

# The Importance of Unconformity-Bounded Sequences in Flood Stratigraphy

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## ABSTRACT

*The Genesis Flood was a tectono-sedimentary event. Globally-controlled tectonic activity disrupted the otherwise continuous deposition of the Flood, forming unconformities. Unconformities are understood as erosive horizons which can extend laterally into correlative conformities. It is explained that an unconformity does represent a boundary with chronostratigraphic significance, since it marks the boundary between an older package of rocks below and a younger package above. Inter-regional or world-wide unconformities separate unconformity-bounded stratigraphic sequences called megasequences (MSQs). Megasequences are defined as regionally extensive rock-stratigraphic tracts of genetically related depositional units, of equal or higher rank than group, and bounded by unconformities (or their correlative conformities) of inter-regional extent. The importance of MSQs in Flood stratigraphy is that they indicate globally-controlled activity of tectonic and/or other mechanisms which controlled sedimentation during the Flood. It is suggested that this concept be adopted for interpreting Flood geology for several reasons, including the fact that MSQs are defined by physical boundaries (unconformities), and are thus lithostratigraphic (as opposed to time stratigraphic [evolutionary]). Each sequence refers to a cluster of strata of varying but continuous (relative) age, that is, continuous deposition (within the sequence/depocentre). It is suggested that MSQs can be used to substitute for the current geological (evolutionary) time system, as they represent more coherent subdivisions of geologic time within a single tectonic domain during the Flood. MSQs from South Africa and eight other regions around the world are described and tentatively correlated, to set up an example-correlated stratigraphic framework for interpretation of Flood stratigraphy.*

## INTRODUCTION

The Genesis Flood was a tectono-sedimentary event: 'on that day all the springs of the great deep burst forth, and the floodgates of the heavens were opened.' (Genesis 7:11)<sup>1</sup>

The springs of the great deep bursting forth describes what is geologically termed as tectonic activity. Tectonic activity (including volcanism) during the Flood would disrupt what would otherwise be continuous deposition of sediments, forming unconformities, which mark the boundaries of stratigraphic sequences. This paper will discuss the concept

of stratigraphic sequences, the nature of unconformities in space and time, and how these unconformities and the stratigraphic sequences they bound can be correlated to create a possible stratigraphic framework for interpreting Flood geology. Note that the term 'stratigraphic' (in this case) refers only to surface-accumulated rocks (sedimentary or not) and not to subsurface-emplaced rocks (that is, igneous intrusions).<sup>2</sup>

One of the motives of this paper is to develop a system in which to describe the depositional history of the Genesis Flood without being dependent on the evolutionary geologic timescale. This is especially true with the preconceived

generalisation that 'Precambrian' means pre-Flood and the 'Phanerozoic' is equated with Flood deposits. My 8½ years experience with South African geology (especially the 'Archaean' Witwatersrand Supergroup and related rocks) has shown me that this concept does not work in southern Africa — only 25 per cent or so of the stratigraphy would be considered Flood deposits, despite striking depositional similarities of the Precambrian rocks to the Phanerozoic rocks. I propose that we as creationists need to re-interpret the rocks, and not the evolutionists' interpretation of these rocks. For this reason, I include in my Flood model 'Precambrian' stratigraphic sequences which are extensive and sheet-like in area and often display syn-tectonic deformation (forming unconformities). While the Day 3 Regression described by Wise<sup>3</sup> could explain some 'Precambrian' deposits, it cannot explain the formation of a deposit which was deformed by complex syn-compressional tectonic activity such as the Witwatersrand Supergroup. I envisage that the Day 3 Regression would have been likely characterised by extensional tectonics and plutonic activity (granites), probably forming 'rift/drift' type depositional sequences in a single regressive phase.

A second motivation for abandoning the evolutionary geologic system is highlighted by the work of Holt.<sup>4</sup> In investigating the position of the Flood/post-Flood boundary at eight or nine different locations in North America, he placed the boundary at a different evolutionary time level at each location, from the Miocene to Holocene. Austin<sup>5</sup> also places the Flood/post-Flood boundary of the Colorado Plateau region at another time level, at the base of the Wasatch Formation (Eocene). This highlights the inadequacy of using the evolutionary scheme in deducing the Flood's boundaries (and depositional history).

I also consider that the tectonic activity (which includes associated volcanic activity) was a *major* cause in disrupting the otherwise continuous deposition of the Genesis Flood. Tectonic activity would have been a primary cause for eustatic mechanisms. Vail *et al.*<sup>6</sup> consider that an eustatic change of sea level on a global scale may be produced by a change in the volume of sea water, a change in the shape of the ocean basin, or a combination of both; however, they also consider that 'geotectonic mechanisms' were the major factor affecting eustatic controls on the global scale<sup>7</sup> (also see Froede<sup>8</sup>). Tidal activity during the Flood<sup>9</sup> would also be dynamically altered by tectonic activity. Tectonic activity was also a major cause of erosion and unconformity development — a major point in this paper. For these reasons, I emphasise tectonic mechanisms in this paper, but not to the exclusion of other mechanisms.

## STRATIGRAPHIC SEQUENCES

The concept of stratigraphic sequences has been developed in the geological literature sporadically over the last 45+ years.<sup>10-15</sup> In general, stratigraphic sequences are rock-stratigraphic units traceable over major areas of a

continent or sub-continent, and bounded by unconformities (or their correlative conformities) of inter-regional scope.<sup>16,17</sup> Sloss<sup>18</sup> originally defined them as equal to, or higher in rank than, a supergroup; modern usage is more general in its application, as shown in the definition of Mitchum *et al.*:

*'A depositional sequence is a stratigraphic unit composed of a relatively conformable succession of genetically related strata and bounded at its top and base by unconformities or their correlative conformities.'*<sup>19</sup>

Nevins<sup>20</sup> looked at the concept of stratigraphic sequences from a viewpoint of Flood geology, noting several characteristics that supported rapid deposition of sediments such as wide-spread, sheet-like basal sandstones and the graded structure of sediments. More recently, Froede<sup>21</sup> discussed the application of sequence stratigraphy to Flood geology, focussing on eustasy and eustatic mechanisms. To fully understand the importance of unconformity-bounded sequences (UBSs) and their application to Flood stratigraphy, a basic misunderstanding concerning unconformities must be cleared up.

## UNCONFORMITIES

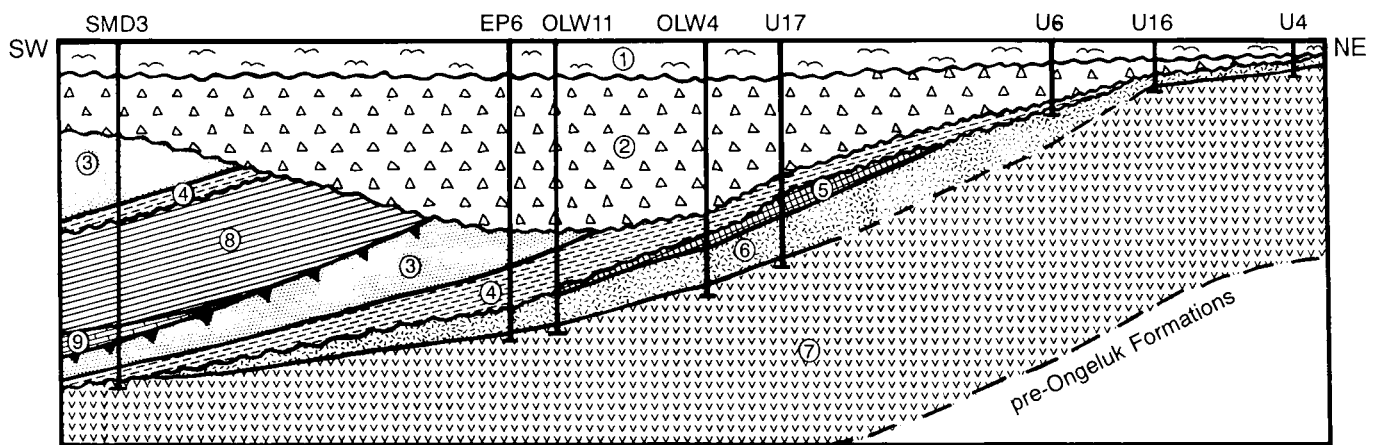
An unconformity, in the pure, physical sense, is simply *'A surface of erosion that separates younger strata from older rocks'*.<sup>22</sup> The essential feature of an unconformity is a structural discordance, which is represented by an erosional surface. (Thus, a paraconformity is *not* an unconformity.) Often (but not always) an unconformity can be easily recognised by the absence of parallelism between the strata. Strictly speaking, an unconformity is detected when the younger overlying stratum does not 'conform' to the dip and strike of the older underlying rocks;<sup>23</sup> often, this relationship can only be determined through regional mapping. Figure 1 offers a good example of this.<sup>24</sup> (The megasequence designations given in this figure are described later in the paper.) Three major unconformities are shown in this cross-section. That the Kalahari Group unconformably overlays the Dwyka Group is only obvious from regional mapping, not from the section (see Figure 14 later, where the Kalahari Group unconformably overlies the Hotazel Formation). On the other hand, the Dwyka unconformity is obvious from the section. The Mapedi unconformity is also an obvious feature, its regional extent highlighted by the thrusting event which shows Mapedi rocks overlying the Asbesheuwels BIF, suggesting the erosion or non-deposition of nine intervening formations. Like the Kalahari unconformity, many unconformities are flat-lying, regionally spread-out features. Roth<sup>25</sup> observed that the Ochoa/Guadeloupe unconformity in the western USA covers nearly 250,000 km<sup>2</sup>. Sometimes a lag conglomerate is deposited on top of the unconformity, usually being the remnants of the rock material that was eroded away. At the very least this represents a break in deposition. There would have been several ways to break the pattern of continuous deposition during the Flood: tectonic

movement of the bedrock being deposited on (regional and local), volcanism (related to tectonic activity), massive lunar tides<sup>26</sup> (periodic event), eustatic mechanisms, etc. Thus unconformities would indicate the occurrence of one or more of these events which occurred in real time during the Genesis Flood. For example, tectonic movements would cause regional uplift of depositional tracts, which would then be differentially eroded away by hydraulic forces (see Figure 4 later).

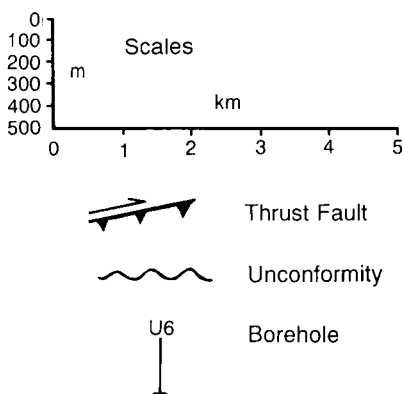
This leads to the point that unconformities do have a time significance; this is one of the most contentious issues regarding unconformities because of the huge time gaps inferred for them by uniformitarian geologists. Roth<sup>27</sup> noted that there was no evidence for such large time gaps in most cases. Time gaps of millions of years would have produced gullies, canyons, valleys, etc., which are rarely seen in the rock record (see Figure 2). In the few cases where these features are observed, Roth argues that the 'presence of erosion is not an argument against rapid action. Erosion can occur very rapidly under catastrophic flood conditions.'<sup>28</sup> For example, the Dwyka unconformity of South Africa (which covers approximately 600,000 km<sup>2</sup>)<sup>29</sup> cut canyons and valleys of various sizes on its northern flanks.

The larger 'Dwyka valleys' are usually formed in areas where faulting and less resistant rock occur in the pre-Dwyka rocks (for example, Hotazel valley — see Figure 1); this combination would have aided the erosion started by the hydraulic action of the Genesis Flood. Roth concluded that as the flat and sub-parallel unconformities seen in the rock record are different from the eroding surfaces of our present earth, unconformities seem to suggest less time — which is readily reconciled with catastrophic models, for example, the Genesis Flood which proposes rapid deposition of these layers and would have bevelled sediments and left flat-lying unconformities. Thus, interpretation of unconformities as representing long periods of non-deposition is solely based on uniformitarian philosophy (for instance, how does one tell the difference between a depositional tract that has been eroded away and non-deposition?).

The other highly debated time issue regarding unconformities is their use as chronostratigraphic markers. While unconformities are not strictly isochronous, neither are they generally diachronous. Diachronous rock units cut across time lines (isochrons); unconformities cut off time lines. Figure 3 demonstrates this. The proximal and distal edges of the lower basin are eroded between times (3) and



LEGEND



#	Geological Unit	Major Lithologies	Megasequence
1	Kalahari Group	Sand, Sandstones	SAF-7
2	Dwyka Group	Diamictite	SAF-6
3	Lucknow Formation	Quartzite	SAF-3
4	Mapedi Formation	Shale, with basal Fe-conglomerate	
5	Moodraai Formation	Dolomite, Chert	SAF-2 (upper)
6	Hotazel Formation	Fe/Mn-formation, Lavas	
7	Ongeluk Formation	Andesitic Lava	
(6 Intervening Formations)		(regional)	
8	Asbesheuwells SubGp	Banded Fe-formation	SAF-2 (lower)
9	Gamohaam Formation	Sparry Limestone	

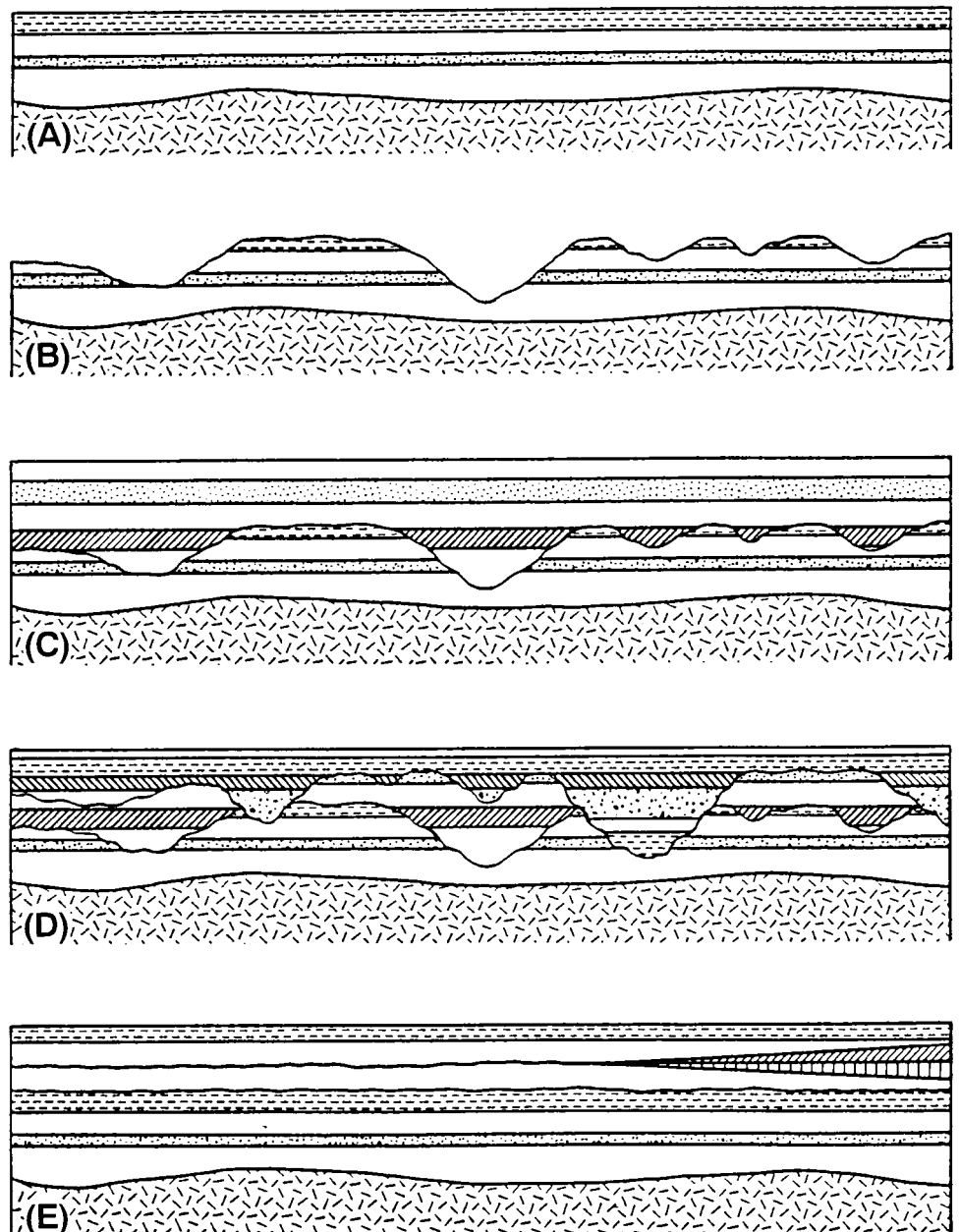
Figure 1. Cross-section from the Northern Cape manganese field (South Africa) showing three major unconformities. See text for explanation. (After Beukes and Smit,<sup>24</sup> Figure 9.)

(5), forming an unconformity surface. Note that the unconformity cuts off the isochrons (3), (4) and (5), and no sediment deposited during these times is preserved beyond the unconformity. The unconformity is younger than time (3) since it cuts off that isochron; it is older than time (5) since that is the last isochron it cuts off. Thus the unconformity is **heterochronous** (other times),<sup>31</sup> as it represents a variable period of time.<sup>32</sup> Since the isochrons do not travel through the unconformity, it is not diachronous.

Another observation is that the upper-bounding unconformity of the lower sequence is 'active', since it represents the limit of erosion that affected the sequence. With the resumption of sedimentation in the upper sequence, the upper-bounding unconformity of the lower sequence becomes part of the lower-bounding unconformity of the upper sequence. At this point, the unconformity becomes the top of the platform ('bedrock') on which the sediments of the upper sequence are deposited and thus become 'passive'. The time significance of this is that the entire unconformity is no younger than time (5), the oldest time sediments were deposited, despite the intersection of younger isochrons with the unconformity. The basal portion of the upper sequence is time-transgressive from the depocentre out to the proximal and distal portions of the basin. The basal portion of the sequence is diachronous, extending from time (5) in the depocentre to time (9) at the distal end of the basin. But the lower bounding unconformity is not diachronous, as no sediments younger than time (5) are preserved below the unconformity.

Thus an unconformity does represent a chronostratigraphic boundary between an older package of rocks below and a younger package above.<sup>33,34</sup> At any **one location** along the unconformity, the rocks below the unconformity are always

older than the rocks above it. Diachronous unconformities are rare, if they exist at all, and certainly would be restricted to inter-regional and world-wide unconformities because of the large areal extent necessary to form one (a possible example of a diachronous unconformity is discussed later in this paper). There will be no attempt to resolve this issue in this paper, but one point is offered for thought: one must not mistake the diachronous contacts of the unconformity-



**Figure 2.** Development of unconformities based on present-day erosional patterns:—

(A) Pattern of continuous deposition.

(B) Erosion.

(C) Resumption of sedimentation. The old erosion surface is still visible.

(D) A second cycle of erosion and deposition further complicates the pattern.

(E) The normal pattern seen in the actual rock record.

One would expect significant erosion below each unconformity if extensive time was involved in depositing the UBSs. Hypothetical diagram from Roth,<sup>25</sup> Figure 4.

bounded sequence for a diachronous unconformity.<sup>35</sup> The deposition of basal transgressive sands are diachronous in nature, but require a pre-existing surface to be deposited on. It is physically impossible to erode and deposit sediment at the same time at the same locality, even under catastrophic conditions; thus locally diachronous unconformities are not possible.

In summary, unconformities indicate geologic events which alter sedimentary patterns of deposition which occur in real time; the geometry of these unconformities would also be influenced by these events. Vail *et al.*<sup>36</sup> recognised the time significance of unconformities on an inter-regional scale, as they are related to cycles of global eustasy (and other mechanisms), which are records of geotectonic and other large-scale processes that reflect major events of geologic history. Applied to the Genesis Flood, inter-regional unconformities would indicate the occurrence of geologic events which were globally controlled at different times during the Flood. With this principle, the broad time significance attached to inter-regional unconformities can be 'quantified'. Exact ages or the length of the time gap need not be known. It may be possible to correlate inter-regional unconformities on a world-wide basis to aid in interpreting the depositional history of the Genesis Flood.

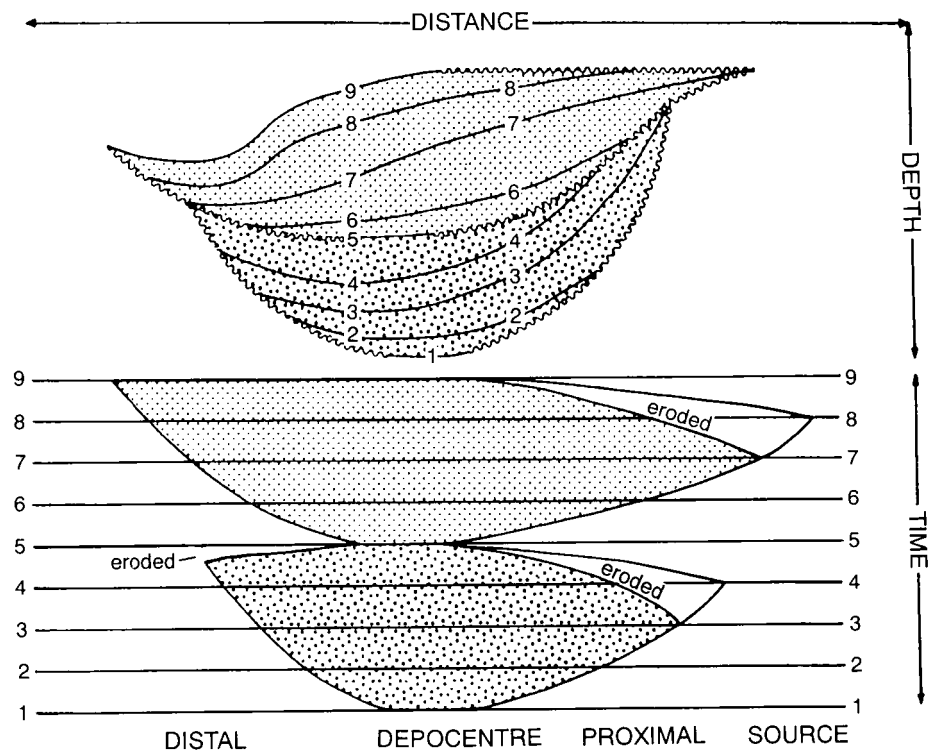
### CORRELATIVE CONFORMITIES

Klein<sup>37</sup> noted (as have many creationists<sup>38</sup>) that many unconformities at some point grade laterally into conformable strata in the depocentre, and the discontinuity disappears. Klein defines the continuous bedding plane extending from the lateral disappearance of an unconformity as a *correlative conformity*, and uses it as part of a stratigraphic sequence boundary. The correlative conformity can be considered as part of the unconformity with a 'zero' time break; that is, the isochron runs exactly parallel to the 'unconformity'. (Correlative conformities may be diachronous in some cases.) A simplistic example of the formation of a correlative conformity is shown in Figure 4. Sediment flow from the left has deposited three cycles of sediments. At time (4), tectonic movement causes an uplift to the left of the basin; hydraulic forces from the sediment flow erode away previous deposits, creating an unconformity.

Tectonic activity stops at the beginning of time (5), allowing accommodation space for the deposition of cycle (5). Cycle (5) unconformably overlays cycles (1)–(4) on the left side, while conformably overlying cycle (4) on the right side. The unconformity becomes a correlative conformity in the middle. Inter-regional unconformities will have very small (areal) correlative conformities, while local unconformities will have larger correlative conformities.

### UNCONFORMITY-BOUNDED SEQUENCES

The importance of UBSs in Flood stratigraphy is that they indicate regionally (or globally)-controlled tectonic or



**Figure 3.** Wheeler diagram showing time relationship of unconformities and UBSs. Note that the time-lines intersecting the unconformities from below are earlier (older) than the time-lines intersecting the unconformities from above, and that time-lines do not pass through the unconformities. (From Winter,<sup>30</sup> Figure 1).

other activity which controlled sedimentation during the Flood. Mitchum *et al.*<sup>39</sup> rated depositional sequences (UBSs) useful in establishing a comprehensive stratigraphic framework because the unit is determined by the physical relations of the strata themselves.

It is suggested that UBSs of inter-regional scope can be used to substitute for the current geological (evolutionary) time system as they represent more coherent subdivisions of geologic time within a single tectonic domain during the Flood.<sup>40</sup> The significance of this is that it may be possible to correlate unconformity-bounded sequences whose bounding unconformities are inter-regional or world-wide. Both

Morton<sup>41</sup> and Ager<sup>42</sup> documented the trend in the geologic record in which certain types of lithologies are more prominently deposited during certain geologic periods. Ager called this the 'Phenomenon of the Persistence of Facies'<sup>43</sup> without offering any explanation as to why this occurs. One of Morton's conclusions was 'that since global systems of rock deposition exist, the deposition of the geologic column must be globally controlled.'<sup>44</sup> Sloss, in his classic paper, recognised six inter-regional unconformities on the North

American craton and described six sequences between them (the Sauk, Tippecanoe, Kaskaskia, Absaroka, Zuni and Tejas sequences).<sup>45</sup> In a later paper, Sloss demonstrated synchronous depositional patterns on both the North American craton and the Russian Platform, suggesting that the depositional patterns are controlled by 'some more complex global mechanism'.<sup>46</sup> **It is suggested that this global mechanism was the global processes of the Flood (for example, the 'breaking up of the great deep' —**

**tectonic activity with associated volcanism).** The hypothesis put forth here is that at certain discrete points in time during the Flood, sedimentation was disrupted on a global level and inter-regional or world-wide unconformities were produced, thus forming UBSs of inter-regional scope which should be correlatable on a global scale. It is suggested that this concept be adopted for interpreting Flood geology for the following reasons:

- (1) UBSs are defined by physical boundaries (unconformities), that is, they are lithostratigraphic (as opposed to time stratigraphic [evolutionary]);
- (2) each sequence represents the spatial and temporal distribution of a complete depositional 'cycle', that is, a geologic history;<sup>47,48</sup> and
- (3) each sequence refers to a cluster of strata of varying but continuous (relative) age, that is, relatively continuous deposition (within the sequence/depocentre).<sup>49,50</sup>

Nevins<sup>51</sup> made several general observations of Sloss's sequences which would support their use as Flood stratigraphic units:—

- (1) The basal sandstones and conglomerates are sheet-like and wide-spread, indicating that flood conditions once prevailed. There is no modern example of these sandstones.
- (2) The sandstone strata generally differentially truncate preceding strata.
- (3) Many sequences have graded structure (coarse to fine, clastic to chemical); reverse grading is also possible.
- (4) The bounding unconformities are also wide-spread.

These general observations hold true with most UBSs seen around the world, thus making the study and correlation of UBSs a good tool for the development of a stratigraphic framework for, and the depositional history of, the Genesis Flood.

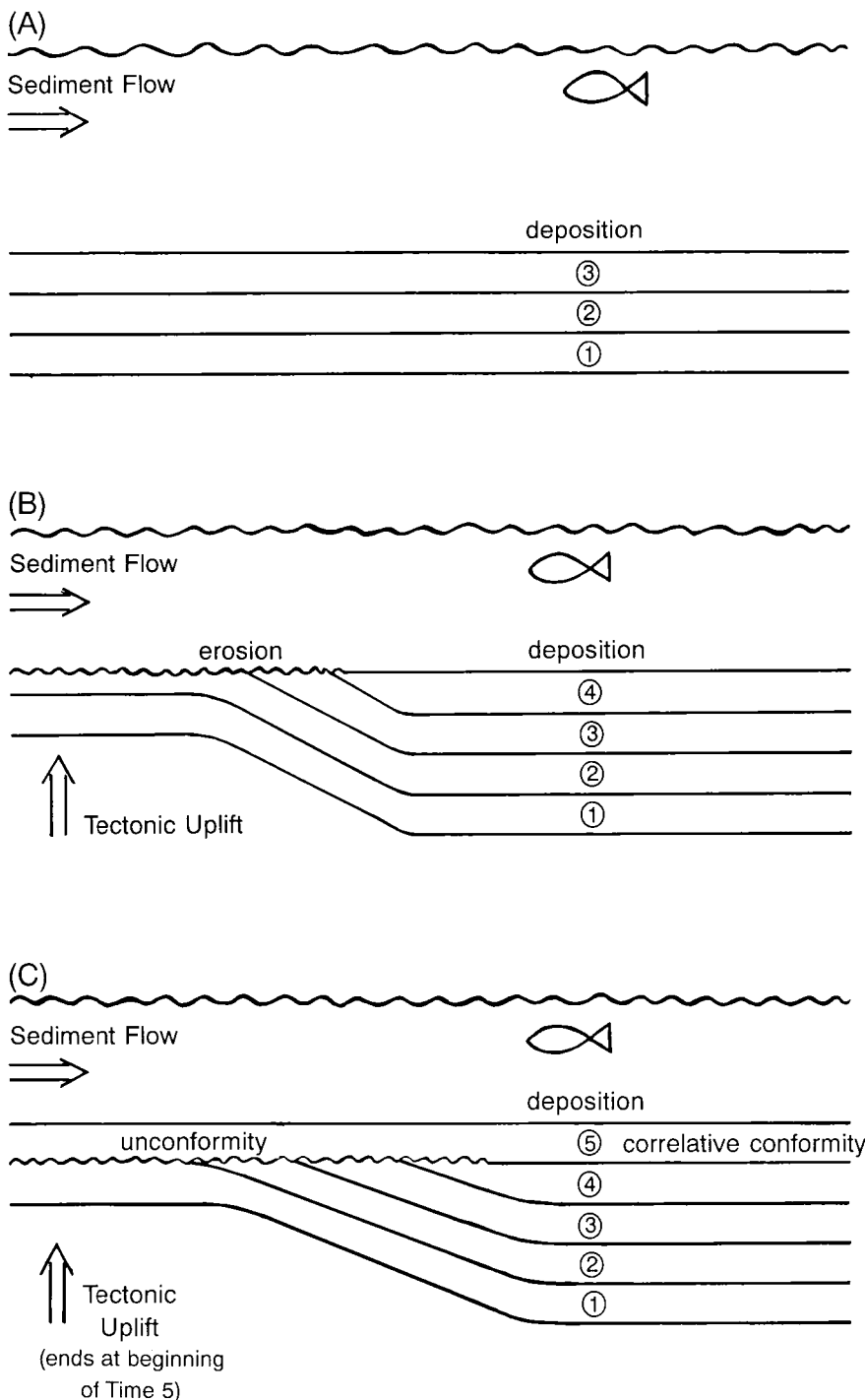


Figure 4. Example of the formation of a correlative conformity (see text for details).

## SEQUENCE HIERARCHY AND MEGASEQUENCES

In order to stratigraphically correlate these UBSs, a hierarchy of sequences is necessary to aid proper correlation. A plethora of terms have been proposed or used in the relevant literature,<sup>52</sup> but nothing has been officially defined.

A suggested hierarchy is set out here for further discussion:—

Megasequence

Sequence (super- and sub-)

(Lithostratigraphic Ranks)

The term Megasequence (abbreviated MSQ) has been previously defined in terms of Flood stratigraphy by Austin and Wise, and is reserved for the top classification within this suggested hierarchy. They define a megasequence as:

*'a regionally extensive package of sediments bounded above and below by unconformities of inter-regional extent. It is typical (but not universal) that a megasequence is a fining upward, coarse-to-fine sequence of clastics capped by carbonates. It is also typical that megasequences include a package of formations of group status or above.'*<sup>53</sup>

There are several problems with this definition, mainly with the restrictive terminology. Primarily, the description of a megasequence as *'a fining upward . . . sequence . . . capped by carbonates'* is impossible to apply in southern Africa as carbonate rocks are relatively rare (especially inland). The one megasequence with extensive carbonates has them at the bottom of the megasequence. It is suggested that this statement not be included in the definition (especially since it is 'not universal'). Additionally, the term 'sediments' excludes volcanic rocks, which are stratigraphic and can be included in a megasequence. I would like to offer the following definition of a megasequence for consideration:

*'A megasequence is a regionally extensive rock-stratigraphic tract of genetically related depositional units, of equal or higher rank than group, bounded by unconformities (or their correlative conformities) of inter-regional extent.'*

The term 'rock-stratigraphic tract' is used rather than sediments, as it is inclusive of all surface-accumulated rocks: sedimentary, volcanic, or other. I have included the term 'genetically' because of the importance of the general related origin of rocks within the megasequence package: a set of related mechanisms occurred during a period of the Flood which led to the depositional pattern observed. This is an important part of the usefulness of megasequences — the interpretation of the depositional history of that part of the Flood. The term 'rank' is used rather than 'status' because the term 'group' is a lithostratigraphic rank. While some megasequences will be bounded entirely by unconformities, some megasequences will be bounded by unconformities with correlative conformities; thus the inclusion of the term in the definition.

The term sequence has also been defined by Austin and Wise in terms of Flood stratigraphy:

*'A sequence is a package of sediments bounded above and below by unconformities.'*<sup>54</sup>

Again, the term 'sediments' is restrictive; additionally, I would like to embellish the definition with some terms from the Mitchum *et al.*<sup>55</sup> definition of depositional sequence to emphasise the usefulness of sequences in establishing a stratigraphic framework<sup>56</sup> for a region (as previously discussed). I would like to offer the following definition of a sequence (in the context of Flood stratigraphy) for consideration:

*'A sequence is a rock-stratigraphic tract composed of a relatively conformable succession of depositional units bounded by unconformities or their correlative conformities.'*

Unconformities of local to sub-regional extent can occur within a sequence, thus the requirement that the rocks only be relatively conformable (that is, it is likely that these rocks would be conformable in the depocentre). The requirement that the rocks be genetically related has been dropped to allow the grouping of 'non-related' formations into a UBS; this type of sequence may stand alone outside of a megasequence, and more than likely to be only of local to regional extent. However, it is typical in most cases that a sequence of rocks will be genetically related. The prefixes *super-* and *sub-* can be used with the term sequence to expand the hierarchy.

Below the rank of sequence no further hierarchy is suggested with regard to units with chronostratigraphic significance. It is suggested that the appropriate lithostratigraphic ranks be used in subdividing a sequence (other than 'subsequence'). The term 'cycle' has been used in other schemes, but it is a very over-used term, and used on a variety of scales; it has been recommended to me that the term not be used.

## DESCRIPTION OF THE MEGASEQUENCES OF SOUTH AFRICA

Megasequences (MSQs) are defined by identifying major (erosive) unconformities in the geological column and then looking at the rocks between them, such as lithologic similarities within the sequence, and related origins of sedimentation and depositional patterns. The regional extent of the strata must be considered, as well as its spatial relationship between the overlying and underlying strata. Table 1 gives the stratigraphic units informally assigned to each MSQ in South Africa (SAF). Spatial relationships of these MSQs are shown in Figures 5 and 6. Stratigraphic sequences are usually numbered from the top down;<sup>57</sup> however, it is easier to discuss the MSQs in terms of depositional history, so they are numbered accordingly here and the first MSQ discussed will be SAF-1, the oldest identifiable MSQ in South Africa. What follows is a description, and not a formal definition, of the megasequences of South Africa. Space does not allow for formal definitions

at this time, and the purpose of this section is to set up a MSQ framework for South Africa that can later be correlated with other MSQ frameworks around the world as an example at the end of this paper. More rigorous definitions of the South African MSQs will be forthcoming. Also note that tectonic controls (or lack of them) on sedimentation are emphasised for the various megasequences, and are briefly

summarised. Unless otherwise footnoted, the data for the South African megasequence interpretation following is based on the SACS,<sup>58,59</sup> Tankard *et al.*,<sup>60</sup> and Visser.<sup>61</sup>

Below SAF-1, within the Kaapvaal Craton, are deformed greenstones and sediments, such as those in the Barberton Greenstone Belt. While stratigraphic relationships can be determined within an individual greenstone belt (for example,

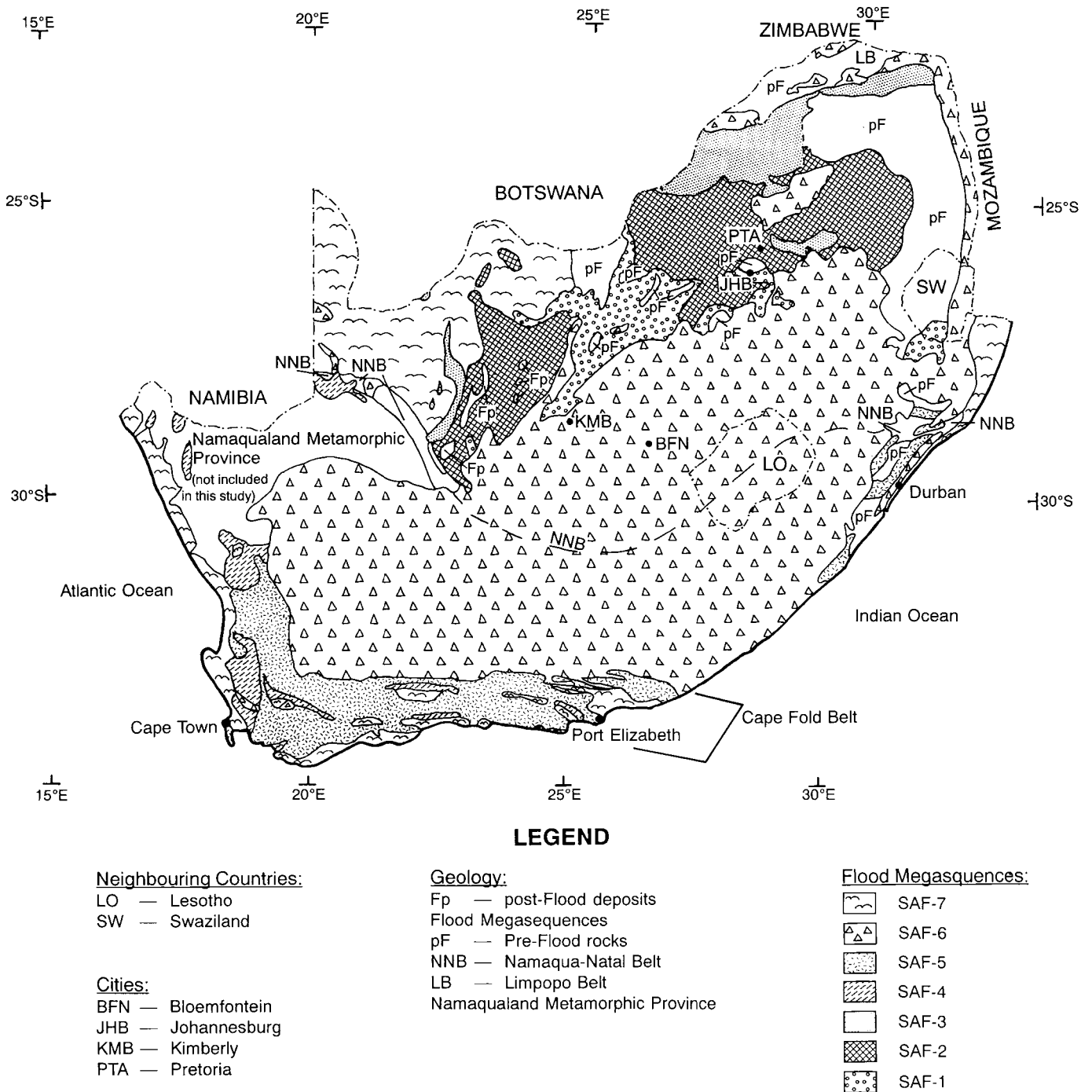


Figure 5. Map of South African megasequence distribution (note: Bushveld Igneous Complex ignored).



MSQ	STRATIGRAPHY			TECTONICEVENTS
post-Flood (Fp)	Various isolated continental and shelf deposits			
SAF-7	Sandveld Group Uitenhage Group	Algoa Group Bredasdorp Group Zululand Group	Kalahari Group Maputaland Group	Uplift of continents; Regression of Flood waters (Psalms 104?) Rifting
SAF-6	(Karoo volcanics) Karoo Sequence	Suurberg Group		Initial Rifting Uplift of Cape Fold Belt global tidal effects? 'quiescent' period? regional uplift: Kaapvaal Craton
SAF-5	Cape Supergroup	Natal Group		
SAF-4	Nama Group Klipphenwal Group (?) Malmesbury Group	Schoemans Poort Fm Kango Group	Gamtoos Formation Kaaimans Group	
SAF-3	Olifantshoek Sequence	Waterberg Group	Soutpansberg Group	NNB collisional event/Kheis Orogeny? (rifting in NE)
SAF-2	Rust de Winter Formation Transvaal Supergroup	Loskop Formation (now includes Griqualand West Sequence)	Glentig Formation	Limpopo Belt collisional event?
SAF-1	Ventersdorp Supergroup Witwatersrand Supergroup (?) Dominion Group	Buffelsfontein Group Pongola Supergroup	Wolkberg Group	Rifting Limpopo Belt collisional event? Rifting
Pre-Flood rocks (pF)	Barberton Sequence Murchison Sequence	Marydale Group other greenstone belt rocks	Kraaipan Group	(sedimentation from Day 3 Regression? [Wise <sup>3</sup> ])

Table 1. South African Megasequences.

the Barberton Sequence), relationships between greenstone belts are more difficult to determine. These greenstone sequences are interpreted here to be highly deformed pre-Flood sedimentary and volcanic rocks originally deposited during the Day 3 Regression described by Wise.<sup>62</sup> As these are not considered Flood deposits, they will not be discussed further.

The MSQ SAF-1 is described as the rocks that overlie an inter-regional unconformity cut into the pre-Flood crystalline basement and underlie an inter-regional unconformity at the base of the MSQ SAF-2 (and younger MSQs). The MSQ is comprised of the Dominion Group, Witwatersrand Supergroup, the Pongola Supergroup, the

Ventersdorp Supergroup, and the Wolkberg and Buffelsfontein Groups. The Pongola Supergroup is considered to be the lateral (distant) correlative of the Witwatersrand Supergroup and the Dominion Group.<sup>63</sup> The inclusion of the Dominion Group is uncertain at this point because of the argument that the lavas within the group may be subaerial — this is still under investigation. It is presently included based on its correlation to the Pongola Group. The predominant lithologies of this megasequence are arenaceous quartzites, conglomerates (many mineralised), and mafic and felsic lavas. The Dominion, Witwatersrand and Pongola all contain basal conglomerates, and iron-rich (magnetic) shales (slates) are common in the Witwatersrand and Pongola

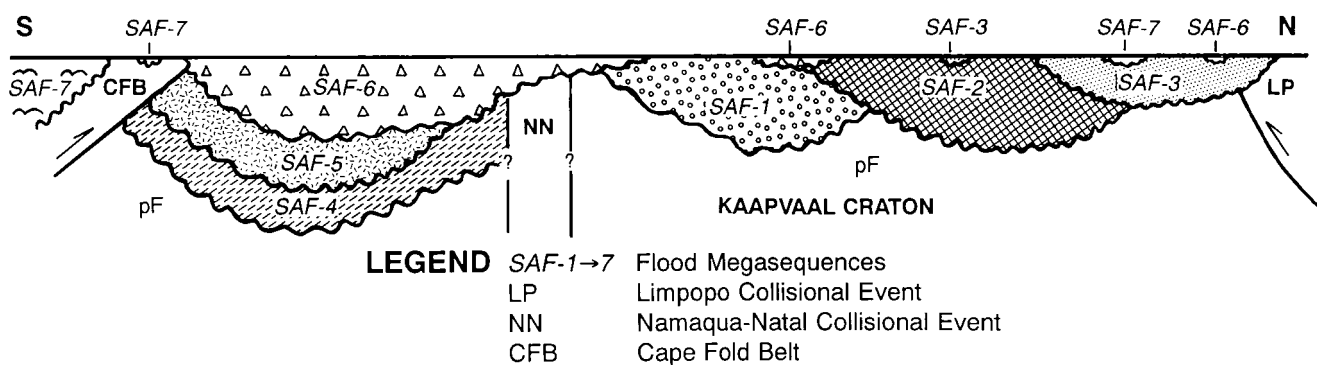
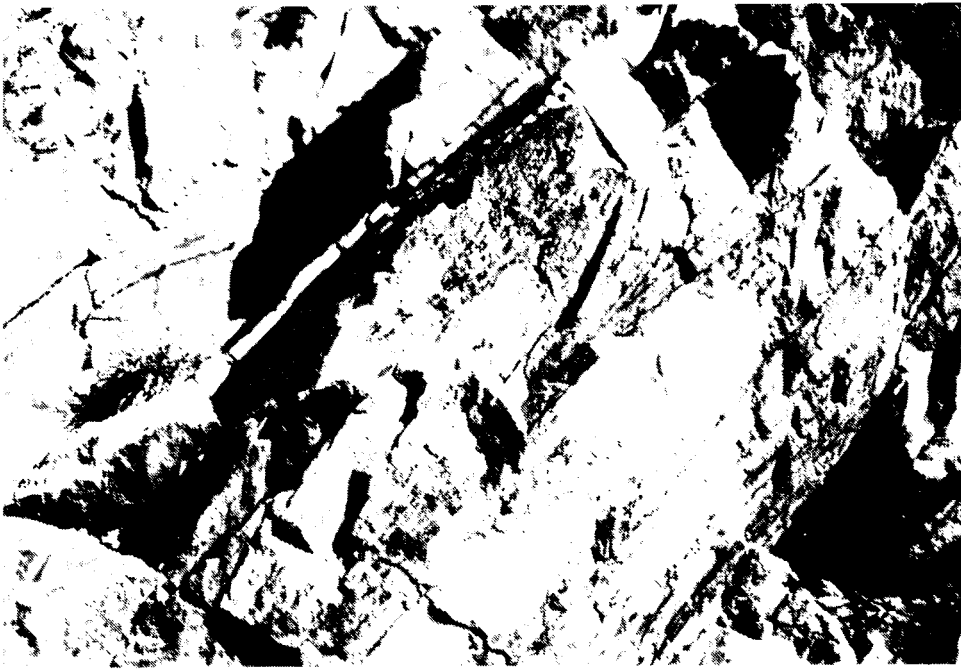


Figure 6. North-south sectional diagrammatic cartoon showing the general distribution of South African megasequences. [Note: SAF-4, -5, and -6 (Suurberg Group) all outcrop in the Cape Fold Belt — see Figure 5].



**Figure 7A.** Sedimentary structures in the Witwatersrand Supergroup (SAF-1) — trough cross-bedding (5–10 cm high) in the south-dipping Brixton Formation quartzites of Johannesburg (Gauteng Province, South Africa).

Supergroups. Carbonates are extremely rare in this megasequence (minor limestones in the middle Ventersdorp, siderite in the magnetic shales). The rocks of SAF-1 have been regionally metamorphosed (variably) up to greenschist facies; apparent grade of metamorphism is more likely due to stratigraphic variations in the original mineral compositions of the rocks rather than the depth of burial and/or the degree of regional geothermal heating.<sup>64</sup> Deposition of the Dominion Group was due to rifting ('the breaking up of the great deep?'), while compressional tectonic activity (the Limpopo Belt?) is thought to have played a role in the deposition of sediments in the Witwatersrand and Pongola Basins. Rifting and the development of half-graben basins was dominant during the deposition of middle Ventersdorp sediments. The upper Ventersdorp, Buffelsfontein and Wolkberg volcano-sedimentary successions appear to be lateral equivalents of each other, as they seem to be deposited in a NE-SW trending trough across the Kaapvaal Craton.

While all of the units within SAP-1 are considered Archaean in radiometric age, they are included in this model as Flood deposits for the reason given earlier: they are extensive and sheet-like in area (except where folded), and most display syn-tectonic deformation (as listed briefly above). Unconformity development in the upper Witwatersrand Supergroup is regionally pervasive, with many unconformities extending over an area greater than 50,000 km<sup>2</sup>. Sedimentary structures such as cross-bedding and ripple marks (see Figure 7) are plentiful in the Witwatersrand Supergroup, and are the same as structures seen in 'Phanerozoic' Flood deposits. More interestingly, van der Westhuizen *et al.*,<sup>65</sup> described raindrop imprints within the Ventersdorp Supergroup (the Sodium Group — now part of the Platberg Group) at five different stratigraphic levels. The

implication of this observation is that if rain first occurred only at the Flood (previous to the Flood mist rose out of the ground to water the earth<sup>66</sup> — Genesis 2:5–6), then these rocks must be considered Flood-deposited (or later — but



**Figure 7B.** Sedimentary structures in the Witwatersrand Supergroup (SAF-1) — ripple marks (casts only) in the south-dipping Orange Grove Formation quartzites of Johannesburg.



**Figure 8.** *Stromatolite colonies in the Chuniespoort Group dolomites of the Transvaal Supergroup (SAF-2), near Sudwala Caves in the Eastern Transvaal Province. 'Bedding' is horizontal in this perspective (author for scale: 1.79 m/5 ft 10 inches).*

that doesn't make sense). Also implied by this observation is that some sort of mechanism allowed for repeated brief subaerial exposure of the deposits during the Flood. Further support for these rocks being Flood deposited is the recognition of organic carbon ('kerogen') in Witwatersrand rocks,<sup>67</sup> implying that organic material was buried and matured within the Witwatersrand Basin. Regional metamorphism would have destroyed any fossil imprints. (See Snelling for further discussion of 'Precambrian' Flood deposits.<sup>68</sup>)

A simple lithologic description of the pre-Flood/Flood boundary is difficult to do here because of the complexity of the deposits. The 'Vendian (Eocambrian) double-tillite' described by Wise does not exist in southern Africa, and therefore cannot be used as a stratigraphic marker. In the central Kaapvaal Craton, the base of the Flood stratigraphic column is represented by the Dominion Group, which has one basal sedimentary formation (with a

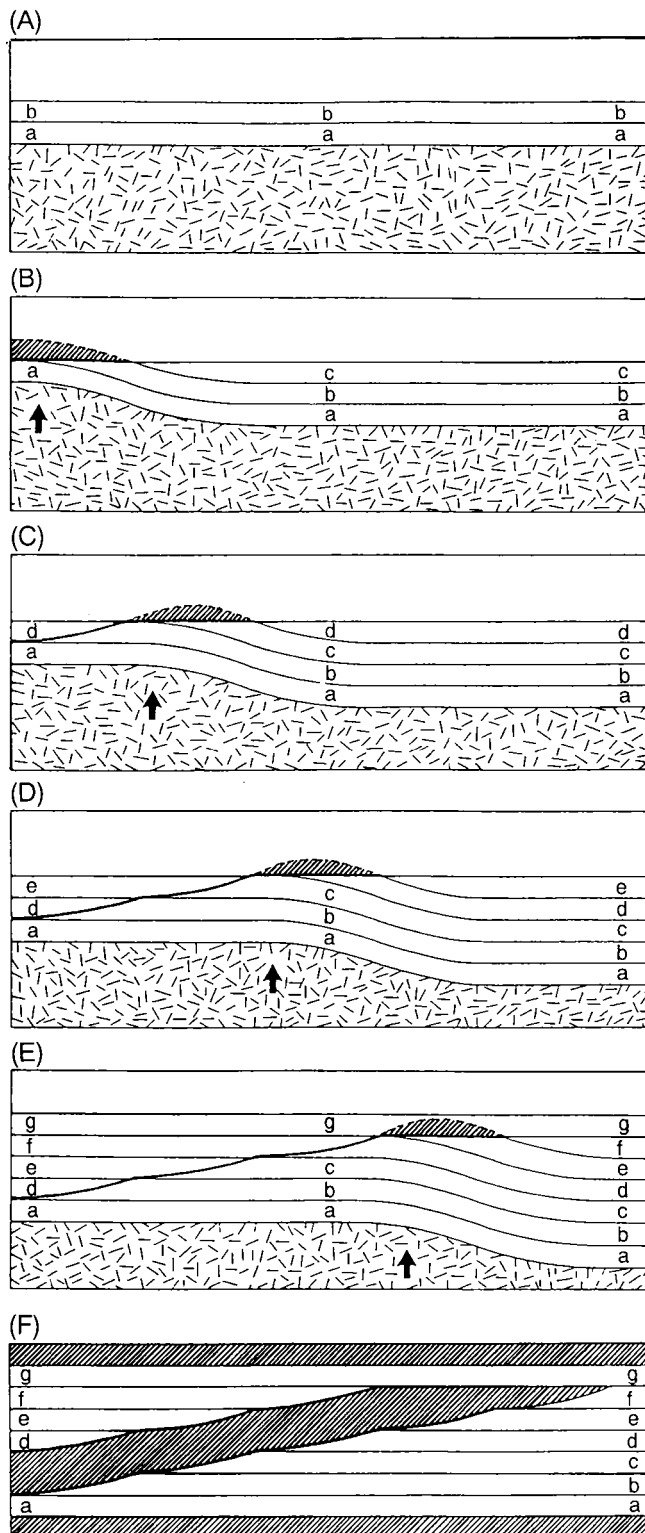
basal boulder-conglomerate) and two upper volcanic formations which progressively onlap onto the basement until the Vredefort Dome, where only the upper volcanic formation is represented.

At Johannesburg, the Dominion Group is not represented and the basal quartzites (with a lag conglomerate at the base) of the Orange Grove Quartzite Formation (see Figure 7B), representing the base of the Witwatersrand Supergroup, rest on a pre-Flood granitic basement. In the eastern Kaapvaal Craton, the base of the Flood stratigraphic column is represented by the Pongola Supergroup. Its basal formations are composed of quartzites in the north, with the development of basal arkosic layers towards the centre; the basal quartzites grade into quartz-sericite

schists and phyllites to the south, as the Pongola Basin approaches the Namaqua-Natal Metamorphic Belt. Neither the Dominion Group nor the Pongola Supergroup are known



**Figure 9.** *Banded iron formation in the Asbesheuwels Subgroup of the Transvaal Supergroup (SAF-2) west of Kuruman, Northern Cape Province. Bedding is dipping slightly west (right).*

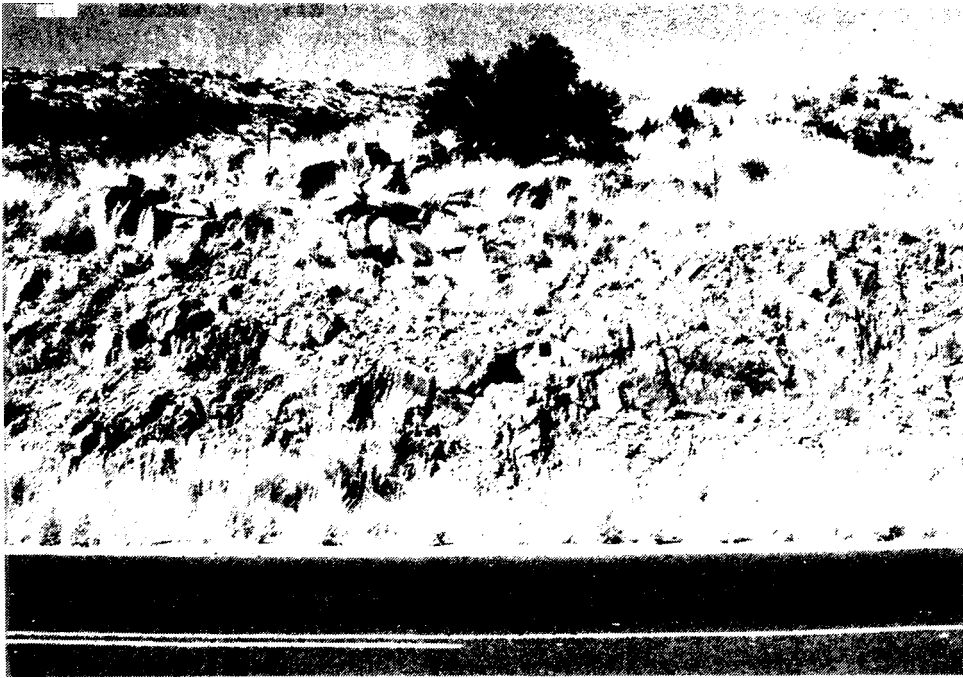


**Figure 10.** Johnson's model of the formation of a diachronous unconformity. The schematic cross-section is parallel to the margin of the basin. (A)–(E): Uplift (crustal flexure) proceeds progressively from left to right, forming a diachronous unconformity. a–g represent chronostratigraphic units. (F): A 'Wheeler diagram' representation of the situation depicted in (E). The diagonal shading denotes periods of erosion and/or non-deposition. Note that units d–f occur on both sides of the unconformity. Also note that at any one vertical location, the rocks above the unconformity are younger than the rocks below the unconformity.

to be represented in the western Kaapvaal Craton, where the oldest rocks mapped are the sedimentary and volcanic rocks of the middle and upper Ventersdorp Supergroup.

MSQ SAF-2 is described as the rocks that overlie an inter-regional unconformity cut into the rocks of MSQ SAF-1 and the pre-Flood basement, and underlie the inter-regional unconformity at the base of the MSQ SAF-3. MSQ SAF-2 is comprised of the Transvaal Supergroup (which now includes the Griqualand West Sequence)<sup>69</sup> and a few ungrouped formations which stratigraphically lie between the Transvaal Supergroup and the Waterberg Group (see Table 1). Lithologically, SAF-2 begins with basal conglomerate formations (the Black Reef in the east and the Vryburg in the west). This is followed by a 'chemical' sequence of carbonate rocks (mainly dolomite) with stromatolite fossils (see Figure 8) and massive banded iron formations (see Figure 9). (See Austin for a discussion on Flood-deposited carbonate rocks.<sup>70</sup>) A regional unconformity lies between this sequence and the overlying sequence of clastic rocks (with minor andesitic volcanics), the Pretoria Group, which is then capped by felsic volcanics and clastic sediments. The 'chemical' sequence is thought to have been deposited during a tectonically quiescent period, while the Pretoria Group is now claimed to be the foreland basin of the Limpopo Orogeny by Cheney and Winter.<sup>71</sup> The felsic volcanism is thought to be in response to extensional tectonics (that is, continued 'breaking up of the great deep'). The overlying sedimentary formations are considered by SACS to be the 'final sedimentary phase of the Transvaal Basin'.

MSQ SAF-3 is described as the rocks that overlie an inter-regional unconformity cut into the rocks of MSQ-2 (and older) and underlie an inter-regional unconformity which separates the rocks of SAF-3 from younger megasequences. The unconformity at the base of SAF-3 is a possible example of a diachronous or time-transgressive unconformity (older in the west and younger in the east). In the west, the basal rocks of SAF-3 rest unconformably on the rocks of the lower part of SAF-2 (see Figure 1), while in the centre a full succession of Transvaal Supergroup (SAF-2) rocks are preserved. The SAF-3 basal unconformity rests on pre-Flood rocks in the northeast, where SAF-2 and SAF-1 rocks are unrepresented. The base of the central Waterberg Basin (SAF-3) may be a correlative conformity, and the basal SAF-3 rocks in the northeast may be younger than those in the centre; the basal rocks in the southwest are thought to be older. This possibility needs to be investigated further. Johnson<sup>72</sup> presented a model (see Figure 10) which illustrates one possible way a diachronous unconformity could develop, envisaging a regional crustal flexure migrating from left to right (west to east?). While the model has possible applications here, one must note that the lithologies above and below the SAF-3 basal unconformity are very



**Figure 11.** 'Red bed' quartzites of the Volop Subgroup of the Olifantshoek Sequence (SAF-3) southwest of Olifantshoek, Northern Cape Province. The structure pictured is a tightly folded anticline, with the bedding steeply-dipping eastward on the left side and steeply-dipping westward to vertical on the right (Kheis Fold Belt).

different before trying to assign any time equivalence across the unconformity.

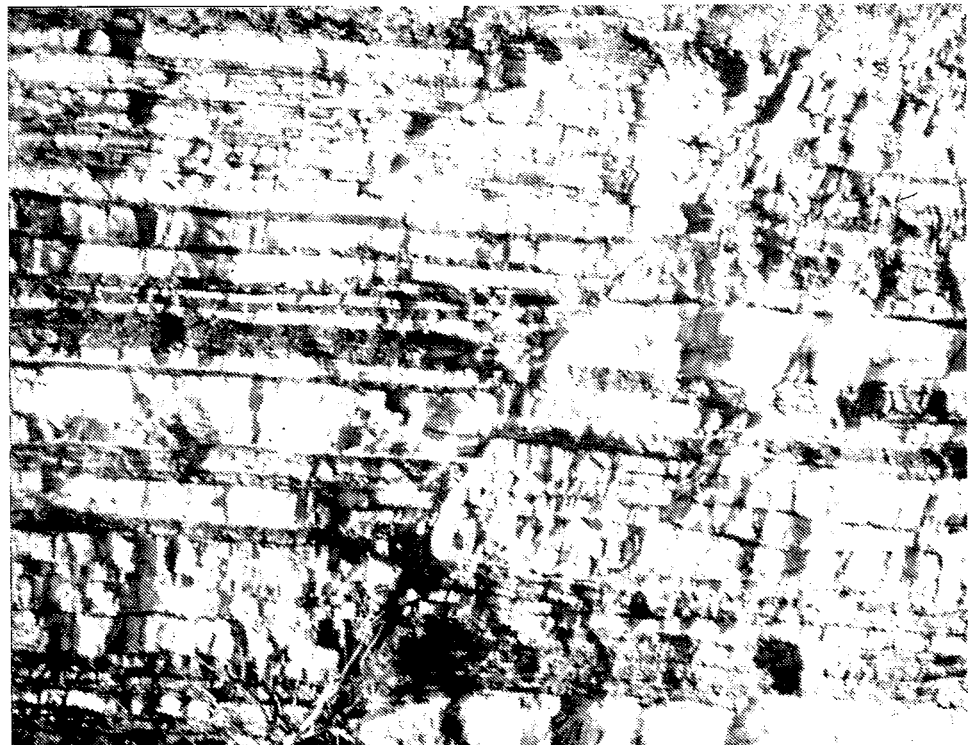
MSQ SAF-3 is comprised of the Olifantshoek Sequence in the southwest, the Waterberg Group in the centre, and the Soutpansberg Group in the northeast (in a graben structure). The introduction of red bed deposits into the geologic column in South Africa occurs in SAF-3, and is the predominant lithology of the MSQ (see Figure 11). Both the Olifantshoek Sequence and the Soutpansberg Group have basal conglomerates or greywackes (diamictites); however, the Waterberg Group has several basal units, with lithologies ranging from felsic volcanics (non-SAF-2) to conglomerates and greywackes to shales. Deposition of SAF-3 sediments is thought to occur due to crustal subsidence, except in the northeast where extensional tectonics dominated.

The tectonic event that created the Namaqua-Natal Metamorphic

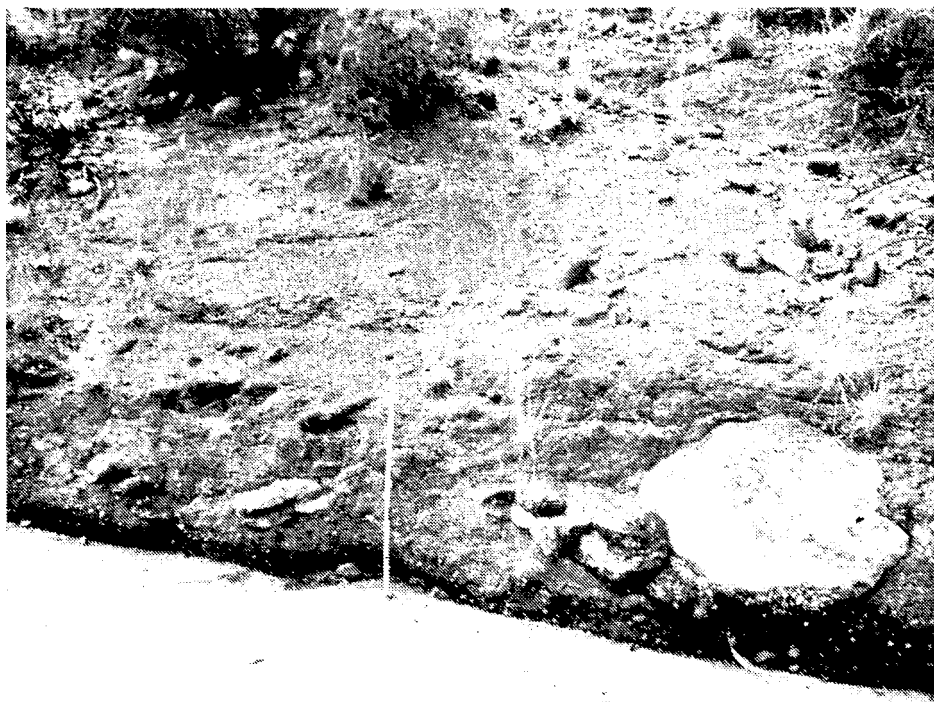
Belt (NNB) may have also uplifted the northern portions of the Kaapvaal Craton, causing a commencement of erosion of SAF-3.

Sedimentation apparently shifted to the south of the NNB at this point in time during the Flood, with minor onlaps of sediments over the NNB to the west.

The MSQ SAF-4 is described as the rocks that overlie an inter-regional unconformity cut into the basement rocks (of uncertain age) south of (or across) the NNB and underlie an inter-regional unconformity at the base of MSQ SAF-5. Aside from the Nama Group, the rocks of SAF-4 (Table 1) all outcrop in the Cape Fold Belt. SAF-4 is a poorly defined MSQ because the bases of many of the units are unobserved, and the relationship between units is uncertain, with two exceptions. The first



**Figure 12.** Interbedded sandstones and shales of the basal portion of the Table Mountain Group at Chapman's Peak, Cape Town (Western Cape Province). The fault throw is about 1 metre. The Table Mountain Group is the basal group of the Cape Supergroup (SAF-5).



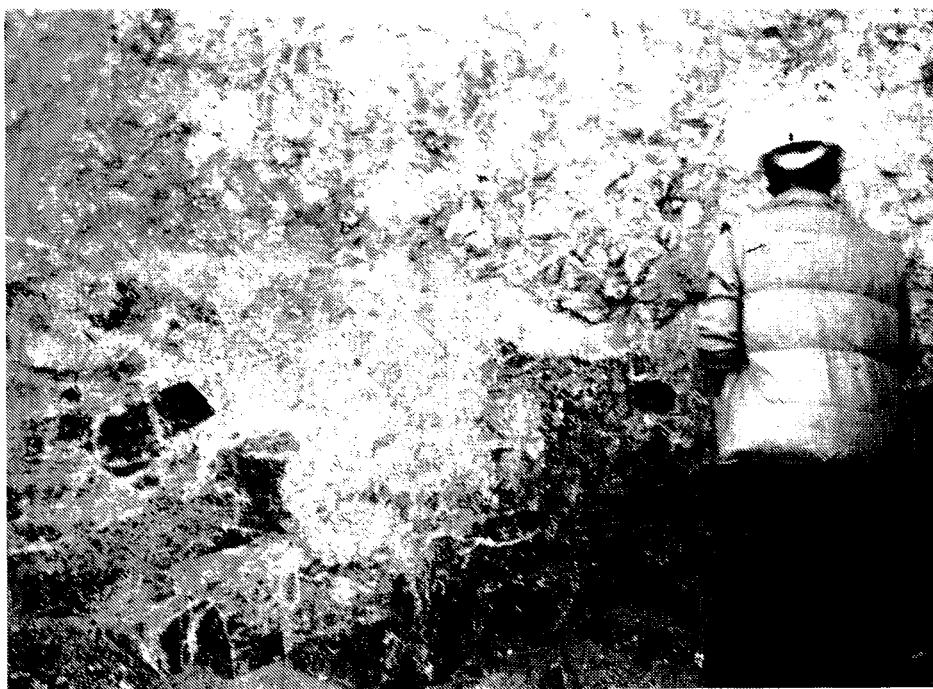
**Figure 13.** Faintly-bedded diamicrite of the Dwyka Group (SAF-6) near Douglas, Northern Cape Province. Note the 1 metre-diameter boulder embedded in the diamicrite, deposited by a debris flow (Oard<sup>73</sup>). The SAF-6 basal unconformity is clearly seen here, with the Dwyka diamicrite overlying a stromatolitic dolomite belonging to the lower SAF-2 megasequence. The striations on the 'SAF-2 pavement' are thought to be caused by boulders dragged by the debris flow.

exception is that the Schoemans Poort Formation lies unconformably on the Kango Group; the second is that the Klipheuwels Group unconformably overlies the Malmesbury Group. The Schoemans Poort Formation was at one time correlated with the Klipheuwels Group on lithological grounds; that correlation is not used at present. Otherwise, SAF-4 is a grouping of pre-SAF-5 rocks south of the NNB, deemed younger than the SAF-3 rocks. The Nama Group, composed primarily of clastic rocks, is better understood because of greater exposure. It unconformably overlays rocks of the Namaqualand Province and the NNB, and contains a basal conglomerate or pebbly sandstone. The Nama Group strata are thought to be the youngest rocks of SAF-4.

MSQ SAF-5 is described as the rocks that overlie an inter-regional unconformity cut into the rocks of SAF-4 and older rocks, and underlie

an inter-regional unconformity at the base of the MSQ SAF-6 (and younger MSQs). SAF-5 is comprised of the Cape Supergroup in the west and south, and the Natal Group in the east. SAF-5 is entirely comprised of clastic rocks, with the predominant rock type quartz arenites (sandstones). Figure 12 shows the interbedded sandstones and shales near the base of the Cape Supergroup. Basal beds of SAF-5 are conglomeratic in the north and east, and coarse and/or immature sandstone in the south. This may be interpreted as a tectonically quiescent period during the Flood. Tidal or eustatic activity may have played a greater role in the formation of this MSQ than tectonic activity.

The MSQ SAF-6 is described as the rocks that overlie an inter-regional unconformity cut into the rocks of SAF-5 and older MSQs and underlie an inter-regional unconformity at the base of MSQ SAF-7. The basal unconformity of



**Figure 14.** Basal sandstones and caliche breccia deposits of the Kalahari Group (SAF-7) unconformably overlying the Hotazel Formation (manganese ore) of the SAF-2 megasequence at Mamatwan Mine, Northern Cape Province. This locality is 27 km southeast of the cross-section of Figure 1, where the SAF-7 basal unconformity overlies the Dwyka Group (SAF-6). Glauconite was identified in the caliche breccia.



SAF-6 cuts across all of the previously described MSQs (SAF-1 to SAF-5) and pre-Flood rocks. Extensions of SAF-6 continue northward into the southern African subcontinent. SAF-6 is comprised of the Karoo Sequence and the Suurberg Group. The major lithology in SAF-6 is mudstones, and are often associated with lenticular sandstones. The Dwyka Group, at the base of SAF-6, is composed primarily of diamictites (see Figure 13). These diamictites are interpreted to represent massive turbidite flows<sup>73</sup> from northern sources (uplift?), and reach thicknesses of 600-750 metres in the southern Cape region. Uplift of the Cape Fold Belt to the south is probably responsible for much of the sedimentation of the middle and upper Karoo, and for erosion of older MSQ rocks. SAF-6 is capped by the flood basalts of the Drakensberg and Lebombo Groups (Karoo) and the Suurberg Group (in the Cape Fold Belt); these seem to have been associated with continental uplift and initial rifting (to form the ocean basins?).

The MSQ SAF-7 is described as the rocks that overlie an inter-regional unconformity cut into the rocks of SAF-6 and older MSQs and underlie an inter-regional (world-wide?) unconformity which is interpreted to have formed by the cessation of sedimentation at the end of the Flood (in offshore areas, this unconformity may have a correlative conformity, as sedimentation would have continued, albeit at a much slower rate). SAF-7 is composed of various geological formations and groups which lie along the coastal regions of South Africa (see Table 1), and the cratonic Kalahari Group, which occupies a relative low region in the mid-continent plateau of southern Africa (1000 m [3300 ft] above mean sea level). Figure 14 shows the unconformable contact of the Kalahari Group on the Hotazel Formation of SAF-2 (*cf.* Figure 1). The base of the Kalahari Group consists of basal sandstones, gravels, and caliche breccia. Glauconite, normally a marine clay mineral, was identified at this site in the caliche breccia, suggesting a subaqueous origin for these rocks. The upper sands of the Kalahari Group are interpreted (at this time) as reworked Flood deposits. The major rock types in SAF-7 are sandstones and shales, with limestones only abundant at certain localities (for example, the southern Cape coast). Both the Zululand and Uitenhage Groups have basal conglomerates. Regression of the Flood waters off of the continent and rift tectonics are thought to have played a major role in the deposition of sediments of this MSQ.

Above the inter-regional/world-wide unconformity which forms the top of MSQ SAF-7 in South Africa are isolated post-Flood (Fp) continental and offshore deposits (see Figure 5). While the Flood/post-Flood boundary is not well defined along the coast of South Africa at this time, post-Flood deposits further inland are easy to identify due to their local nature, and the ability to describe their depositional history using present-day processes. Examples of these deposits are the calcretes formed in the Northern Cape Province (derived from SAF-2 dolomites), various terrace and river gravel deposits, peat and sand deposits associated with warm springs (for example, the Florisbad Formation), and post-Flood river

fill deposits (for example, the Virginia Sand Formation, in which a fossilised specimen of *Mammuthus subplanifrons* was found). Cave deposits are also included as post-Flood; many deposits, such as the Sterkfontein Formation, contain australopithecine and hominid faunal fossils. The 'age' of the Flood/post-Flood boundary is different from location to location, ranging from Pliocene to Holocene on the evolutionary scale. Along the coast of South Africa, the Flood/post-Flood boundary is not well defined at this time, partially due to the lack of research and partially due to SACS' present re-shuffling of stratigraphic assignments and the introduction of new formation names along the coast. Hopefully, this situation will be rectified in the next couple of years.

Post-Flood deposits generally cannot be grouped into a megasequence due to their local and non-genetic relationship with respect to each other. Offshore deposits may possibly be grouped into sequences — if they are unconformity bound. In cases where deposition is still occurring (for example, fluvial deposits), sequences cannot formally be defined as there is no upper bounding unconformity.

## MEGASEQUENCE CORRELATION

The next step is to analyze major MSQs of the Phanerozoic and Precambrian of several sub-continental locations around the world and attempt to correlate these MSQs with each other. Eight additional sites have been chosen (based on the local availability of published data):—

- North American Craton (Mid-continent, Gulf Coast and Atlantic Coast)
- Europe: Russian Platform
- Western Europe
- Scotland
- Arabia/Persian Gulf
- West Africa
- South Australia
- South China Sea

The relevant literature available for each region was reviewed and bounding unconformities selected for the megasequences as could best be determined from the literature. A re-occurring problem in this exercise was the dependence on others' evolutionary-based interpretations — certainly not the ideal for trying to do a Flood-based interpretation, but often it couldn't be helped. Thus what is presented is an interpreted framework of megasequences. The major purpose for which they were developed was to create an example of megasequence correlation which involved real geology, rather than using a purposely perfect, fictional example with bogus data. **It must be stressed that what follows is an initial working model with room for improvement (especially by local geologists).** Summaries of the selected regions follow.

### North American Craton (NA)

Table 2 lists the Flood MSQs proposed for North

America. Sloss's<sup>74</sup> sequences are used; Precambrian depositional sequences are also included,<sup>75-79</sup> for reasons given in the introduction. Wise previously defined the pre-Flood/Flood boundary as the base of the 'Vendian (Eocambrian) double-tillite'<sup>80</sup> in North America, mainly based on the preserved (macro-) fossil record. Unfortunately, this definition is not correlatable world-wide (for example, Southern Africa). Wise has not dealt satisfactorily with the massive volume of Precambrian sequences deposited in areas outside the USA (for example, greater than 900,000 km<sup>3</sup> in South Africa alone), not to mention the complex syn-tectonic activity which accompanied deposition — and all this would have had to happen in less than 24 hours. It is also my conjecture that the pre-Flood/Flood boundary will occur at different stratigraphic (evolutionary) 'ages' from location to location (similar to the Flood/post-Flood boundary.<sup>81</sup>)

I have included the 'Precambrian' Grand Canyon Supergroup as a Flood deposit based on Snelling's argument,<sup>82</sup> the fossil record within the supergroup (albeit disputed), and my own bias (as discussed earlier). This is not to say that Austin's argument<sup>83</sup> is invalid, or that NA-1 and NA-2 are definitely Flood deposits; this is simply an interpretation, whose purpose is to show that Precambrian depositional sequences can be fitted into a Flood stratigraphic framework.

MSQ NA-2 has been informally named the 'Skookumchuk' based on a suggestion by Bally *et al.*<sup>84</sup> (following Sloss' practice of naming sequences after Native American tribes), derived from their observation that the

MSQ	STRATIGRAPHY
RP-9	Quaternary Tertiary (Eocene?)
RP-8	Tertiary (Palaeocene) Cretaceous (Coniacian)
RP-7	Cretaceous (Turonian) Cretaceous (Hauterivian)
RP-6	Cretaceous (Valanginian) Upper Jurassic
RP-5	Lower Jurassic Triassic
RP-4	Permian Devonian
RP-3	Silurian
RP-2	Ordovician 'Eocambrian'
RP-1	Serdobskian
pF	'basement' rocks

Table 3. Generalised MSQ correlation for the Russian Platform.

MSQ	STRATIGRAPHY
NA-8	Tejas Sequence
NA-7	Zuni Sequence
NA-6	Absoroka Sequence
NA-5	Kaskaskia Sequence
NA-4	Tippecanoe Sequence
NA-3	Sauk Sequence
NA-2	'Skookumchuk' Sequence: Purcell 'Series' (e) Grand Canyon Supergroup (a) Catactin, Swift Run, and Lynchburg Formations (b) Keweenawan Supergroup (c)
NA-1	Mazatzal, Hess Canyon, Adler, and Hondo Groups (a) Grenville Group (b)      Gouldburn Supergroup (d)
pF	Vishnu Schists (a)      Peddler and Lovington Formations (b) Marquette Flange Supergroup (c)

(a) — Colorado Province      (d) — Slave Province  
(b) — Grenville Province      (e) — 'Beltian'  
(c) — Superior Province

Table 2. North American Megasequences.

Purcell Series (Canadian Rockies) is unconformity-bounded. They also interpreted the upper-bounding Windermere Unconformity to be due to effects from the Grenville Orogeny — which occurred on the other side of North America. Thus eight MSQs are here suggested to exist on the North American craton.

### Europe

This region was difficult to work in as most of the stratigraphic geology and correlation is based on chronostratigraphy rather than lithostratigraphy.<sup>85</sup> Generalised MSQ correlations were constructed for three localities in Europe, using the evolutionary time scheme to indicate the location of inter-regional unconformities.

### Russian Platform (RP)

Table 3 shows the generalised MSQ correlation for this region; nine MSQs were interpreted. Data sources used were Nalivkin,<sup>86</sup> and Sahagian and Jones.<sup>87</sup>

### Western Europe (WE)

Table 4 shows the generalised MSQ correlation for the Paris Basin, English Channel, Central British Block, and the North Sea. Note the variable positions of correlated unconformities in evolutionary time.



MSQs	STRATIGRAPHY		
	Paris Basin	English Channel	Central British Block/ North Sea
WE-8	Quaternary Tertiary (Palaeocene)	Quaternary Tertiary (Eocene)	Quaternary Tertiary (Palaeocene)
WE-7	Cretaceous (Maastr.) Cretaceous (Conian.)	Tertiary (Palaeocene) Cretaceous (Albian)	Cretaceous (Maastr.) Cretaceous (Cenom.)
WE-6	Cretaceous (Turonian) Cretaceous	Cretaceous (Aptian)	Cretaceous (Albian) Cretaceous
WE-5	Jurassic Permian	Cretaceous (Neocom.) Permian	Jurassic Permian
WE-4	(no data available)	Carboniferous Devonian	Carboniferous Devonian
WE-3		(no data available)	Silurian Ordovician (Ashgill)
WE-2			Ordovician (Caradoc) 'Eocambrian'
WE-1			Monian Supergroup
pF			'basement' rocks

**Table 4.** Generalised MSQ correlation for Western Europe.

Eight MSQs were interpreted. Data are from Duff and Smith,<sup>88</sup> and Aigner *et al.*<sup>89</sup>

### Scotland (SCT)

Table 5 shows the generalised MSQ correlation for this region; eight MSQs were interpreted. Scotland's stratigraphy may be more correlatable to North America than to Europe. Data are from Craig.<sup>90</sup>

### Arabia/Persian Gulf (APG)

Table 6 shows the proposed MSQs for this region; there may be more than six MSQs in this region as no information was readily found regarding the stratigraphy of the Arabian Shield (thus the oldest suggested MSQ being labelled APG-2). Data are from Aigner *et al.*,<sup>91</sup> and Alsharhan and Kendall.<sup>92</sup>

### West Africa (WAF)

West African Flood MSQs are shown in Table 7. Data are from Wright.<sup>93</sup> Seven MSQs are interpreted for West Africa.

### South Australia (SAS)

Eight MSQs were interpreted for South Australia (see Table 8). SAS-4 and SAS-5 are based on scant data, but the unconformities appear to be real. Data are from Parkin<sup>94</sup> and Veevers.<sup>95</sup> The MSQs correlate well with Veevers'

'Regimes'.

### South China Sea (SCS)

Table 9 shows the generalised MSQ correlation for this region; there are probably more than five MSQs in this region as no information was available regarding the pre-Permian stratigraphy (again, the oldest suggested MSQ is labelled SCS-2). Of interest with this MSQ column is that the post-Flood unconformity is well developed on the Chinese mainland and the change from unconformity (onshore: ~~~) to correlative conformity (offshore: ---, see Table 9) is well-documented. The regional geology and the pre-SCS-5 regional events are described in Holloway.<sup>96</sup> MSQ SCS-5 and SCS-4 (and their bounding unconformities) can be correlated to Indonesia.<sup>97</sup>

Table 10 shows an example correlation of the nine regionally-described MSQs outlined here. While the correlations are simplistic, it suggests that world-wide correlations based on unconformities may be possible, with the unconformities

MSQ	STRATIGRAPHY	
SCT-8	'Quaternary' Cretaceous	
SCT-7	Jurassic	
SCT-6	Triassic Permian (upper)	Stornway Beds New Red Sandstones
SCT-5	Permian (lower) Devonian	Old Red Sandstones
SCT-4	Silurian Ordovician (Ashgill)	
SCT-3	Ordovician (Caradoc) 'Eocambrian'	Dalradian Supergroup
SCT-2	Torrison Group Sleat Group Stoer Group	Moine rocks (?)
SCT-1	(?) Loch Marie Series	Moine rocks (?)
pF	'basement' rocks	('Lewisian')

**Table 5.** Generalised MSQ correlation of Scotland.

MSQ	STRATIGRAPHY	
APG-7	'Quaternary' Tertiary	(no data available for this megasequence)
APG-6	Aruma Group	
APG-5	Wasia Group Kahmah Group Sahtan Group	
APG-4	Akdar Group Haushi Group	
APG-3	Haima Group	Mila Group
APG-2	Huqt Group	Hormuz Group/Formation?
?	'Basement Complex'	(no details available)

Table 6. Arabian/Persian Gulf Megasequences.

representing geologic/hydrologic events which occurred during the Genesis Flood. Similarities in lithologies between locations aid in correlating MSQs.<sup>98,99</sup> This was the way SAS-1 was correlated to SAF-1 (and WAF-1). MSQs RP-2, WAF-2, SAF-2, and SAS-2 are correlated based on their basal carbonate successions, and MSQs NA-2, SCT-2, and SAF-3 are correlated based on their inclusion of 'red bed' type lithologies. However, different MSQs can have different rock types, depending on more local sediment sources, and still be correlated based on other criteria, including their general position in the stratigraphic column. The example correlation given is a cursory one, and not assumed to be absolutely correct. The labelled unconformities in Figure 10 are inferred to be world-wide, and due to global-scale,

MSQ	STRATIGRAPHY	
WAF-7	Niger Delta Chad Formation	Imo Shale Gwandu Formation
WAF-6	Sokoto Group Asu River Group	Rima Group Continental Hamadian
WAF-5	Tegma Sandstone Group IrhazerClays	
WAF-4	Obosum Group	
WAF-3	Pendjari Group	
WAF-2	Dapango-Bombouaka Group Katangan	
WAF-1	Birmian-Tarkwaian rocks	
pF	greenstone belts	

Table 7. West African Megasequences.

MSQ	STRATIGRAPHY	
SAS-8	Loxton Formation Bookpurnang Formation	Parilla Formation
SAS-7	Port Willunga Beds Buccleuch Group Knight Group	Gambier Limestone
SAS-6	Neales River Group Blythesdale Group Birkhead Formation Hutton Formation	Sherbrook Group Otway Group
SAS-5	Nappamerrie Formation (scant data) Gidgealpa Formation Merrimelia Formation	
SAS-4	Devonian Ordovician	(scant data)
SAS-3	Lake Frome Group Hawker Group	Kangaroo Island Group Kanmantoo Group
SAS-2	Wilpena Group Burra Group (Adelaidian Sequence)	Umberatana Group Callanna Beds
SAS-1	Gawler Range Volcanics Corunna Conglomerate Formation Moonabie Formation	
pF	Clive Metamorphics Willyama Complex	

Table 8. Megasequences of South Australia.

globally-controlled tectonic activity. The MSQ correlation shown in Table 10 presents an initial framework for deducing the geologic history of the Flood based on lithostratigraphy without having to depend on the current geological (evolution-based) time system. This is important, as MSQ correlations cross evolutionary 'time lines'; for example, MSQ NA-8 (see Table 2) includes Tate Palaeocene to Pleistocene' sediments on the Texas Gulf coast, but would include 'early Cretaceous to Pleistocene' sediments on the Virginia coastal plain. Another example would be that of the correlation of 'Proterozoic' NA-1 with 'Archaean' SAF-1.

Please note that at no single locality in the world do all the described megasequences for a region lie atop one another; the time relationships are horizontal as well as vertical in space. Figures 5 and 6 demonstrate this for the South African MSQs.<sup>100,101</sup> Even in the Grand Canyon, as deep as it is, there are only four MSQs represented:<sup>102</sup> NA-6, NA-5, NA-3 and NA-2 (resting on pre-Flood rocks).

### PRESENT LIMITATIONS

There are presently two basic limitations to this method.

MSQ	STRATIGRAPHY	REGIONALEVENTS
post-Flood	Pleistocene and younger	end Flood
SCS-6	Pliocene Oligocene (upper)	Regression of Flood waters Rift break-up
SCS-5	Oligocene (lower) Palaeocene	Rift onset
SCS-4	Cretaceous	'Yenshanian'
SCS-3	Jurassic	'Indosinian'
SCS-2	Permo-Triassic	???
?	(no further information)	

Table 9. Generalised Megasequences for the South China Sea.

Firstly, it is mainly restricted to cratonic regions and passive margins. Due to locally and regionally variable sedimentation, it is not applicable to collision zones or active margins (for example, the Namaqua-Natal Metamorphic Belt of South Africa). Klein also argues that UBSs (MSQs) cannot be correlated into foreland basins because 'a fundamental tectonic control influences the sequence arrangement'.<sup>103</sup> Klein reports that his attempt to correlate Sloss's cratonic sequences into the Appalachian foreland basin failed. I suggest that Klein's attempted correlation may have been based on assigned (evolutionary) geologic time, rather than on comparing lithostratigraphic packages. On the other hand, most of the Karoo Sequence is a foreland basin to the Cape Fold Belt, and yet it seems to correlate well even with Sloss's scheme.<sup>104</sup> More work needs to be

done to investigate this issue.

Secondly, much of the MSQ definitions presented here (except for parts of North America and South Africa) are dependent on (evolutionary-time based) interpretations of other geologists. For example, in the Grand Canyon, Kaskaskia (NA-5) Redwall Limestone lies unconformably on Sauk (NA-3) Muav Limestone.<sup>105</sup> However, a recent investigation into this unconformity questions whether it is real. Snelling reports that

*'the actual observational evidence in the field supports the contention that continuous deposition occurred as the Redwall Limestone was deposited on top of the Muav Limestone, there being some interfingering and fluctuations during the postulated "changeover" period. There is no buried erosion surface evident, so the facts strongly suggest that the Redwall Limestone was deposited immediately after, and about the same time as, the Muav Limestone.'*<sup>106</sup> (Emphasis his.)

Geologists familiar with individual regions need to construct and verify megasequence stratigraphic columns for those regions.

### CONCLUSION

In conclusion, it is suggested that megasequences (and their bounding unconformities) can indicate globally-controlled tectonic (including volcanic), tidal, eustatic and hydraulic activity, which would have controlled sedimentation during the Flood. Unconformities are understood to be erosive boundaries created by the combination of tectonic movements, tidal effects, eustasy and hydraulic action. As explained earlier, unconformities do have time significance, as they mark the occurrence of an event in real time which interrupted the otherwise continuous deposition of sediments

during the Flood. The determination of MSQs in a region gives the stratigraphic framework of the depositional history of the Genesis Flood for that region. From the correlation of MSQs, it may be possible to construct a Flood stratigraphic framework in which to interpret the depositional history of the Genesis Flood for the entire earth. As Table 10 shows, the example correlation done suggests that five of the inter-regional unconformities defined in each region are possibly world-wide in

REGIONS:	NA	SCT	WE	RP	APG	WAF	SAF	SAS	SCS
	NA-8	SCT-8	WE-8	RP-9	APG-7	WAF-7	SAF-7	SAS-8	SCS-6
	NA-7	SCT-7	WE-7	RP-8	APG-6	WAF-6	SAF-6	SAS-7	SCS-5
	NA-6			RP-7	APG-5			SAS-6	SCS-4
								SAS-5	
MSQs:	NA-5	SCT-6	WE-6	RP-6	APG-4	WAF-5	SAF-5	SAS-4	SCS-3
		SCT-5	WE-5	RP-5					
	NA-4	SCT-4	WE-4	RP-4	APG-3	WAF-4	SAF-4	SAS-3	SCS-2
	NA-3	SCT-3	WE-3	RP-3	APG-2	WAF-3			
	NA-2	SCT-2					SAF-3		
			WE-2	RP-2		WAF-2	SAF-2	SAS-2	
	NA-1	SCT-1	WE-1	RP-1		WAF-1	SAF-1	SAS-1	
									pre-Flood rocks

Table 10. Example Correlation of MSQs.

extent, indicating the possibility that five major tectonic/eustatic (or other) events were globally-controlled. It is suggested that this concept be adopted for interpreting Flood geology for several reasons, including the fact that MSQs are defined by physical boundaries (unconformities), and are thus lithostratigraphic (as opposed to time stratigraphic [evolutionary]). Each sequence refers to a cluster of strata of varying but continuous (relative) age, that is, continuous deposition (within the sequence/depocentre). It is suggested that MSQs represent more coherent subdivisions of geologic time within a single tectonic domain during the Flood, and should be utilised to replace the presently used uniformitarian geologic time system for analysis of the depositional history of the Genesis Flood.

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