountain ranges in

the Mesozoic (Boyd and Snelling 2014: 91). But as Andrew Snelling (Ibid: 92) points out, this poses problems as fossils are found in what is recognised as the Mesozoic and Tertiary, supposedly deposited during the time when the waters were receding.

Walker's model is more concerned with being aligned to scripture than the geological column. It envisages 40 days of heavy rainfall which resulted in the waters rising until the sixtieth day, which then remained constant until day 150, before receding for a further 220 days (Boyd and Snelling 2014: 93). Snelling (Ibid: 93) notes that because Walker did not make direct correlations between the strata in the geological column and his time line, his model is confusing to people seeking to bring the geological record into agreement with the biblical record.

3.3. Some Modern Geological Responses to the Young Earth Creationist Subterranean Water Postulate.

Modern geology's responses to the YEC model have been widely documented, but because the focus of this thesis lies elsewhere, only some will be listed for information purposes, but will not be discussed. These include:

- Repudiation of a subterranean water layer under the crust, on the basis that there is no supporting evidence for this hypothesis;
- Engineering geology mechanics argues that a subterranean water geological structure would have been unstable, and hence would have collapsed and forced the water to the surface long before Noah's time;
- Subterranean waters are often super-heated to well above boiling point, the vast energy of which would have been freed catastrophically during the waters release;
- Subterranean waters, when released as high pressure fountains, would have eroded the sides of the fissures at unbelievable rates, resulting in widespread completely mixed erosional deposits, which are absent from the geological record.
- The catastrophic mountain building theory ignores the unimaginably vast energy that would have been released as heat during rapid crustal plate collisions, surely enough to have boiled the oceans and converted sedimentary strata almost completely into metamorphic rocks, which is clearly not the case.

- Geological studies point to numerous periods of global glaciation over the last 500 000 years (Monastersky 1992), the last of which ended about 11 000 years ago. Suggestions that the last glacial event occurred as a result of the Deluge about 4000 years ago lack credibility as ice layers in ice-core records have been accurately dated to much older dates.
- The problem of fossilised spores and pollen grains of all plants, which are diagnostically unique to individual species (Duff 2008: 169), not being randomly distributed throughout the geological column, which the YEC model for a single catastrophic flood event would suggest. Instead, they are differentiated with the fossils of extinct primitive plants' remains being located in the lowest oldest strata, while modern flowering plant fossils only occur in the higher younger strata (Ibid: 173). The YEC postulation that hydrodynamic sorting (Boyd and Snelling 2014: 158-159) can account for the occurance of minute organic particles such as these, in the various strata in which they appear, is dismissed as unrealistic at best.
- YEC's dogmatic assertion that all sedimentary deposits resulted from a single universal Deluge, is unable to explain the origin of the pitch-tar, a sedimentary mineral, which was used to caulk Noah's ark, Genesis 6:14, (Hill 2002: 174).
- The Global Circulation Concept raises problems with respect to the deposition of calcium carbonate chalk minerals, and the Coconino Sandstone in the GC (see Section 4.6.4.3.), as standard geological models indicate that calmer aquatic conditions are required for these sediments to have been deposited.

It must be noted that there are other challenges by conventional geology to the YEC Flood model, but those listed above are sufficient to make the point that there are numerous areas of great conflict between the two schools which must be urgently addressed before any YEC geology is taken seriously.

A new YEC approach to the "Great Deep fountains" has emerged, and this will be discussed as it will be influential in the discussion of the GC's geology in the next section.

3.3.1. A Vulcanological Explanation for the Waters of the “Great Deep”.

Gary Parker (2006: Section 3.9), believes that the solution to the "fountains of the deep" problem lies not in thinking of distinct definable water reservoirs under the crustal surface, but in recognising that the deep earth magmas contain vast amounts of dissolved water[57]. He postulates that massive worldwide volcanic action could provide the water necessary for a universal deluge, which he believes rose steadily across the globe over five or so months before subsiding. Although he does not provide a trigger mechanism for the outbreak of the vulcanism, he notes that any action that led to a weakening of the cap rock over liquid magma would have resulted in an eruption. As natural science has long accepted that the earth has often been the target of large asteroid collisions, I can see no reason why a large asteroid strike might not have fractured the crust at some weak point, thus setting off a chain reaction around the earth. Parker himself concedes that a large asteroid’s collision with an ocean would have produced waves causing catastrophic results around the globe.

Having noted the above, we now focus on the examination and evaluation of the YEC arguments and scientific methodology relating to their assertion that the GC was formed catastrophically as a result of the Deluge. In order to do this, our point of departure will be an examination of YEC geology’s erosional and depositional models before commencing an overview of the GC’s geology, which will include an understanding of its geological column, and the major constituents of that structure.

3.4. Some Erosional and Depositional Models in Young Earth Creationist Geology.

Modern geology, as has been stated, operates from a perspective of slow change. Where the erosion of rocks and the depositing of sediments is concerned, this means that most sedimentary rocks are believed to have resulted from decades or even centuries of gradual erosion of rock in one place, before transport processes such as water, wind, or ice moved those sediments to another place where they were deposited and grew incrementally.

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[57] Read and Watson 1977: 149, 384, note that much of this water is released during volcanic activity.

In contrast, YEC geology believes that almost all sedimentary rocks resulted from the Deluge. They maintain that more sediments can be laid down by a violent catastrophic event acting over a short period of time, than uniformitarian processes over centuries. Furthermore they contend that because sedimentary deposits are traditionally viewed through the lens of uniformitarianism, they believe that the ages of sedimentary rocks have been incorrectly represented. To support their position that the GC is young and was formed by the Deluge, they refer to much smaller catastrophic events as models of how the GC could have formed. One of the YEC's major case studies relates to the Mount St. Helens eruption in Washington State, U.S.A. in mid May 1980. In this event, YEC sees proof that catastrophic events can radically alter the landscape and deposit sizable sedimentary strata within a very short time.

Amongst the almost 120 m of differentiable strata, which vary from 1 mm to 1 m in thickness, deposited after the Mount St. Helens eruption, are the deposits of 12 June 1980, which are approximately 12 m thick. These strata show "many thin laminae and beds" (Austin 1986), which challenges the conventional thinking that requires much longer periods of time, and in many cases quieter environmental conditions, for such clearly defined stratified deposits to have occurred. Stephen Austin (1988), notes the similarity between these layers formed by pyroclastic flows, and the quickly formed layers recorded in laboratory sedimentation tank experiments, and sees no reason why a natural catastrophe should not produce stratified layers, a notion that defies contemporary thinking that teaches that chaos, not 'order', results from a cataclysmic event.

The Mount St. Helens eruption also forced a rethinking in relation to the length of time required for the fossilization of organic matter. The earthquake that presumably caused the event sheared about 2,0 cubic km off the volcano which then fell into the adjacent Spirit Lake. This generated a wave estimated by Voight et.al (1981) (cited by Austin 1984) to be in excess of 250m in height, that decimated the surrounding forestland uprooting millions of trees over an area of about 385 square. The returning floodwaters washed millions of tons of soils, ash and a sizeable percentage of the trees back into the lake when they returned, thereby raising the lake bed by

about 100 m (Meyer and Carpenter 1983, as cited by Austin 1984). Two processes followed, both of which had implications for fossilization, (Austin 1986).

In the first process, the uprooted trees in the vast log “mats” that covered the lake, were continually being jostled against each other by lake surface currents, thereby losing their bark. The bark once waterlogged, then sank to the lake floor, where conditions were such that peat formation began. Austin (1986) states that the proto bark-peat is very similar in composition to some coal fields in the eastern U.S.A.

The inference is that perhaps similar catastrophic events such as the Mount St. Helens eruption, rather than long uniformitarian processes, may have been the origin of the eastern U.S.A. coal fields. While conventional geologists might summarily dismiss this idea, the processes at work in Spirit Lake deposits, (which should be closely monitored to ascertain the rate of transformation), must oblige natural science to be open to other possibilities for the formation of coal. On the other side of the debate, YEC geologists cannot be allowed to extrapolate what they believe they see happening at Spirit Lake, to other coal fields on the other side of the continent, without good research to underpin their suppositions.

In the second process at Spirit Lake, many of the uprooted floating trees were first dragged into a semi-vertical position by their heavier roots. Later as the whole trees became waterlogged, they sank and were ‘planted’ root first into the lake sediments, thus giving the impression of being a submerged forest. Archaeological investigation revealed that some trees had been substantially buried by the constant inflowing of sediments before other trees sank down to be ‘planted’ in their turn. This staggered ‘planting’ has created the impression of successive levels of younger later forests, when in actual fact all had been uprooted virtually instantaneously, and only their ‘planting’ dates varied, and then only by weeks or months, not the decades or centuries that would have been required by uniformitarian processes (Austin 1986).

The Mount St. Helens event also underscored the arguments for the erosional power of rapidly moving volumes of water, mudflows and glacial ice. Austin (1986) refers to a large mudflow that occurred on 19 March 1982 which was another consequence of the Mount St. Helens eruption. During the eruption in May 1980, a vast amount of

pyroclastic material, (mainly pumice at an estimated temperature of 300°C), was deposited at the southern exit point of Spirit Lake, which was one of the sources of the Toutle River, creating a dam.

The pumice deposits could not initially settle properly in order to lithify, as the heat from the pumice vaporised the water and ice trapped below, which vented as steam. The escaping steam formed numerous explosion pits, some of which became sizable cavities and depressions, the largest being approximately 700 m long, 300m wide and 40 m deep (Rowley et.al. as cited in Austin 1984). A pyroclastic flow some weeks later in mid-June filled about 20% of the above depression (Austin 1984).

Over the following period, close monitoring by teams of geologists recording and investigating the ongoing eruptions and the consequences thereof would reveal interesting and unexpected erosional processes and results. The first would relate to the short term erosion within the explosion pit depressions, and the second to the catastrophic failure of the dam that had sealed off the Toutle River headwaters.

In the first case of the explosion pits, monitoring revealed that slumping of the side walls, as well as the appearance of rills and gullies, set in within the first week after the initial eruption. Other steam explosion pits in the newly deposited pumice also quickly formed gullies up to 16m deep due to water erosion and gravity transport[58] (Austin 1984). These rapidly emerging erosional features were contrary to conventional uniformitarian principles, which traditionally requires years or decades for such topographies to develop.

The YEC geologists used these erosional occurrences to argue that had the events surrounding the Mount St. Helens eruption occurred elsewhere in an unmonitored remote zone, modern geologists studying the site after cooling and lithification had occurred, and observing the rills and gullies, would have almost certainly ascribed a much older and therefore incorrect date, to the eruption aftermath based on the

[58] Also called mass wastage, is the movement of rock materials downslope due to gravity. These may be either slumping sedimentary materials, or solid rock moving along fault lines or bedding planes. In many cases such movement is directly related to the presence of excess water which acts as lubrication (Whitten 1972: 216).

erosional “history”. I am persuaded by this argument, because as a geological student who was intending to specialise in sedimentology, that was how I had been taught to interpret such a landscape. This, YEC says, raises the question as to whether other recent sites, including the G.C., have not been incorrectly dated as a result of incorrect uniformitarian geological interpretations.

The second erosional event was to occur some 22 months later after the pyroclastic material dam failed catastrophically, and it too revealed the power of rapid erosional forces. Throughout the time from the dam’s creation, the waters behind it had been increasing. On 19 March 1982, a small eruption in Mount St. Helens’ crater melted the snowpack, which caused flood waters and a mudflow to travel down the mountain and into the Spirit Lake dam. This violent addition to the dam’s reservoir resulted in a wave which surged over the dam, and immediately cut through it releasing the entire dam’s contents as a massive mudslide down the valley. This mudslide eroded a small canyon system, about 1/40 the scale of the GC in the Toutle River valley system within a matter of hours. Headward erosion of the first eruptions’ deposits also occurred which retreated far enough upstream to once again reintegrate the previously cut off North Fork of the Toutle River into the dendritic **s**ystem (Austin 1984).

John Morris (2001), contends that where the formation of systems such as canyons are concerned, that a short duration catastrophic flood event is more likely to gouge out rock than slow uniformitarian processes acting over millennia. He cites the example of the 1926 Gardena Farming community event, where good Spring rains had increased irrigation canal flow rate to about 2,27 cubic meters per second (cumecs). When diverted into a subsidiary ditch so as to allow an obstruction to be removed from the main canal, the water quickly transformed the 5,5 m^2 ditch cross-section into a small canyon over the next week, removing an estimated 465 000 m^3 of material that included silt, sand and rock, about 1/10 000 the size of the GC.

Cavitation is another hydrological process which causes extreme, indeed catastrophically rapid erosion. Cavitation occurs when the extreme rapid flow of water over an uneven surface produces vacuum bubbles (Morris 2012b). These vacuum bubbles then immediately implode and the water then crashes back to close

the hole. Christopher Brennen (1995:Section 3.6) notes, “that cavitation bubble collapse is a violent process that generates highly localized, large-amplitude shock waves and microjets in the fluid at the point of collapse”. Morris (2012b) cites the example of the massive destruction caused in mid-June 1983 to the spillway of the Glen Canyon Dam at Lake Powell[59]. Following heavy rains, the spillway was opened for water to flow under controlled conditions directly into the Colorado River and GC. Such was the velocity of the water, that unknown to the dam’s hydrological engineers, cavitation forces[60] had been at work during the first four days of the spillway bypass action. On 15 June1983, the destructive power of the cavitational forces were revealed when blocks of steel reinforced concrete spillway wall, bedrock and mud slurry were ejected from the spillway exit. By the time that the spillway was closed, a cavity requiring 1700 m^3 of concrete fill had been created in the spillway’s surrounding rock.

From these three events, both Austin (1986) and Morris (2001, 2012b) infer that flood waters in the Deluge magnitude category, could easily have carved out the GC in a few months.

The GC is however, no localized irrigation ditch, small lake, or subterranean hollow. Estimates as to the volume of rock strata excavated vary from source to source, but are somewhere in the order of 4200 – 4300 cubic km. This raises the question as to whether small scale examples as cited above can realistically be extrapolated to determine what forces shaped the GC. I also suggest that there is the real possibility of circular reasoning in the YEC postulation, as the inference is that the GC’s excavation points to a vast amount of water being present, which in turn is used to argue for the Deluge, which provided the waters that formed the GC.

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[59] W. K. Hamblin (Beus and Morales 2003:319) noted that hydrological information derived from records obtained by studies at both Lake Powell and Lake Mead “provides the best insight into the nature of the sediment deposited in the lakes behind the lava dams, their history and ultimate destruction“. While Hamblin makes mention of “hydraulic plucking” (ibid:322) in the erosional processes operating on the dams, he failed to understand cavitation’s destructive ability, and may therefore have seriously overestimated their longevity (see Section 4.6.2.3.)

[60] As determined by the US Army Corps of Engineers (Morris 2012a).

Another problem with the classically accepted YEC catastrophic erosional models is highlighted by an alternative YEC model known as the Deluge Drainage model and is discussed in the next section.

3.6. The Structure of the Grand Canyon.

3.6.1. The Geography, Geological Column and Stratigraphy of the Grand Canyon.

3.6.1.1. The Geography and Formation Models for the Grand Canyon.

As noted in the General Introduction, the GC[61] extends for 248 km along the Colorado River in northern Arizona, in a south-westerly direction from Lake Powell in the east at 1113 m above sea level to Lake Mead in the west at 339 m above sea level. The gorge varies from rim to rim in width from 1600 m at its narrowest, to about 16 000 m at its widest point, and has a maximum depth of 1829 m (Beus and Morales 2003:1). Modern geology teaches that the Colorado River formed the Canyon over billions of years[62], while YEC geology believes that the Colorado River simply occupies the gorge excavated by the Deluge after the soft freshly deposited sediments were eroded.

For some decades, YEC geology taught that the GC was formed shortly after the Deluge had passed, when residual water dams created on higher ground by the Deluge failed catastrophically, poured through the newly created gap, and scoured out the canyon. Recently however, a second model which proposes that the GC formed during the recession phase of the Deluge has begun to attract attention.

The older Breached-dam model, first proposed by Walter Brown[63] and later expanded upon by Edmond Holroyd, argues for a single giant trapped reservoir of water to the east of the Kaibab Plateau, estimated to cover between 25 000 to 35 000 square km (author's own calculation). The greater north-easterly section of this

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[61] See Billingsley, G. H., 2000, Geologic map of the Grand Canyon 30' x 60' quadrangle, Coconino and Mohave Counties, north-western Arizona: U.S. Geological Survey Geologic Investigations Series I-2688, map scale 1:100,000. http://pubs.usgs.gov/imap/i-2688/

[62] A recent alternate postulation is that the GC was formed in different stages as watersheds changed over the millennia, and that other long extinct rivers carved much of the GC, which was inherited by the Colorado River about 5 to 6 million years old ago, and continued the erosion processes. (Monastersky 1987; Achenbach 2014).

[63] Walter T. Brown, "In the Beginning", 1980.

reservoir was named the Green River/Grand Lake, and the smaller south-easterly part, the Hopi Lake. This body of water then breached a weaker portion of the still soft Deluge deposited sediments at a point near to the commencement of the GC, and over an extremely short period of time, estimated at a few weeks at most, carved out the GC, so as to drain the reservoir towards the west (Scheele 2012).

Further consideration of this model has however, revealed aspects of the geomorphology of the region which cannot be explained in terms of this theory. Among others these are:

- Why the breach occurred at a higher point on the escarpment to form the GC, when the Grand Staircase region, 100 km to the north and about 1000 m lower, would have provided an easier pathway for the waters off the plateau?
- Why the models used to argue for the GC being formed by a breach-dam scenario, such as Mount St Helens gorge (discussed previously), do not show dendritic drainage pattern characteristic of mature river drainage systems such as the GC? (Scheele 2012).

In contrast to the above, the Deluge Drainage model does offer an explanation for these phenomena.

Scheele (2012) suggests that due to the movement along the continental margins (discussed elsewhere), deformation of the continent was occurring and that upliftment of the sediments in the GC area was pronounced. As the Deluge receded, the waters drained away to the west in a wide relatively shallow flow, flowing both around and over the rising ridge. Scheele believes that there is sufficient evidence to prove that the precursor to the GC was a super wide ‘river’, and that it conveyed the bulk of the continental waters seaward in a wide shallow canyon which he says can be identified on either side of the GC.

As the level of these waters dropped however, they began to interact with the upwardly buckling ridge, and became increasingly constricted as the continental bed rose. Unable to move laterally, the waters were forced to move faster as the same

volume needed to pass over the rising ridge as beforehand due to the unrelenting pressure of the waters behind. This faster stream[64] in the general drainage pattern then cut down through the soft sediments near the top of the ridge, eroding a gully which grew exponentially as more and more water chose this 'lower' point as an exit for the reservoir. It was this second narrower, but deeper gorge that would become the proto GC and which would drain the last of the continental waters away to the ocean. In time, the Colorado River would flow through it, deepening it to its impressive current size. As Scheele (2012) noted, "The present size of the Colorado River is a good fit with the size of this deeper canyon".

This model is supported by research into the inter-tidal patterns of sediments generated in the Wadden Sea in the Netherlands. Here the development of higher ridge channels and dendritic drainage pattern over the sandbanks as the tides withdraw, closely resembles the large scale dendritic pattern as seen in the GC, with its myriad of side canyons, and their tributaries (Scheele 2012).

The Deluge drainage postulate also 'explains' why a number of other much smaller canyon gorges are found parallel to the GC where it leaves the escarpment to enter Lake Mead. Most of these are dry, probably because the gully that became the GC eroded at a faster rate and developed its dendritic drainage basin more quickly, thereby providing an alternative deeper passage off the escarpment and hence 'captured' the other canyons eroding headwaters[65] (Scheele 2012).

An evaluation of the two YEC models suggests that while the Deluge Drainage model provides a better 'fit' for the geological evidence than the Breached Dam model, that in its present form it still fails to meet the criteria for a full scientific hypothesis. YEC therefore needs to invest a lot more critical thinking in the Deluge model if it is to receive any consideration as a scientific option to explain the GC.

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[64] Read and Watson (1977: 168) note that doubling a river's velocity may increase its sediment transporting power by between 30 and 60 times, which would increase corrasion, (vertical erosion by a river that results in down-cutting (Whitten 1972: 104)), accordingly.

[65] Some of these canyons are however sufficiently far away, about 70 km or so, to have small rivers flowing from their exit points from the escarpment (Scheele 2012).

3.6.1.2. The Geological Column of the Grand Canyon Region.

The GC's geological column can be divided into two main parts, separated by the Great Unconformity. Below the Great Unconformity lie the Precambrian rocks, while above it almost the entire Paleozoic Era rocks, (the upper most Permian Period rocks are absent), of the Phanerozoic Aeon, are found. No rock formations from the younger Mesozoic Era or youngest Cenozoic Era, (also part of the Phanerozoic), are present. In addition to the GU, other contact zones between rock formations have been identified by conventional geology as unconformitys, e.g. the Temple Butte – Tonto Group contact, but the YEC reject this believing that the strata were deposited sequentially during the Deluge, and hence call this the Great Paraconformity (see Fig. 2). In terms of the conventional Geological column, the YEC model excludes the rock sequences that comprise in ascending order, the Upper Cambrian, Ordovician, Silurian, and Lower Devonian Periods.

<table>
<tr><td colspan="2">Kaibab Formation (Fm)</td><td rowspan="4"></td><td rowspan="4">Mid Permian Period (Pd)</td><td rowspan="15">Paleozoic

Era

248 – 554 million years ago (Mya)</td><td rowspan="16">Phanerozoic

Aeon</td></tr>
<tr><td colspan="2">Toroweap Fm</td></tr>
<tr><td colspan="2">Coconino Sandstone (Ss)</td></tr>
<tr><td colspan="2">Hermit Shales</td></tr>
<tr><td>Esplanade Ss</td><td rowspan="4">Supai

Group</td><td rowspan="4"></td><td rowspan="4">Lower Permian Pd
Pennsylvanian Pd</td></tr>
<tr><td>Wescogame Fm</td></tr>
<tr><td>Manakacha Fm</td></tr>
<tr><td>Watahomogi Fm</td></tr>
<tr><td colspan="2">Surprise Canyon Fm</td><td rowspan="2"></td><td rowspan="2">Mississippi Pd</td></tr>
<tr><td colspan="2">Redwall Limestone</td></tr>
<tr><td colspan="2">Temple Butte Fm</td><td></td><td>Up.Devonian</td></tr>
<tr><td colspan="3">Unconformity /Great Paraconformity</td><td></td></tr>
<tr><td>Muav Ls</td><td rowspan="3">Tonto

Group</td><td rowspan="3"></td><td rowspan="3">Mid Cambrian Pd
Lower</td></tr>
<tr><td>Bright Angel Shale</td></tr>
<tr><td>Tapeats Ss</td></tr>
<tr><td colspan="4">Great Unconformity</td><td></td></tr>
<tr><td>Sixty mile Fm</td><td></td><td rowspan="6">Grand

Canyon

Super

Group</td><td rowspan="6">Late (544 - 900 Ma)

Proterozoic Aeon

Middle (900 – 1700 Ma)</td><td rowspan="7">Precambrian

544 – 2500 Mya</td></tr>
<tr><td>Kwagunt Fm</td><td rowspan="2">Chuar
Gp</td></tr>
<tr><td>Galeros Fm</td></tr>
<tr><td colspan="2">Nankoweap Formation</td></tr>
<tr><td>Cardenas Lava</td><td rowspan="5">Unkar

Group</td></tr>
<tr><td>Dox Fm</td></tr>
<tr><td>Shinumo Qtzt.</td><td></td><td></td></tr>
<tr><td>Hakatai Shale</td><td></td><td></td></tr>
<tr><td>Bass Ls</td><td></td><td></td></tr>
<tr><td colspan="4">Unconformity</td></tr>
</table>

Crystalline core			Early Proterozoic Aeon	

Figure 1. Simplified Geological Column. Adapted from Beus and Morales (2003:7), and Parker (2006). (Contested zone marked as Unconformity/ Great Paraconformity).

The cross section of the Grand Canyon (Fig. 2) from Parker (2006), serves to illustrate the rock strata and some of the geological features mentioned above, only a few of which will be examined in more detail due to the sheer volume of data available.

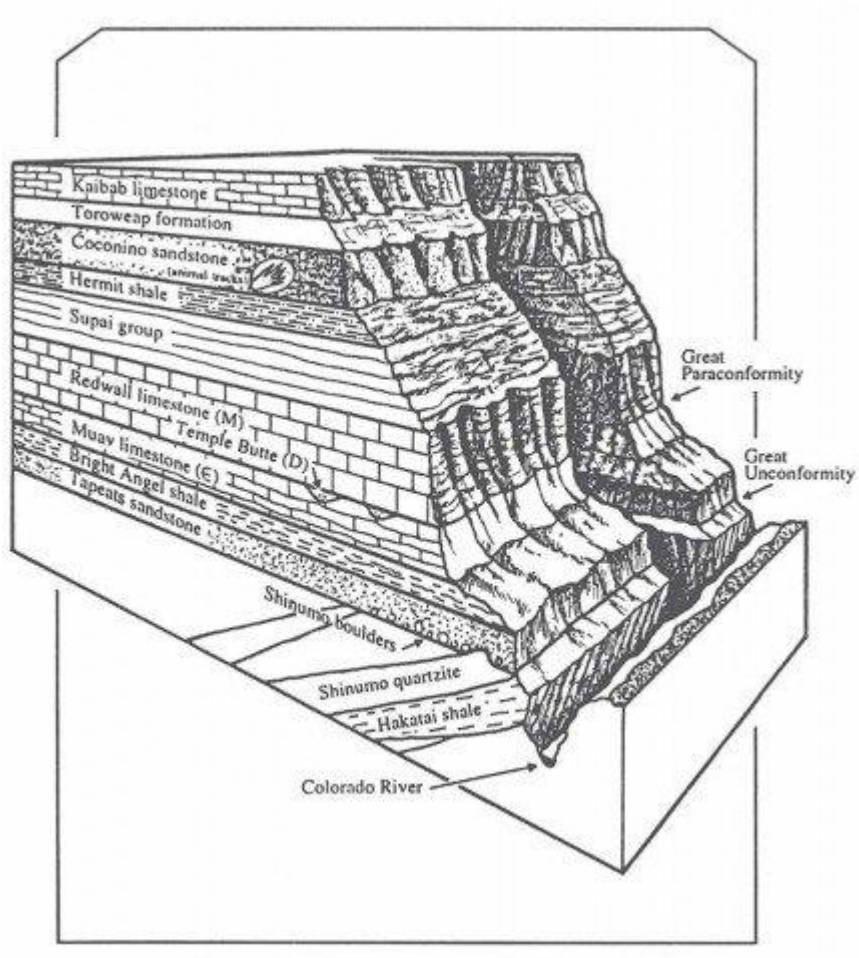

Figure 2. Cross Section[66] of the Grand Canyon, from Parker 2006 (Figure 34).

[66] YEC notes that numerous strata found in the Standard Geological column are not represented in the GC Cross Section. From this, YEC geology argues that the column is an artificially contrived scientific red herring (John Morris 2012a).

Following general geological convention, the discussion will commence with a discussion of the oldest igneous and metamorphic rocks, before examining some contested selected strata of the sedimentary rocks. It must be stressed that due to the parameters of this thesis, this study can only indicate general trends in YEC geology, and must be considered as an introduction to the ongoing debate on the age and formation of the GC.

3.6.2. The Igneous and Metamorphic Rocks of the Grand Canyon.

3.6.2.1. The Crystalline Core Rocks.

The lowest part of the GC geological column comprises the crystalline core. This zone includes igneous rocks such as the Zoroaster granites, and metamorphic rocks such as the Vishnu schists, which are components of the Granite Gorge Metamorphic Suite (Beus and Morales: 2003). YEC geology teaches that the igneous components were created in the initial opening day of creation, while the metamorphic rocks resulted from the forces God applied on Creation Day Three when He separated the land and sea, Genesis 1:9-13 (A. A. Snelling 2004).

Among the Brahma schists, amphibolites[67] derived from basalt lavas, are to be found. Although metamorphic rocks are known to present problems where dating is concerned, as most dates appear to indicate the date of the metamorphic event, the Brahma Schist amphibolites have been dated by conventional geologists to be in the age range of 1690 – 1710 Ma. This range was derived by dating both the underlying Rama schist and superior Vishnu schist (Hawkins, D.P.; S.A. Bowring (1999) "Contributions to Mineralogy and Petrology", Vol 134:150-169, and, Hawkins, D.P.; S.A. Bowring; B.R. Ilg; K.E. Karlstrom, and M.L. Williams (1996) "Geological Society of America Bulletin", Vol 108: 1167-81, as cited by Snelling 2004).

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[67] A varied group of isomorphous inosilicate minerals resulting from ion replacement. The resultant minerals show complex chemical composition where the general formula $(WXY)_{7-8}$ (Z_4O_{11}) $_2$ (O, OH, F) $_2$, where W can be Ca or Na, X is Mg or Fe $^{2+}$ Mg $^{2+}$; Y is Ti, Al, Fe $^{3+}$; Z can be Si and Al. (Read and Watson 1977:107). Horneblende is the commonest amphibolite, often occurring as a "metamorphic derivative" in "deep-seated igneous rocks" (Ibid: 108).

The YEC Radio Isotopes and the Age of the Earth (RATE) project has challenged the above dates, and cast doubts on the reliability of radioisotope dating, if not on the whole concept, then at least on the dating of metamorphic rocks and minerals. The RATE project sampled 27 amphibolites from “various Inner Gorge outcrops”, including seven samples from a single amphibolite body near Clear Creek, at Mile 84 from Lees Ferry. The samples were dated by two independent, but unnamed[68], internationally accredited facilities. A Canadian laboratory tested the K-Ar breakdown, while an Australian counterpart tested the Rb-St, Samarium (Sm) – Neodymium (Nd), and Pb-Pb isochron ages (Snelling 2004).

Snelling (2004) reports that K-Ar results were exceptionally discordant for the 27 samples, and gave ages that varied from 405.1±10 to 2574.2±73 Ma. Furthermore, two amphibolite samples that were only 84 cm apart gave ages of 1205±3 Ma, and 2574.2±73 Ma respectively. Similarly, the isochron ages for the other three aging tests also showed results that failed to confirm the samples ages, giving three different isochron ages for the same samples. The Rb-Sr testing dated samples in the 1240±84 Ma range. The same samples were dated at 1655±40 Ma according to the Sm-Nd process; and the Pb-Pb tests put them at an even older 1883±53 Ma. In addition, none of these ages corresponded to any discernible geological event.

The reported results, and conclusions on the inaccuracy of radio-isotope dating with respect to metamorphic rocks by the YEC community, does compel the unbiased reader to treat with caution any ages assigned by these techniques to metamorphic rocks.

3.6.2.2. The Igneous Lavas of the Grand Canyon.

Steven Austin (1988; 1992) has raised questions as to the reliability of the K-Ar and Rb-Sr dating techniques, when determining the ages of igneous rocks. His challenge is derived from the studies of the basaltic Cardenas Lavas and Western Grand Canyon lava flows. Geologically the Cardenas and Western GC lavas are recognised as being of vastly different ages because of their places in the standard

[68] No reason for this omission is given.

geological column. The Cardenas Lavas, in the lowest section of the column, are classified as being part of the Precambrian Unkar Group. Using the K-Ar method they were been dated by McKee and Noble to vary in age from 781 ±20 Ma to 810 ±20 Ma. Ford, Breed and Mitchel, using the same method dated the Cardenas Lavas at an average 845 ±15 Ma. McKee and Noble, however also performed Rb-Sr tests which gave a much older isochron age of 1090 ±70 Ma. The Rb-Sr age range, which better 'fits' the accepted geological age, was then accepted, and the younger K-Ar results rejected. The younger results were ascribed to "uniform argon loss" after cooling. This however, is a disingenuous explanation as it is extremely unlikely that a significantly large enough amount of argon would be uniformly lost after hardening, so as to give a younger age of more than 120 Ma (see 1.3).

Austin (1988) notes that Rb-Sr dating of the much younger superior Western lava flows by Leeman (1974), gave an average isochron age of 1500 Ma, making them older than the Cardenas Lavas more than 3000 m below them. This date was then disregarded as it was impossible that an upper column rock could be older that a Precambrian rock. We therefore have one case where the Rb-Sr technique was considered reliable when dating igneous rocks from the crystalline core, and another where it was deemed unreliable when dating much younger lava flows.

Austin (1988) cites explanations for such anomalies by Gunter Faure (1986); and Brooks, James and Hart (1976). Faure (1986) argued that where an unusual imbalance existed in the ratio of the 87Sr isotope to 86Sr isotope in the magma before cooling occurs, false dates would be recorded. This followed on from Brooks et.al. (1976), who noted 22 such Rb-Sr cases of patently false isochron ages. They sought to explain the false readings in terms of the chemical composition of the deep-earth parent magma. Austin (1988) dismisses the above, and believes that the cause is related to a change in nuclear decay rates that resulted from the Deluge. As noted in Section 1.5, this postulation has no scientific backing from any discipline, and cannot therefore be considered.

3.6.2.3. Volcanic Dams in the Grand Canyon.

Closely related to the above debate is the dating of the now eroded volcanic dams that regularly blocked the GC in the past. Modern geology has long recognised that volcanic lavas are to be found in the northern Arizona and GC geological columns, and are grouped into the Uinkaret Volcanic Field rocks, dated at 0,4 -1,8 Ma. Studies by Koons in 1945 and Maxson in 1949 (Rugg and Austin 1998), indicated that the lavas were produced from volcanic cones[69] and fissure eruptions, and consisted mostly of olivine[70] basalt flows, and basaltic cinders. It is the very fluid fissure lavas, with an average thickness of 1 - 2m, that are represented in the upper GC column. Rugg and Austin (1998) contend that many of these fissure lavas reached the GC to form cascades, with the larger flows creating dams.

Hamblin (Beus and Morales 2003: 341) believes that some geologists, (and by this I assume YEC geologists), have taken the evidence of cascade lava damming the CG as recorded in the Toroweap Valley and Whitmore Wash areas, and extrapolated them as the cause of all dams and are thus guilty of "a tendency to conclude that the cascades were the source of all intracanyon flows". In response to this position, he notes that there is considerable evidence that much of the lava, perhaps the bulk, was extruded directly into the GC's inner gorge in the form of intrusions, volcanic cones and dikes. Two graphic examples of intrusions are found in the Mile 178 and Mile 180 regions where 200 m high basalt masses are found. Similarly, the large "Vulcan's Throne" cone, and the other smaller cones in the Toroweap fault zone indicate that active volcanoes contributed to the GC lavas and the dams (ibid: 341 - 342).

Sources differ as to how many of the dams coexisted, when they were formed, and how long they endured before being eroded away. While the 1940's studies argued that some of the dams did exist concurrently, Hamblin (1994) (cited in Rugg and

[69] Koons identified almost 160 cones of varying heights, with an average flow thickness of 8m (Rugg and Austin 1998).
[70] Isomorphous nesosilicate series, general formula $(Mg,Fe)_2(SiO_4)$, (Read and Watson 1977:111)

Austin 1998) rejected the older work in favour of a succession of more stand-alone dams, and adopting an erosion rate based on the Niagara Falls retreat rate (Beus and Morales 2003: 323), estimated that the GC would have been blocked for about 240 000 years during the volcanic period (ibid: 324). The first dating of a dam was by McKee et.al. (1967)[71], when using the K-Ar method the Toroweap's age was calculated at 1,16±0,18 Ma., later revised by Dalrymple et.al. (1998) to 0,56 ± 0,07 Ma (ibid: 333).

Scott Rugg and Steven Austin (1998) have challenged the reliability of previously accepted ages, and the longevity of the numerous lava flows that dammed the GC during the Pleistocene, which YEC geologists say is post-flood, and not ancient as is accepted by modern geology. Their case has two main thrusts, on the one hand, they argue against the reliability of some of the key radiometric dating procedures used in dating the GC volcanics; and then adopting a field examination approach to the GC's rocks, they reinterpret the evidence from a YEC perspective.

In their radiometric argument, Rugg and Austin (1988) have focused on a point mentioned by both McKee and Hamblin, namely that many samples were excluded from the age analysis of a particular body of rock due to "excess argon", while others were deemed "acceptable". Rugg and Austin noted that neither the reports by McKee or Hamblin (1984) had specified the criteria used for determining what constituted a sample's "excess argon", as the reason for that sample's exclusion from the final reckoning. I contend that such a serious scientific omission must raise questions over the methodology of those dating procedures, and whether the dates derived from the "acceptable" samples reflect a reliable age, or a skewed age determined from selected data.

Rugg and Austin (1998) then sought to verify McKee's Toroweap Dam age result by a "basanite"[72] sample which was collected 300m downstream from McKee's site, and designated QU-16. The sample was milled to -230/+270 mesh. The milled particles

[71] Rugg and Austin (1998) give McKee as 1968.
[72] "An olivine bearing alkali basalt containing feldspar and feldspathoid", (Whitten 1972: 48).

were then suspended in a methylene iodide - ethyl alcohol liquid with a specific gravity of 3.20, and then separated by centrifuge and magnetism. Three different test samples were then prepared from the separated particles for K-Ar analysis at the Geochem Laboratories in Cambridge, Massachusetts. The test samples were designated QU-16FG (plagioclase and glass); QU-16HM (orthopyroxene and Fe-Ti oxide); and QU-16HN (olivine). The test results were plotted against McKee's sample results (recalibrated using the Steiger and Jager (1977) constants to 1,19 $\pm$ 0,18 Ma, and designated A Flow), in Table[73]1.

	%K	40K ppm	% 40Ar*	40Ar* ppm	40Ar*/40K	"Age" Ma
A-Flow	0,9475	1,130	3,1	$0{,}780 \times 10^{-4}$	0,690 × 10-4	1,19±0,18
QU-16FG	1,468	1,751	5,9	$3{,}49 \times 10^{-4}$	2,00 × 10-4	3,4±0,2
QU-16HM	0,693	0,826	5,0	$1{,}49 \times 10^{-4}$	1,80 × 10-4	3,1±0,3
QU-16HN	0,253	0,302	5,0	$3{,}65 \times 10^{-4}$	12,07 × 10-4	20,7±1,3

(Table 1. From Rugg and Austin 1998:4)

All three of the QU-16 samples show significantly more 40Ar than McKee's A-flow sample did. These gave ages that varied from QU-16HM's age of 3,1±0,3 Ma; through QU-16FG's age of 3,4±0,2 Ma, to QU-16HN's age of 20,7±1,3 Ma, all considerably older than the A-flow ascribed age of 1,19$\pm$0,18 Ma (Rugg and Austin 1998).

Rugg and Austin's tests therefore confirmed both McKee and Hamblin's assertion that many of the GC volcanic rocks showed excess argon. Instead of discarding these results as anomalies, because as YEC geologists they ascribe to a GC that is only thousands of years old, (let alone the 3 - 20 Ma that the QU-16 samples tested

[73] We note that probably due to the fact that Dalrymple et.al. (1998), was publishing around the same time as Rugg et.al. (1998), that the latter did not note Dalrymple's much younger revised age for the unknown Toroweap specimen.

at), they question the general reliability of K-Ar dating the GC volcanics, asking “Has any GC lava dam been demonstrated not to contain “excess argon”?” (1998).

As a consequence of the above investigations, YEC has called into question the reliability of all radioisotope procedures. With specific reference to the GC basalt lavas, Snelling (2004) wrote, “Thus there is no reliable evidence to dispute that these metamorphosed basalt lava flows deep in the Grand Canyon date back to the Creation Week only thousands of years ago”.

In saying the above, Snelling is guilty of attempting to create an impression that because the K-Ar radioisotope dating of the GC lavas has proved unreliable:

(i) All radioisotope dating is unreliable, and as a consequence,
(ii) That the YEC case for a young age for the lavas has been proven.

It is obvious that these two points are unrelated. Firstly, the scientific consensus is that radioisotope dating is reliable in most instances. As seen in Sections 1.3.; 1.4.; and 1.6., modern laboratories are committed to producing as accurate a result as is possible.

Having noted the above, the unreliability factor for the K-Ar process has however been demonstrated where in some cases “argon loss” was indicated as reason for younger isochron dates, while in other cases “excess argon” resulted in ages that were patently too old for reconciliation with the geological column. Likewise the Rb-Sr process which gave acceptable dates for the Cardenas, gave readings deemed unreliable in dating the younger lavas, due to either “chemical composition anomalies”, or “Sr isotope imbalances”. There are therefore demonstrable problems with these two dating procedures where the dating of rocks is concerned.

Secondly, the failure to disprove something does not mean that the matter has been proven, it simply means that the evidence and arguments were inconclusive, and that judgement on that matter must be reserved until conclusive evidence germane to the issue can be presented.

While I cannot support a sweeping dismissal of an entire scientific discipline on the basis of some anomalies, I believe that mainline science must by its very commitment to scientific honesty, not discard as irrelevant any results that do not fit its support of an ancient earth. Such anomalous results should be included in an appendix and annotated with the reason for their exclusion. The failure to have carried out such a procedure makes the scientists who wrote up the results guilty of practising "bad science", and creates the impression of their commitment to a particular interpretation of the earth's age, rather than to scientific accuracy and objectivity. The very same "crime", of which YEC science is commonly accused.

In their other argument, Rugg and Austin (1998) examined the formation and erosion of the 13 predominantly olivine basalt lava dams as identified by Hamblin (1994). They reject the postulate of a succession of dams (see above), the radiometric ages for the dams, and the claimed longevity of the dams, contending that the evidence supports rapidly formed, short duration dams that all existed within a 2000 year period.

Hamblin (1994) calculated that the total volume of the basalt in the dams was about 25 km^3 (Rugg and Austin 1998). Rugg and Austin (1998) note that this is not an excessively large volume of lava to have been extruded over two millennia, when compared to other documented eruptions which produced enormous lava volumes in much shorter time spans[74]. They argue that it is not unrealistic to assume that most of the GC dams could have been formed very rapidly. In the cases of the smaller single lava flow dams[75] such as Gray Ledge, Massive Diabase and Black Ledge, they believe that dam formation could have occurred in hours, while the larger single flow lava dams could easily have formed in a few days or weeks. Hamblin (Beus and Morales (2003:320) concurs that most single flow dams' formation was quick, by which he means days or weeks, and not in terms of hours as the YEC geologists avow. Both geological perspectives allow that multiple flow dams would have taken

[74] Thorarinsson (1969) calculated the 1783 Lakagigar eruption in Iceland at 12 km^3 of basaltic lava over an eight month period (Rugg and Austin 1998).
[75] GC dams are categorised as either single or multiple lava flow dams, with the multiple flow dams being further classified as having either fewer than 10 flows, or more than 10 flows.

longer to form, with those having fewer than 10 flows probably forming within a few months, while the more complex “D” and Whitmore dams, both with at least 40 strata, could have been formed in a few years. The largest of all the dams was the three (possibly four) flow Prospect, which Hamblin believed to have had the potential under uniformitarian conditions of damming the Colorado completely for about 22 years (Beus and Morales 2003: 329).

Examination of a number of dam remains has revealed that erosional forces and sedimentary deposition processes have played a part in their geological history. Evidence of scouring and deposition are found on surviving surfaces at the Prospect and Esplanade dams. In the cases of Buried Canyon and Gray Ledge dams, the gravel deposits were 60 m thick, (with some boulders weighing in excess of a ton), and 45 m thick respectively (Rugg and Austin 1998). The Whitmore dam, which extends from Mile 187 downstream, has more than 40 thin flows in a 270 m high wall that includes gravel beds sandwiched between lava strata, suggesting that it might have taken a few years to form (Rugg and Austin 1998; Beus and Morales 2003: 337-339).

Uniformitarian geology accepts the above as indicative of lengthy periods of time. Rugg and Austin (1998) believe otherwise, and interpret the evidence as proof of short intermittent catastrophic flood events. They maintain that during such flooding, the dams would have been subject to a number of physical processes. Throughout the entire flood event, scouring of the obstructive dam by the transported sedimentary load would have occurred. When the water flow reached a critical velocity, cavitation would have augmented the scouring, resulting in even more rapid erosion. Once the flood began to diminish, deposition of the materials in transport would begin. Some of the sediments, including the coarser gravels, would fall onto the dam’s surface to be incorporated in the structure at the next lava flow, as noted in the Whitmore dam, above.

In support of their argument that the GC lava dams were short lived, Rugg and Austin (1998) refer to the absence of sedimentary deposits indicative of dam siltation as proof that the dams never reached the maturity of full siltation. They refer to Hamblin’s study of the 13 GC dams, where he calculated the height of the dams and

just how far the lakes created by them would extend upstream, and using figures based on the Colorado River's flow rate and stream suspended load bearing capacity, how long they would take to firstly fill with water, and then the time needed to be silted up.

In the cases of the small dams such as Gray Ledge, Massive Diabase, Layered Diabase and Black Ledge, all would have been filled[76] within three weeks, and silted up within one to seven years. The slightly larger Lava Falls and "D" dams would have taken about three months to fill, and about 30 years to be silted closed. The medium sized Esplanade, Buried Canyon and Whitmore dams would have required about eight months to fill, and taken about 90 years to be fully silted. The large Ponderosa dam would have required 18 months to fill, and be silted up in about 160 years, while the even larger Toroweap dam would have needed slightly more than 2 ½ years to fill with water and 350 years of silting. All of these should have left sedimentary deposits behind, but their deposits' residues would have been dwarfed by those of the lake behind the gigantic Prospect dam.

Hamblin calculated that the Prospect dam would have had a water level 90 m higher than that of Lake Powell, and extended more than 500 km into the hinterland as far as Moab in Utah (Rugg and Austin 1998; Beus and Morales 2003: 324). It would have flooded all the side canyons above the dam, including most of the Havasu and Kanab canyons, and extended up the Little Colorado. Prospect Lake would have required 23 years to achieve this state, needed about 3000 years to be silted in, and had a life span of about 10 000 years[77]. That is if it was subject only to uniformitarian processes.

Rugg and Austin (1998) have suggested that had Prospect Lake endured as long as claimed by Hamblin, that there should have been thousands of sedimentary deposits dotted around the landscape to mark its passing, especially in places of low

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[76] Hamblin (Beus and Morales 2003: 313f) continually refers to these figures as being relevant had the dams been created instantly. Unlike the YEC geologists, he believes that most of the multiple flow dams may have been substantially eroded between eruptions.
[77] Hamblin (Beus and Morales 2003: 324) estimates most dams to have had a longevity of 10 000 – 20 000 years.

erosional activity such as the high lying flat Tonto Platform, which would have been flooded to a depth of about 90m. In fact, they claim that the sedimentary deposits found are usually not in protected low erosional protected zones, but in low-lying drainage, (i.e. high erosional), regions. They conclude from this lack of residual sedimentary evidence that few if any of the lava-dams survived long enough to be filled with sediment, and estimate that the total time for which the GC could have been dammed up was 1300 years at most.

In response to the claims that the sedimentary deposits from Prospect are scanty, and low lying, Hamblin refers to the considerable gravel, sand and silt deposits located at about 1200 m in the Moab and Lake Powell Bull Frog areas (Beus and Morales 2003: 324f).

Sediments at a high level would discredit the YEC claim that the Prospect dam was destroyed before it silted up, and prove that it lasted much longer than the few hundred years that YEC believes. This would make the YEC geologists guilty of sweeping statements and bad science at the least, and deliberate misrepresentation at the worst. Furthermore, in support of their contention that the dams were short lived, Rugg and Austin (1998) point to the failure of two similar dams in recent history, the first in Alaska in 1912, and the second in Mexico in 1982. In both instances, the dams failed within a year of formation.

In examining the evidence for the ages of the GC dams, and their duration of obstruction of the Colorado River, my evaluation is that neither of the two schools of geology have conclusively proven their cases for either short or long interval damming of the Grand Canyon, and that further dispassionate research will be required to resolve the issue.

3.6.3. The Great Unconformity.

One of the key YEC arguments for the claim that the GC resulted from the Deluge is built around the readily discernible contact zone between the lower Precambrian rocks, and the Palaeozoic Era rock formations that lie above the Precambrian, and which is known as the Great Unconformity. YEC believes that the Great Unconformity is proof of the devastation rendered by the Deluge, while modern

geology teaches that it represents an unknown period of lengthy erosion, most probably of “several hundred million years” after upliftment of the basement rocks (Beus and Morales 2003: 91).

Parker (2006) views the GC as the perfect showcase of both post-creation pre-flood sedimentary deposits by uniformitarian processes, and Deluge sedimentary deposits. The lower Precambrian strata, being separated by the Great Unconformity, from the superior Deluge deposits.

Parker (2006) has challenged conventional geological thinking which contends that the Precambrian rocks underwent gradual uplift over unknown aeons, and were subjected throughout this period to uniformitarian processes of weathering and erosion, which produced the Great Unconformity. He states that uniformitarian processes would have rapidly eroded soft friable strata like the Hakatai shales, to produce chasms or valleys, while the much harder overlying Shinumo quartzite would have prevailed as spurs sticking through the "younger" overlying Great Unconformity, and into the foundation member of the overlying strata, the Tapeats sandstone, in far more places than is the case.

Having dismissed the gradual uniformitarian processes as an explanation for the Grand Unconformity, Parker (2006) then proposes in terms of his earlier postulation, a catastrophic model for the Great Unconformity's formation. He believes that the area where the GC occurs was subjected to the massive global volcanic action which produced the great fountains. This volcanic action forced the Precambrian rocks upward catastrophically to their current angles of repose.

The strata, so newly tilted out of the horizontal plane, were then blasted to pieces and planed flat by the stupendous hydrological forces that operated when the global Flood currents began, leaving the "angular unconformity" of the Great Unconformity. Furthermore, the presence of Shinumo quartzite boulders in the Tapeats Sandstone, which rests on the Great Unconformity, and is according to conventional geology 550 million years younger than the uppermost Precambrian strata, are I believe, more convincingly explained by a catastrophic model, where rapid deposition of sedimentary material was deposited immediately on the unconformity, than by

uniformitarian processes which would point to missing strata which must have repeatedly been deposited on and around the Shinumo boulders, only to be eroded and weathered away over the 550 Ma cycle (Treiman 2003).

Young Earth Creationism teaches that the Tapeats Sandstone, (see Section 4.6.4. below), and all the other sedimentary rock strata above the Tapeats were all laid down during the Deluge. They argue that the common orientation of the bedding plains of these sedimentary rocks prove that they were laid down under the same maritime conditions. Furthermore, they believe that these beds are recorded in numerous places globally, but because of different local names, their relationship to each other, and to the Deluge, has been obscured[78] (Barrick 2014, Lecture 28,29).

Hill (2002: 174; 2006: 124-26 notes that although there are numerous examples of massive scale flood deposits around the world, there is no evidence that links any sedimentary rocks anywhere in the world, to the Deluge. She also argues that modern geology has determined that there are numerous mechanisms, other than marine conditions, under which sedimentary rocks are formed. In some instances, sedimentary beds formed by different processes follow, or overlap each other, and thus she rejects the idea that all sedimentary deposits resulted from a single worldwide deluge.

Having noted the above, selected sedimentary rock sequences will be examined in the light of both YEC and modern geology's claims for that specific group. Again in terms of geological practice, the lowest strata will be discussed first, before moving up the geological column.

3.6.4. Selected Sedimentary Deposits in the Grand Canyon Geological Column.

3.6.4.1. Tonto Group: Deluge's First Deposits?

The Tapeats Sandstone, which lies unconformably on the Great Unconformity, is the lowest formation of the Tonto Group. As such it is acknowledged as being the oldest

[78] Hoesch (2008) believes that the Moenkopi shales found near the GC are related to similar deposits in England, Germany, Spain and Bulgaria.

of the Cambrian rocks. Above the Tapeats, the two younger formations in this group are the Bright Angel Shale in the middle, with the Muav Limestone capping this group, (see Diag.1).

Geologists from all schools agree that these deposits are marine in origin, but that is as far as their agreement extends. The YEC geologists claim the Tonto Group are the first of the Deluge deposited sediments, and insist they were laid down rapidly in a deep water environment within a few days. In contrast, modern geology interprets the group as evidence of deposition at varying depths in near shore environments migrating in an easterly direction (Beus and Morales 2003:90).

Within the GC, the Tapeats Sandstone member varies in thickness from 30 – 120 m, pinching out in places where the underlying Great Unconformity is irregular and presents 'hills and peaks' above its eroded plain. The Tapeats primary lithofacies[79] comprises "medium to coarse grained feldspar and quartz-rich sandstone", occasionally including "pebble sized quartz-rich conglomerates" in places along the contact with the Great Unconformity (Beus and Morales 2003: 92).While trace fossils are relatively abundant, few body fossils are known, and these have been all found in the upper transition zone with the lowest beds of the Bright Angel Shale member (Ibid: 93).

Studies performed in the 1940's suggested that the Tapeats sandstone was deposited in shallow marine conditions of less than 33 m, with the cross-bedding caused by inshore rip currents. Recent studies in the late 1970's indicate that some deposition occurred in tidal flats zones (Beus and Morales 2003:99).

A strong argument for deposition in the inter-tidal zone is found in the herringbone cross bedding found to occur in a number of places. This structure forms in zones where the currents are known to change on a regular cyclic basis, as in cases where tides ebb and flow. Similarly, well defined drainage patterns indicative of ebbing tides have been recorded in a number of places revealing that deposition was not continuous, but determined by tidal forces (Beus and Morales 2003: 100). These

[79] Characteristic rock type.

phenomena are contrary to the unidirectional flow demanded by the YEC global current pattern for their deposition model.

The central member of the group, the Bright Angel Shale (BAS) is geologically speaking, the most exciting of all strata in the geological column, for it is here that the first signs of the Cambrian explosion are to be found. In a lithofacies comprised mostly of clay shale, with elements of conglomerate and siltstone in places, fossils abound. These include numerous brachiopods including Lingulella, Paterina and Nisusia; hyolithes; and 47 species of trilobites, as well as primitive molluscs speculated to have come from shallow water zones, and numerous trace fossils from varied species (Beus and Morales 2003: 94,96).

The beds of the BAS, which vary in thickness in the GC from 82-137 m, show considerable diversity, with planar tabular and trough cross-stratification. In some places beds display fining upward sequences, while in others coarsening upward sequences occur. As is the general trend within the group, the beds 'young' towards the east, blending into the upper Muav Limestone member in many locales (Beus and Morales 2003: 94)

In its turn, the Muav Limestone at the top of the group comprises mainly beds of calcareous mudstone, and packstones in thicknesses from 252 m in the west but thinning to 42m in the eastern end of the canyon, many of which show dolomitic properties. Outcrops of micaceous shale, siltstone, fine-grained sandstone and silty limestone are also present in some of the seven identified members of this formation (Beus and Morales 2003: 95).

Larry Middleton and David Elliot (Beus and Morales 2003: 97,99), indicate that the trace fossils of burrowing organisms in the Tonto group point to shallow water environments, and show that some traces cut through beds that became cross-bedded sandstones. Further trace fossils point to detritus consuming annelids moving through the sediments. This would rule out the YEC rapid deposition as such creatures would be buried and crushed under the countless billions of tons of Deluge sediment long before being able to make their burrows, work their sediment substrate, or migrate upward through sediments, as trace fossils suggest.

An evaluation of Middleton and Elliot (Beus and Morales 2003: 89-106) indicates, as is conceded by the authors, that this formation has not been adequately studied, and that the conclusions derived by the earlier studies may not be as complete as they should be. In fact the frequent referral to studies done more than 70 years ago indicates that much more is yet to be learned about the Tonto Group. It also appears at this time that the evidence against the Tonto Group being Deluge deposited sediments is marginally stronger than the arguments in favour thereof.

3.6.4.2. The Redwall Limestone Fossils: “Proof” of the Deluge?

The Redwall Limestone deposits of the Mississippi Period which are known throughout the northern Arizona countryside, are clearly visible at numerous places in the GC gorge walls, varying from 120 m to 250 m in thickness. The Redwall is comprised of the lower fine-grained limestone and/or dolomite of the Whitmore Wash member, and the superior alternating chert and gray limestone and /or dolomite beds of the Thunder Springs member (Beus and Morales 2003: 115 – 118).

Modern geology teaches that the Redwall’s deposits were formed in shallow maritime conditions during two episodes of continental marine transgression and regression. While fossils are rare in the lower Whitmore, numerous fossil types that vary from fine bryozoan fragments through crinoids, bivalves, cephalopods, trilobites, brachiopods and corals are to be found in the Thunder Springs member (Beus and Morales 2003: 120-122).

Young Earth Creationists argue that these fossils must have been deposited by the Deluge, as the deposits are on the continent and not in a maritime environment. In doing so, they reject the evidence for any changes in sea level due to upliftment of the continent. Unfortunately for YEC, they also fail to take into account the fact that while the Redwall deposits are mostly conformable upon the Upper Devonian Temple Butte Formation, it is noted that in other locales that the Redwall rests directly on the Great Paraconformity, an indication of a lengthy period of erosion (Beus and Morales 2003: 117).

Taken together, the weight of evidence for the Redwall Limestone depositional environment points to a shallow marine milieu as the most likely candidate.

3.6.4.3. The Coconino Sandstone: A Study of Sediment Transport and Deposition in the Grand Canyon Region.

Young Earth Creationism teaches that the GC was carved out of Deluge deposited sediments. The question then arose as to the sediments origins', as it was impossible for them all to have resulted from the Deluge's erosional activity, as violently destructive as it was during that year long event. Austin et.al. (1994: 612), recognised this problem and proposed that the two other sediment reservoirs already present, namely the sediments God created during the initial creation for life to exist, and erosional sediments derived from the older underlying "Archean and Proterozoic sediments" between the creation week and the Deluge, were reworked along with the newly produced Deluge sediments.

The Coconino Sandstone, classified by modern geology as being part of the Early Permian, is a widespread formation that along with its associated formations covers about 520 000 square km in the region, occurring in Arizona, Colorado, Kansas, Nevada, New Mexico, Oklahoma, and Texas, and also has some outcrops in Nevada and Utah, (Beus and Morales 2003:163; Morris 2010; Helble 2011: 33). At the Coconino's southern boundary near Pine, Arizona it is about 300m thick, but in the GC where it is near the top of the geological column, it varies from 20 – 180 m in thickness (Beus and Morales 2003: 164). Throughout its range, it is characterised by cross bedded sets at an average angle of 25° [80] with bed thicknesses of 12 - 24 m (Beus and Morales 2003: 179). The consensus by geologists, working from the evidence within the beds as provided by slump features, small scale stratification, low relief ripples, and trace fossils is that the Coconino area was originally a desert produced by Aeolian processes operating over millennia, before lithification (Beus and Morales 2003: 171-172).

[80] YEC geologists insist that angles below 27° prove marine, and not aeolian deposition (Thomas 2014).

Middleton et.al. (Beus and Morales 2003: 163) have noted that despite being widespread and easily accessible to geologists, the Coconino Sandstone has not received the detailed studies that such a large formation merits. I suggest that it is because of this omission that YEC geologists such as Morris, Austin and Snelling have been able to manoeuvre in this area and postulate that the Coconino Sandstone provides evidence of massive flood deposits formed very quickly within a few months at most. The YEC arguments and "evidence" for an aqueous environment for the Coconino Sandstone's formation will be examined and discussed individually.

Morris' (2010) first contention is that the Coconino Sandstone "interfingers[81] with other formations of unquestionable marine origin, implying that the Coconino is also marine". Middleton et.al. (Beus and Morales 2003: 164) supports the claim of the Coconino being found 'intertongued' with other rock groups such as the Toroweap Formation in the GC, and Schnebly Hill Formation in the south, and to the east 'grades' into the Glorieta Sandstone of western New Mexico.

In examining the Toroweap Formation one is struck by the fact that a number of different rock types that are closely associated together were obviously formed by different processes under dissimilar environmental conditions. It appears that sedimentary deposition occurred in five different environments, namely open and restricted marine conditions, through tidal flats and sabkas[82], to aeolian dune conditions. The Toroweap Formation therefore does not support a continually submerged flood environment, but one where the sea was either advancing onto or retreating from the continent (Beus and Morales 2003: 195).

The Schnebly Hill Formation is undoubtedly marine in origin and formed underwater. Geological research indicates that the prehistoric Pedrosa sea, underwent a series of four advances and retreats. During the first, second and fourth advances it converted land desert dunes into submarine wave deposits which became the

[81] "Interfingers" and "intertongues" are synonymous terms.
[82] Sabkha – "broad, salt-encrusted, supra-tidal surfaces or coastal flats bordering lagoonal or inner shelf regions" (Whitten 1972: 397).

Schnebly Hill's sandstone members, and during the third advance deposited a single thin mixed carbonate and silt bed. All sea advances were followed by periods of retreat that allowed the sediments to lithify before the next cycle began. The evidence therefore does not support the YEC contention that these beds were deposited under the same environment, but that long periods separated the formation of every member (U.S. Dept. of Agricuture – Forestry Service. Geology & Minerals: Coconino NF, Red Rock District, Bell Rock n.d.).

While the Glorieta Sandstone is considered to be a shallow marine equivalent of the Coconino Sandstone with which it intertongues, it is in fact an example of a multi depositional environmental sediment. Throughout its lower and middle zones, this fine to medium grained siliceous sandstone shows evidence of shallow marine deposition, while the upper strata indicate that deposition occurred under aeolian conditions (Baars 1974). Once again, the YEC contention for a purely marine depositional environment of a formation related to the Coconino is called into question.

On the evidence presented above, I am obliged to reject the YEC contention that the formations surrounding the Coconino are definitely of a marine origin, and therefore also their conclusion that the Coconino sandstone is most likely marine in origin.

The second assertion made by YEC relates to the supposed evidence for a Coconino marine environment as seen from the fossil record. Because there are no known physical fossils in the Coconino Sandstone, and that only trace fossil tracks have been found, the YEC geologists have seized this opportunity to suggest that the Coconino Sandstone shows "fossil trackways and burrows best understood as being related to underwater activity, not to a dry, sand dune environment" (Morris 2010). This assertion does not appear to have much support from the evidence gleaned over the past century from the study of trace fossils as recorded in the rocks.

While it is true that some trace fossil tracks bear relation to some modern crustaceans, many others appear to be the tracks of millipedes, or arachnids such as

spiders and scorpions, and others were most likely produced by small vertebrates (Beus and Morales 2003:168, 170).

Experiments with different sand moisture contents by McKee in the 1940s indicated that dry sand, even up to slopes of 27 °, will record the tracks of small invertebrates, and if slightly moistened, e.g. by mist or light dew, the sand will preserve those impressions long enough to be filled by silt blown by a gentle breeze. Similarly, recent studies have shown that "sandy surfaces submerged in standing water" will also preserve and record trace fossils. (Beus and Morales 2003: 166).

The conclusion reached from the above is that such is the nature of the trace fossils in the Coconino Sandstone, that while it is not possible to rule out that some may have been made under marine conditions, it is more likely that dessert dune conditions prevailed.

Morris' (2010) third assertion is that the Coconino's "sand grains are poorly sorted and somewhat angular, not at all like desert sands with well-sorted and rounded grains". This is in stark contrast to the report of Middleton et.al., which recorded that the "Coconino Sandstone is composed of fine-grained, well-sorted, and rounded quartz grains and minor amounts of potassium feldspar" (Beus and Morales 2003: 171).

It is possible that because of the enormous volume of Coconino Sandstone (and its associated formations), spread in various thicknesses over a number of states that both parties are correct for selected individual sites. The fact however, that Middleton et.al., could point to good examples of wind eroded sand grains[83] as a general feature, would suggest that Morris had not done his research properly, a sign of poor scholarship in this case.

Having noted that the Coconino Sandstone deposit is very extensive, with a volume estimated by Austin to be in the region of 42 000 cubic km [84] (Helble 2011: 32), we

[83] Cited by Helble (2011: 29).
[84] Helble (2011:36) believes this to be an underestimate, and that the true volume is closer to 50 000 cubic kilometres.

now examine the problem of the origin of its sediments. Austin's postulate, which is based on the dipping of the beds in a southerly direction, is that the sediments probably lay to the north of the present location of the Coconino deposits (Helble 2011: 33).

According to the YEC model, this enormous volume of sediment would have had to have been transported and deposited within a very short time, which Helble (2011: 34) says equates to no more than 12 days at most. This calculation is based on the fact that being near the top of the geological column, all the material below it would have had to have been laid down prior to the Coconino deposits, leaving only a limited amount of time before the Deluge abated.

Modern geology, however, recognises that under usual conditions deposition rates of sediments are notoriously low, in the region of 10 cm per annum. It has however been recorded that under flash flood conditions that 10 cm of deposition can occur in an hour. Snelling believes that the Deluge maintained such extreme flash flood conditions for many months, and could therefore easily have deposited the 1500 m of sediments known around the world to harbour fossil remains, within 5-8 months (Helble 2011: 30).

Helble (2011: 30) notes that Snelling does not offer an explanation as to the origin of all this sediment which covers almost "three-fourths of the Earth's current land surface". He also notes that Austin divided the Deluge deposits into "pre-flood", "early flood", "late flood" and "post flood" strata (ibid : 26). Along with other scientists, he calculates that the depositional rate for the "early" strata to be laid down was about 8,2 m per day (ibid: 32).

Helble then examined the problem faced by YEC geology to explain the deposition of the cross bedded Coconino Sandstone in terms of a marine depositional environment. Helble (2011: 31) notes that Austin started from the known heights of the cross beds and attempted to determine the depth of the water required and the optimum velocity of the water currents needed for those bed heights. In doing so Austin reworked John R. L. Allen's equations from "Physical Processes of

Sedimentation"[85] on the relationships between the water depth and velocity, which are used to calculate sub-marine sand-wave heights. Furthermore, Austin also used graphs taken from Rubin and McCulloch (1980) to explain the relation between water depth and velocity to sediment bed forms occurring in sand of specific grain sizes. Helble noted that the sand grain size of the Coconino covered a much larger range than sand evaluated by Rubin et.al, and was therefore unlikely to be suitable for what Austin was arguing.

Austin then went further than Rubin and McCulloch and extrapolated their graph to be able to derive the results most congruent with his hypothesis, namely that water velocity had to be between 0,9 m/sec and 1,55 m/sec at a depth of about 54 m to produce the bedding features present in the Coconino (Helble 2011: 32). This I would suggest is the worst kind of science, where a scientific process is manipulated in order to reach an expected result.

As to the transportation of all this sediment, the YEC model requires that all 42 000 cubic km move constantly and uni-directionally southwards at a speed of 5 - 8 km/h until it was deposited in its current position within 12 days (Helble 2011: 32). Helble finds this assertion to be impossible, and demonstrates mathematically that in real terms this means that 48 metric tons of sediment would have been crossing every meter of the Coconino's 1600 km boundary, every second for 12 days (ibid: 35).

As has been seen above, the transportation of the sediments required to lay down the Coconino sandstone as per the YEC model invoked a constant uni-directional current. Some YEC geologists believe that this current is best provided by a series of Tsunami's triggered by catastrophic movement when rapid subduction occurred along the continental plates boundaries (Austin et al. 1994: 13,14; Austin and Wise 1994: 44). These plate shifts resulted in the raising of ocean beds at numerous places, providing deep sea sediments for transportation onto land, and caused continental inundation and flooding across the globe. These Tsunamis then

[85]J. R. L. Allen, Physical Processes of Sedimentation (London: Unwin University Books, 1970). Helble notes that in Allen's subsequent book "Principles of Physical Sedimentology" (Caldwell, NJ: The Blackburn Press, 1985), he omitted the equations used by Austin.

generated the uni-directional currents that YEC needed for the marine depositing and cross bedding of the Coconino sandstone.

Citing Coleman's[86] Tsunami research, Helble (2011: 36) indicates three points which argue substantially against the YEC postulation for Tsunami caused deposition. In the first instance, Tsunami waters surge onto land, causing devastating erosion, and then return to the sea, dragging the material loosened back with them[87]. This would not result in structured beds such as the Coconino's cross bedding plains, but in undifferentiated deposits. Second, Tsunami waves have little impact on sediments in water deeper than their wavelengths, and only manifest their transmitted energy when forced upward by shallowing coastal zones. Third, Helble points out the inconsistencies of Austin's arguments in stating in one place that the Coconino's layers "could be formed by 'sustained unidirectional currents of 90 to 155 centimeters per second in 'deep water'", and in another he suggests that 5 m/sec tsunami currents offer "the best modern analogy for understanding how large-scale Grand Canyon cross beds form". The question therefore arises, which currents formed the beds, the slow or the fast? Such confusion is not a sign of scholarly thought.

In weighing up all the evidence as to the depositional environment of the Coconino Sandstone, it must be stated that the YEC case for rapid sedimentary deposition in a marine environment has not been made. In fact, the evidence appears to support the uniformitarian perspective that the Coconino Sandstone is the product of an aeolian dessert, and was formed over a much longer period than is allowed for under the YEC premise of an earth younger than 20 000 years. Further data that should not be ignored, is the evidence derived from periodic flooding and archeological materials collected in the Grand Canyon.

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[86]P. J. Coleman, "Tsunami Sedimentation," in R. W. Fairbridge and J. Bourgeois, eds., The Encyclopedia of Sedimentology (Stroudsburg, PA: Dowden, Hutchinson and Ross, 1978), 828-31.
[87] See Spirit Lake deposits above.

3.7. Flooding and Archaeology in the Grand Canyon.

While for most of the time the Colorado River lies relatively quietly at the bottom of the GC, this is not always the case. Explorer John Wesley Powell noted in 1875 that after the winter snows had melted, that countless creeks and rivers met to "unite to form the Colorado which rolls, a mad, turbid stream, into the Gulf of California" (O'Connor et al 1994: 1).

Studies by O'Connor et al. (1994:5) underscored the fact that Powell had only had an inkling as to the potential might of the Colorado. In a blind side alcove with walls some 50 m high, that they informally named the Axehandle Alcove, some 3 km below the Lees Ferry flood gauge, O'Connor's team found evidence of numerous large floods. The organic samples[88] they collected from different levels on the canyon wall indicated that over the last 4500 years there had been no less than 15 flood events where the volume of water exceeded 5500 cumecs. Of these 10 floods exceeded 6800 cumecs, and one about 1200 to 1600 years ago had a flood volume greater than 14 000 cumecs.

It is noteworthy that none of the above floods approached the 43 000 cumecs potential for this zone as predicted by the Costa curve model for the drainage basin above Lees Ferry (O'Connor 1994:7). This would indicate that the potential for corrasion, side wall scouring and the obliteration of invaluable archaeological materials during extreme flooding, cannot be overestimated. O'Connor (1994: 6) cites the work of Leopold and Maddock (1953) at Grand Canyon gauge, and of Burkham (1986) at Lees Ferry, as proof that much smaller floods of recent years resulted in a measurable lowering of the canyon floor.

In evaluating the evidence for a young or old GC based on archaeological evidence we are obliged to concede that flooding in the gorge over the millennia has destroyed any possible evidence that might have indicated human habitation prior to the proposed Deluge event. While the YEC community would undoubtedly argue that

[88] Samples derived from three sources: (i) charcoal from human occupation between floods, (ii) plant material, and (iii) fecal matter from pack rats (Neotoma) (O'Connor et al. 1994: 5).

the absence of ancient artefacts or organic remains proved a young age for the GC, unbiased evaluation demands that an open verdict be declared on this subject until conclusive evidence for either case be presented.

4. THE FUTURE OF YOUNG EARTH CREATIONISM: SCIENCE OR DOGMA?

4.1. An Overview of the Problem

It would not be an unfair assessment to state that YEC is at a crossroads between continuing to be viewed as religious dogma wearing a thin veil of science, or to be taken seriously as a school of science with a strong Christian emphasis. I believe that the way that YEC has done its science until now has caused the wider scientific community to think of YEC in terms of the former, while YEC sees itself as being in the latter category with the goal of reconciling Scripture and the earth sciences. Any field of study that starts from this noble position should therefore have an inherent commitment to the highest standards of scholarship and Christian ethics and integrity. When we examine the YEC writings however, it becomes obvious that on occasion, the propagation of the YEC position appears to be more important than a commitment to scientific accuracy. In many instances religious dogma, not honest science is promoted. Such a position does not honour the Lord Jesus Christ who is the embodiment of Truth, and it certainly cannot promote His cause. As Christians we must remain committed to reveal the truth even if that truth differs from what we believe it should be. Like Abraham faced with the command to sacrifice Isaac, Christians in the sciences must go forward in faith trusting that God will reveal Himself and be glorified through His creation.

In terms of the above, my research across the broad spectrum of the science and theology debate has revealed that YEC is guilty of poor scholarship in a number of areas, which will need to be addressed.

4.2. Poor Young Earth Scholarship Practices.

In the first instance, many YEC scientists have been guilty of writing on subjects in which they have not been trained. The classical example of this is the cornerstone of modern YEC, Whitcomb and Morris' "The Genesis Flood". While none would challenge Dr Morris in his field of engineering, (his textbooks on hydraulic

engineering were accepted throughout American universities), he was unqualified to write on a young earth. Such practices, which are common within YEC circles, are unacceptable to the wider scientific community, which does not accept that a doctorate in discipline A allows one to write about discipline B. As such, this practise should be discouraged within the YEC community immediately.

The second problem that needs to be addressed within the YEC community is what can charitably be described as the problem of “academic achievement exaggeration”. During my research I came across numerous articles by Dr. XYZ’s, only to discover that the doctorate was either an honorary degree, or from some small non-descript almost unknown university with no standing in the wider scientific community. Apologist Kent Hovind is an example of the latter. In other cases, claims were made for a writer linking him/her to a high profile academic institution when in fact he/she had only been a visiting guest lecturer for a semester at some point in their career. Christians should be above such underhanded attempts to plump up their profiles so as to make it appear that they are more qualified or respected academically than they are.

Third, the world scientific community frowns on retired academics suddenly returning to write on their own field after a total absence of some years from academia. Such is the rapid production of new information on almost every subject that only those actively involved in current research, or academically employed, are considered to be eligible to write on that subject.

Fourth, YEC scholars usually only publish in their own journals, which are seldom subjected to what the wider scientific community would consider to be authentic peer reviewing. As such, the papers, which may in actual fact be of a high academic quality, are in most cases never read or dismissed as dogma by the wider scientific community.

Fifthly, YEC has in many instances opted to misuse miracle as an explanation for an event that has been recorded. This indicates academic laziness and an unwillingness to pursue true scientific method. The age of the “God of the gaps” explanation is long past.

Once YEC deals with these issues, some of the obstacles to acceptance will be removed and a better interaction with the scientific community can be expected.

4.3. The Way Forward For Young Earth Creationism.

I believe that YEC has an important role to play in revealing the secrets of God's creation, but this will only occur when the wider scientific world is convinced that there is a real commitment to the rigorous world of scientific method and peer reviewed science in YEC. To do this the YEC needs to look both outward at the natural sciences, and inward at its scientific worldview.

To date the YEC has been looking outward. It has been challenging accepted natural science on issues such as the mechanisms of macro-evolution, and the accuracy of radio-isotope decay measurement in igneous rocks, and in doing so has caused people to question their hitherto blind acceptance of what has been passed on as scientific fact. YEC must continue to do so, but it must also seek to produce hypotheses that operate within the immutable laws of science. And to do this it must look inward at how science is done in the YEC world.

The place to start would be at Creationist Conferences with less acceptance of the papers being presented, and more robust debate over issues occurring. The YEC community must look seriously at all of its postulations, and ask of itself the hard questions that peer reviewed scholarly research papers demand. YEC cannot afford to wait for the natural sciences to disprove poorly conceived proposals and ideas. Christian honesty and integrity demands that YEC root out bad science, even if that bad science has concordance with scripture.

An example of a way forward would be to adopt as a role model the work practices of someone like the world renowned astrophysicist Dr Danny R. Faulkner. Faulkner, one of the foremost authorities on Black Holes, continues to seek to unravel the mysteries of God's universe, and to reconcile those discoveries with scripture. His hypotheses in his area of expertise, are carefully crafted, and not easily dismissed.

This does not mean that the scriptures are to be relegated to a position that is subservient to science, and so books such as Boyd and Snelling's "Grappling with

the Chronology of the Genesis Flood" (2014), where biblical scholarship and science colaborate, are to be embraced. It is my hope that more such books will emerge in time. Unfortunately, as I am unable to read Hebrew, I was not able to evaluate the convoluted arguments contained therein as pertaining to the Hebraic component of this work, and will leave such an evaluation to Hebrew scholars. I did however gain the impression that the authors felt that the Hebrew texts argued for both a young earth and a global Deluge. In this they are not alone, Wayne Grudem, whose personal perspective appears to support the position of a young earth wrote that "Scripture seems to be more easily understood to *suggest*[89] (but not require) a young earth view, while the observable facts of creation seem increasingly to favour an old earth view" (1994: 307).

In order to be seriously considered by the general scientific community, YEC scientists will need to heed the call to adhere to strictly delimited scientific practices. This will require a commitment to honestly evaluating all scientific evidence gathered, and to presenting that evidence without any religious bias. This will mean committing to a true Christian moral ethic that places honesty and the pursuit of truth, above blind faith and pseudo-scientific methods.

GENERAL CONCLUSION

Evaluation of Young Earth Creationist Claims for a Young Grand Canyon.

In the investigation of the problem as to whether the GC's geology provides the substantive evidence that YEC claims proves a young earth, this paper examined a number of fields.

In the opening chapter the development of thought on the earth's age started with Ussher's date, and then moved through the earliest modern geological postulations on natural processes by Hutton and Lyell which led to the development of the Principle of Uniformitarianism. These scientific explanations were soon widely accepted and embraced throughout the western Christian world until the resurrection of the older ideas under the influence of the SDA Church in the latter half of the 19th

[89] Grudem's emphasis.

century. After a lengthy period of marginal influence outside SDA Church circles, the YEC movement gained new momentum with the release of Morris and Whitcomb's "The Genesis Flood" in 1961.

The YEC defense of a recent creation was then offset by an investigation of some of the dating methods used in natural science. While the reliability of some of the less important dating procedures could be challenged when used in isolation, the common practise of cross checking results against other procedures has established the reliability of most of these technologies.

The major focus of this chapter was however, an investigation of the reliability of Radiometric dating with respect to dating rocks. YEC has challenged the accuracy of radiometric dating of samples on a number of occasions, and as a result natural science has taken the necessary remedial action to address those issues. It was noted that the YEC claims for changes in the half-life rates of elements after the Deluge has no factual basis, and must be rejected. This means that the evidence for an ancient earth as determined by the decay of radiometric isotopes within the minerals that constitute rocks is accordingly, overwhelmingly convincing. Within this section a special emphasis was given to Radiocarbon dating.

The various techniques and technologies used in Radiocarbon dating were exhaustively examined. This examination revealed that 14C dating is extremely complex, with many possible causes for failure, but also that when correctly applied that it provides accurate ages for artefacts containing organic materials up to about 50 000 – 60 000 years old. This value is greater than allowed by YEC, and seriously challenges their contention for a young earth.

The second chapter examined the biblical support for Noah's global Deluge, and a young earth. The investigation covered, and dismissed, the claims that the Biblical record was only a reworking of other older near eastern writings relating to the creation of the cosmos, the origin of mankind, and the Deluge, showing that the evidence favoured the independence of the Biblical record from outside sources. As to the earth's age, Luther and Wesley believed in a recent creation and Deluge, although these points were not crucial to their protestant evangelical theologies.

Furthermore, we noted that while the argument that Noah's flood as God's divine punishment on sin is convincing, the evidence as to whether it was globally universal in nature was inconclusive.

The third chapter examined the YEC perspectives on creation and the Deluge. It revealed that no single cohesive model on creation or the Deluge exists, and that much work needs to be done in this field. It is however encouraging to note that younger YEC writers such as Scheele, are challenging older ideas that are unclear or just bad science.

Where YEC has used studies from recent events such as the Mount St. Helens eruption, and the Glen Canyon Dam failure, to argue some of their points, valuable contributions to science may occur, provided that they refrain from over-extrapolation by insisting that small scale examples are directly applicable to the massive natural feature of the GC.

In the focus on the GC as proof of the Deluge, it is obvious that the sheer size of this natural phenomenon means that geologists have barely begun to unlock the story of its formation and structure. As a result, it is possible that YEC and natural geologists could reach quite contradictory conclusions about different outcroppings of the same rock strata or formation. This does not however, excuse fuzzy thinking or sweeping statements from either geological school.

In examining the arguments relating to the ages of the GC's igneous and metamorphic rocks, we found that natural science was guilty of flawed procedures at times, which if deliberate, meant that a case for manipulating results could be made against them. On the other hand, YEC science was guilty of being too quick to disregard all radioisotope dating of rocks, which has proven to be reliable in many instances.

The problem of explaining the origin of the Great Unconformity remains, to my mind at least, unresolved. While natural science argues for millennia of erosion, I find that the YEC explanation for a catastrophic event causing this structure to be more convincing. This concession does not however entail an endorsement of the YEC

postulation that the Great Unconformity resulted from a global Deluge, and another mechanism may well provide the answer to this puzzle.

The final section of this chapter dealt with some of the significant sedimentary rock formations of the GC. An evaluation of the evidence indicates that many of the formations show multi-environment deposition, and not the solely marine environment of a global Deluge. Furthermore, as demonstrated by the sediment load calculations, it would be nigh impossible for so much sediment to have been deposited within the few months allowed by the YEC Deluge model.

Despite the fact that the above evaluation of YEC geological claims for a young GC can, due to the selected sampling of some of the strata in the GC geological column, and the brevity with which those rocks were discussed, only serve as an introduction to the subject, I believe that sufficient depth was given to the above discussion to allow a provisional evaluation of the YEC geological position to be made.

Accordingly I suggest that when taken together, the geological evidence as investigated above does not appear to support the contention by YEC geologists that the sedimentary rocks found in the GC region were deposited under the universal Deluge conditions that have traditionally been ascribed to Noah's Flood. Neither does the evidence seem to support the associated assertion that shortly after the abatement of the Deluge that the GC was excavated catastrophically within a very short time span.

The final chapter sought to foresee the future of YEC science. I believe that YEC needs to address a number of issues relating to how it does its science, and that once it meets these criteria, and perhaps others, that it will be able to make meaningful contributions not only to science in general, but also to its affirmed intention to bring glory to God.

In conclusion, I am obliged to state that my investigation into the GC's geology is based on only some of the research that has been done in the region, and that all geologists admit that research into the GC, and its associated rock formations, has barely scratched the surface. Geologists would agree that many thousands of man

hours of research still need to be invested in this wondrous gorge before all its secrets are revealed, and that accordingly my evaluation of YEC geology is based on data currently available, which may be supported or contradicted by further research.

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