

CRSQ

CREATION RESEARCH SOCIETY QUARTERLY



CRS
salutes the
CSF and the
International
Conference on
Creationism!

Volume 35

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Celebrating Our 35th Year of Publication

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Front Cover

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Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh.—Exodus 20:11

Editor's Comments

Our June issue of the *Creation Research Society Quarterly* marks the 35th year of publication. Creation models continue to improve, as illustrated by the very fine papers presented in this issue.

Also, we are dedicating the June *Quarterly* to the International Conference on Creationism, slated to take place again this summer in Pennsylvania as this issue goes to press. Wayne Frair presents a dedication summarizing some of the history of this important event.

D. Ashley Robinson and David P. Cavanaugh continue to explore their techniques for identifying Genesis kinds, this time examining and classifying cats, whether they be cheetahs, bobcats, lions, or what. With the publication of these papers, perhaps this will induce other creationists to work on these identification problems from a Biblical perspective.

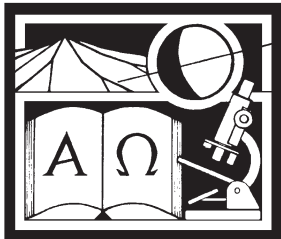
In Van Andel Creation Research Center Report Number 2, Froede, Howe, Reed, and Meyer continue their interesting series of Creation Research Society sponsored research

dealing with the geology around and near the society's research center. The banded iron formations present some puzzles which they attempt to solve. A report that is currently in progress will study igneous formations in the vicinity.

Jerry Bergman considers the importance of mosses in the overall balance of the ecosystem. Creation Research Society President Emmett Williams, along with Goette, Stark and Matzko, presents a study of fossilized wood from Big Bend National Park, Texas.

Two notes from the panorama of science, one by Chris Chui and another by Froede, Williams, and Brelsford explore related questions regarding the erosion of rock, and their relation to age of the earth issues. Book reviews and letters to the editor are an important part of the *Quarterly*, and we encourage readers to continue to send these for consideration.

Eugene Chaffin, Editor, *CRSQ*



CRS Salutes the CSF and the International Conference on Creationism



In 1979 the Creation Science Fellowship (CSF)* in Pittsburgh, Pennsylvania, held its first meeting which had been fostered by David Nelson. From the beginning the goal of the leadership of the CSF has been to present state-of-the-art creation science. Many researchers and academics soon were attracted to this origins group, and attendance at monthly meetings was 70–100 people. They commenced publishing a monthly newsletter which still is being issued.

The group realized that creationism needed a rigorous peer-reviewed conference with the sole purpose of furthering creation models based firmly on the latest scientific information. So from 1982–1984 the CSF Board and others discussed organizing such an international gathering. In July of 1984 they issued their call for papers to be presented at the First International Conference on Creationism (ICC) in August 1986. Three subsequent conferences have followed

at four-year intervals. These assemblies have engaged leading creationary scientists from the United States and an increasing number from many foreign countries.

A goal of the CSF has been to establish *positive* creation models, and their Third ICC was dedicated to this proposition. At the 1994 conference hundreds of the participants wrestled with accomplishing this task. Now at this Fourth Conference (Geneva College, Beaver Falls, PA, August 3–8, 1998) this same goal is the target on which the attendees are sighting.

In a somewhat broader sense it has been the aim of the Creation Research Society (CRS), which was founded in 1963, to organize creationary scientists and to address the scientific community. Now the CRS is pleased to salute the CSF for its motives and accomplishments; and further, the CRS commends all participants (speakers, attendees, and many other workers) in this Fourth Conference. Together we accept the challenge of combining ultimate causation with current science in composing coherent Biblical/scientific concepts of creation. As we work together we trust that all glory will go to our Creator God, Jesus Christ.

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Evidence for a Holobaraminic Origin of the Cats

D. Ashley Robinson and David P. Cavanaugh*

Abstract

The baraminology of living cats has been investigated using recently described quantitative methods. A variety of characters including ecological, morphological, chromosomal, and molecular data were used to characterize 17 cat species, the spotted hyaena, and the meerkat. Application of phenetic and cladistic clustering algorithms defined three subgroups of cats, which are: the genera *Panthera* plus *Neofelis*, *Acionyx* plus *Puma*, and *Felis* plus allied genera. Quantitative analyses suggested that the three cat subgroups

each form a monobaramin. Hybridization records suggesting a potential for gene flow between two of the monobaramins, plus extensive phenetic overlap between all three of the monobaramins suggested all felids could be lumped into a single monobaramin. Statistically significant gaps between the cat and outgroup taxa suggested these species were apobaraminic. Monobaraminic continuity within the cats and apobaraminic discontinuity between the cat and outgroup taxa leads to the hypothesis of a single Felid holobaramin.

Introduction

Subfamilial relationships within the cat family Felidae have not been firmly established. O'Brien et al. (1987) note that cats have been classified into as few as two genera and as many as 20. Such a biosystematic conundrum may be due, in part, to the search for natural groups within a macro-evolutionary framework. Baraminology is a creationist biosystematics that seeks to establish the identity of specially created groups of organisms called baramins. As the basic unit of biological creation, the baramin is hypothesized to represent the true natural group which biosystematists seek. The goal of this paper is to provide new insights into the systematics of living cats using recently described quantitative methods in baraminology (Robinson and Cavanaugh, 1998). Several ongoing questions are addressed including the reliability of different criteria for identifying holobaramins, and the interpretation of homoplasy within a creationist context.

Materials and Methods

Data Acquisition and Analysis

We selected 287 polymorphic characters (Appendix I) representing 17 cat species, the spotted hyaena, and the meerkat (Table I). The hyaena and meerkat were selected as outgroups because they are members of the same superfamily, the Aeluroidea, to which cats belong. We classified the data into four general criteria including ecological, morpho-

logical, chromosomal, and molecular characters. The complete data matrix is available upon request. Baraminic distance, the proportion of mismatched characters between two species, was used as a measure of resemblance. A panel of diagnostic statistics were used to describe the relevance (A), diversity (C and d_{avg}), and signal (SI) within the data set (Robinson and Cavanaugh, 1998).

Table I. List of species included in this study.

Taxon	Common Name	Code
Superfamily Aeluroidea		
Family Felidae		
<i>Panthera leo</i>	lion	Ple
<i>Panthera tigris</i>	tiger	Pti
<i>Panthera pardus</i>	leopard	Ppa
<i>Panthera onca</i>	jaguar	Pon
<i>Panthera uncia</i>	snow leopard	Pun
<i>Neofelis nebulosa</i>	clouded leopard	Nne
<i>Pardofelis marmorata</i>	marbled cat	Pma
<i>Lynx rufus</i>	bobcat	Lru
<i>Lynx canadensis</i>	Canadien lynx	Lca
<i>Caracal caracal</i>	caracal	Cca
<i>Leptailurus serval</i>	serval	Lse
<i>Prionailurus bengalensis</i>	leopard cat	Pbe
<i>Profelis aurata</i>	African golden cat	Pau
<i>Profelis temmincki</i>	Asian golden cat	Pte
<i>Acionyx jubatus</i>	cheetah	Aju
<i>Puma concolor</i>	cougar	Pco
<i>Leopardus pardalis</i>	ocelot	Lpa
Family Hyaenidae		
<i>Crocota crocuta</i>	spotted hyaena	Ccr
Family Viverridae		
<i>Suricata suricatta</i>	meerkat	Ssu

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Baraminic distances and most of the diagnostic statistics were calculated with a Macintosh computer program developed by the first author. The MANTEL 3.0 program of the R package (Legendre and Vaudor, 1991) was used to calculate the criterial correlations, and to estimate their significance using Mantel's test. The Bonferroni correction was used to establish a significance level ($P = 0.0002$ in this study) for evaluating the criterial correlations. The CLUSTAL W program (Thompson, Higgins, and Gibson, 1994) was used to align the DNA sequences, and to calculate uncorrected transitional and transversional sequence differences as described previously (Robinson, 1997). The DATA DESK 3.0 statistical package (Odesta Corporation, Northbrook, Illinois) was used for the organismal correlation analyses. A neighbor-joining (Saitou and Nei, 1987) dendrogram based on baraminic distances was generated using the NEIGHBOR program of the PHYLIP 3.54 computer package (Felsenstein, 1989). Cladograms were generated using the PAUP 3.1.1 computer program (Swofford, 1993) treating all characters as unordered and unweighted. A 50% majority rule consensus tree was constructed using the heuristic search option, random addition of taxa, MAXTREES set to 100, and TBR branch swapping parameters. Both the phenetic and cladistic dendrograms were evaluated statistically with 200 bootstrap iterations.

Scriptural Considerations

While the acts of biological creation recorded in the Scriptures form the philosophical basis of baraminology (that creation of different taxa precludes their evolutionary continuity), the Scriptures may seldom affect the routine work of identifying and classifying baramins. A recent study concluded that although the Hebrew word *min* may be a word of biological origin, and may have a basic meaning of division, its relationship to the creationist term baramin is unclear (Williams, 1997). The word *min* is not used with specific reference to cats. There are, however, other passages of Scripture that may be relevant to cat baraminology.

The Hebrew word *namer*, meaning spotted, has been translated as leopard and cheetah because both species have spotted coats. Based on behavioral clues such as the propensity to ambush rather than chase prey (Jeremiah 5:6, Hosea 13:7) we suggest *namer* refers to the leopard, *Panthera pardus*. Isaiah 11:6-9 describes a herbivorous Garden of Eden environment with lions and leopards (Hebrew *namer*) present. The coexistence of multiple cat species in the original Garden would support a hypothesis of polybaraminic cat origins; specifically a separate origin for congeneric cat species. We suggest this passage reflects Garden of Eden conditions not organisms since the only humans in the Garden were Adam and Eve, and other humans are mentioned in the Isaiah 11 record. Furthermore, the context is a prophetic statement of the conditions of the earth as restored by the Messiah, the Branch from Jesse. Jeremiah 13:23 also provides an interesting comment relevant to cat baraminology, "Can the Ethiopian change his skin or the leopard its spots? Neither can you do good who are accustomed to doing evil."

This rhetorical question suggests the individual leopard cannot change genetically inherited traits. However, variation in human characters can occur through generations as indicated by Acts 17:26. We suggest the Jeremiah 13 passage likewise allows for variation in cats to be expressed through generations.

Results

Evaluation of Criteria

The combined data set was applicable to an average of 97.3% of the species (Table II). The more relevant criteria tended to contain more characters. For example, there were no missing data among the 199 molecular characters whereas the ten chromosomal characters were only applicable to an average of 83.7% of the species. The organisms differed on average among 27.5% of their characters with a 22.2% probability of a mismatch at the average character. An inverse relationship was found between the number characters and diversity of a given criterion. For example, the probability of a mismatch between two species ranged from 54.7% with the ecological characters to 19.3% with the molecular characters. The combined data set plus the morphological, chromosomal, and molecular criteria considered separately contained a statistically significant level of baraminic signal. These data suggested a heterogeneous assemblage of organisms was sampled. In contrast to the results reported for Catarrhine primates (Robinson and Cavanaugh, 1998) there was no association between many of the

Table II. Summary of data used to characterize the felids and aeluroid outgroups.

Criteria	No. of Characters	Diagnostic Statistics			
		A	C	d_{avg}	SI
Combined	287	0.973	0.222	0.275	314.403***
Ecological	8	0.842	0.547	0.553	62.800
Morphological	70	0.932	0.255	0.324	258.571***
Chromosomal	10	0.837	0.307	0.411	122.583*
Molecular	199	1.000	0.193	0.249	190.524**

* $P < 0.05$

** $P < 0.005$

*** $P < 0.0005$

criteria (Table III). Only the baraminic distances calculated from morphological and molecular data were significantly correlated.

A variety of techniques exist for assessing biosystematic relationships at the level of genes and proteins. The use of mitochondrial DNA (mtDNA) has received increased attention because several of its properties are uniquely suited for studies of phylogeny (Avise, et al., 1987). For example, in many organisms the mitochondrion is maternally inherited and not subject to the scrambling effects of recombination. Genetic differences in mitochondrial genes are therefore largely the result of mutation. Closer inspection has re-

Table III. Product-moment correlation matrix of baraminic distances calculated for each pair of criteria.

	Eco	Mor	Chr	Mol
Ecological	–			
Morphological	0.527	–		
Chromosomal	0.419	0.602	–	
Molecular	0.468	0.786*	0.627	–

* $P < 0.0002$

vealed a certain type of nucleotide substitution called transitions are more frequent between taxonomically similar organisms (Holmquist, 1983). These mutations result when purines are substituted by other purines or pyrimidines are substituted by other pyrimidines. Transversal substitutions predominate between divergent taxa. Such substitutions represent the replacement of purines for pyrimidines and vice versa, which is an exchange of structurally different molecules. A study of turtle mtDNA has suggested substitutional patterns might provide useful data for baraminologists by reflecting a process of limited variation (Robinson, 1997). In this survey we examined portions of both 12S-rRNA and cytochrome *b* mitochondrial genes for substitutional patterns (Figure 1). The cat-hyaena comparisons slightly overlapped for the 12S-rRNA gene, whereas both outgroups were separated from cats by a transversal gap for the cytochrome *b* gene.

Cluster Analyses

The phenetic and cladistic dendrograms were notably congruent (Figure 2). Although the phenetic dendrogram was more highly resolved, no topological discrepancies were observed. While the separate baraminic membership criteria were not significantly associated with each other (Table III), they did not significantly conflict since both the phenetic and cladistic analyses based on the combined data set were able to resolve three major subgroups with confidence. Subgroup A was composed of the large cats and received 96% and 85% bootstrap support in the respective cluster analyses. The intermediate-sized cheetah and cougar formed subgroup B with 76% and 81% bootstrap support respectively. Subgroup C was represented by the seven small cat genera, although these species did not form a single bootstrap supported cluster. Groups such as the ocelot plus leopard cat, African golden cat plus caracal, and the lynxes received moderate to strong bootstrap support in one or both analyses. The outgroup taxa formed subgroup D, and their separation from the cats was fully corroborated with 100% bootstrap support in both cluster analyses.

Baraminic Distance Variation Analyses

In general, intragroup versus intergroup comparisons can be made by estimating 95% confidence intervals around average baraminic distances. Overlapping intragroup and intergroup confidence intervals would suggest there is no statistically significant difference in the baraminic distance

variation of the groups being compared. The average baraminic distance within group X would not differ significantly from the average baraminic distance between groups X and Y, which would suggest groups X and Y may be monobaraminically related. On the other hand, non-overlapping confidence intervals would suggest the range of baraminic distance variation is significantly different. In this case, the average baraminic distance within group X would be significantly lower than the distance between groups X and Y, and may be diagnostic of an apobaraminic division separating groups X and Y (Robinson and Cavanaugh, 1998).

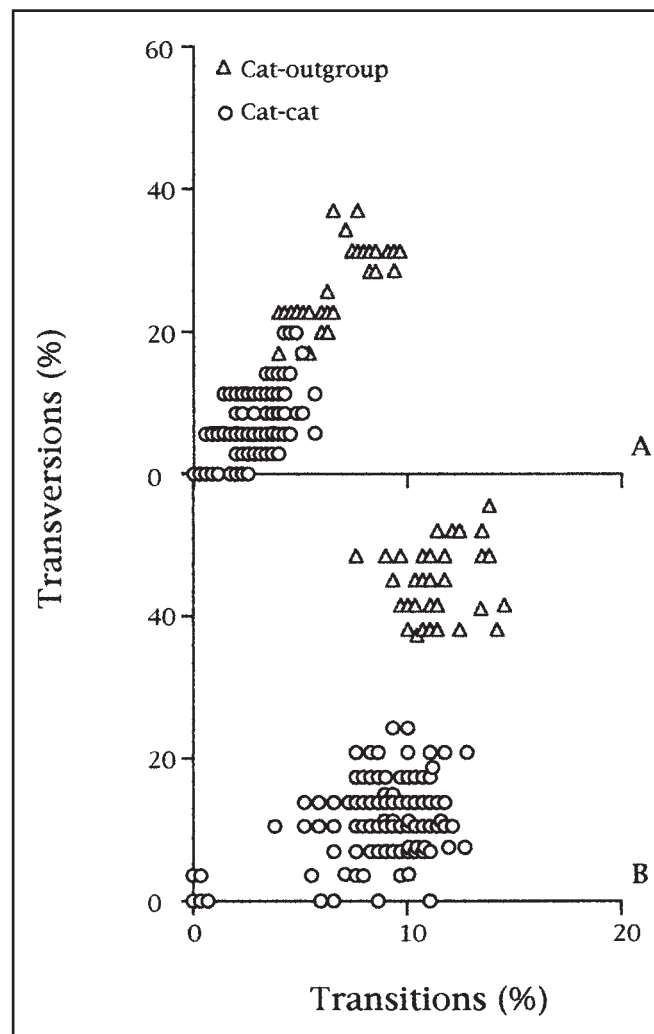


Figure 1. Transition versus transversion sequence differences for 12S-rRNA (A) and cytochrome *b* (B) genes.

In this study, baraminic distances ranged from 1.5% between the two lynx species, to 58.8% between the lion and meerkat (Table IV). Based on the combined data set, the average baraminic distance of cat species within a genus did not differ significantly from that found within the phenetically and cladistically defined subgroups (Table V). The same pattern was found with each criterion considered separately except with the chromosomal data. Baraminic distance variation within a given cat subgroup was therefore

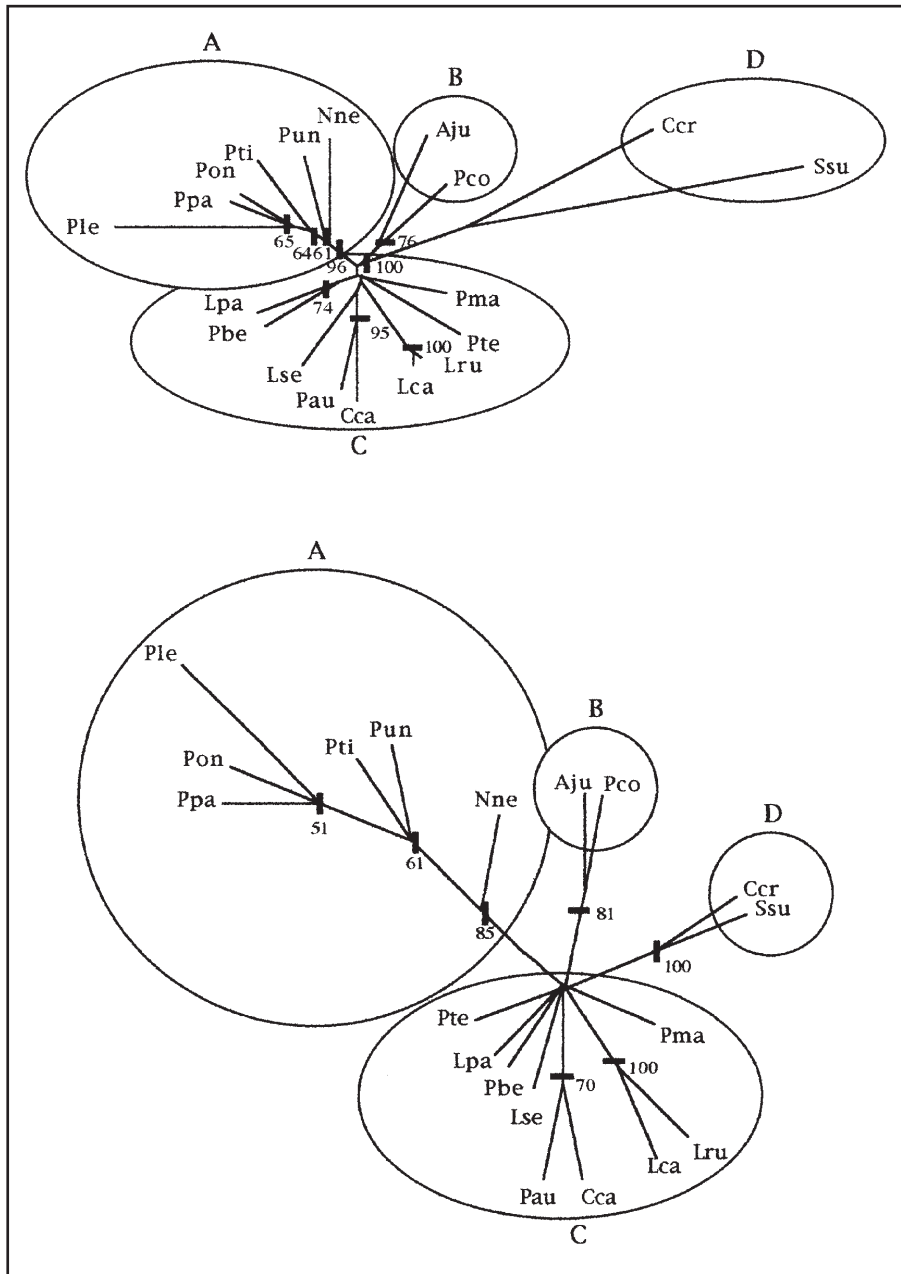


Figure 2. Unrooted neighbor-joining (upper) and cladistic (lower) dendrograms. The branch lengths are proportional to baraminic distances in the neighbor-joining dendrogram. Bootstrap values supporting branches with at least 50% confidence are numbered and highlighted. Four major subgroups labelled A-D have been marked with ellipses.

equivalent to the baraminic distance variation within a genus. Such data support a classification of three cat genera corresponding to *Panthera* (subgroup A), *Acionyx* (subgroup B), and *Felis* (subgroup C). Also based on the combined data set, a statistically significant gap of 4.2% was found between the average intrasubgroup and intersubgroup baraminic distance. This distinction of subgroups was supported by all criteria except the chromosomal data.

For two reasons, we do not interpret the gap of 4.2% as evidence that cats are apobaraminic. First, the short internal

branches and long terminal branches depicted in the phenetic dendrogram (Figure 2) suggested deep divisions were present within the Felidae family. This type of taxonomic structure is expected to reveal some degree of discontinuity between the different cat subgroups. Second, a small gap of 4.2% could be within the range of experimental error. Note that, in a previous study, the gaps based on morphological and ecological baraminic distances which separated humans from nonhuman primates were 20.4% and 45.7% respectively (Robinson and Cavanaugh, 1998). A gap of this size, 16.5%, was found between the average intersubgroup and cat-outgroup baraminic distance, based on the combined data set (Table V). The separation of cats from outgroups was further supported by all of the criteria.

Organismal Correlation Analyses

Correlation analyses of baraminic distance sets can be used to identify two species as monobaraminic or apobaraminic. A positive correlation between all of the baraminic distances of two organisms (less the zero distance between the organism and itself) indicates the two organisms have equivalent sets of baraminic distances, and suggests the organisms may be monobaraminic. In contrast, a negative correlation between the baraminic distances of two organisms may mark these organisms as apobaraminic because their baraminic distance sets are antithetical (Robinson and Cavanaugh, 1998).

We have used previously a graphical method for summarizing the numerous correlation analyses that can be made when different taxonomic groups and different baraminic membership criteria are examined (Robinson and Cavanaugh, 1998). Figure 3 summarizes 20

such analyses for the present study. Correlation coefficients noted on the right side of a graph are positive and may identify monobaramins, whereas correlation coefficients noted on the left side of a graph are negative and may identify apobaramins. Statistically speaking, correlation coefficients that could be obtained by random data lie in the middle of a graph; the baraminic relationships inferred by these comparisons are statistically unresolved. However, for unresolved comparisons a trend towards the right or left side of a graph hints at the baraminic relationship that might be sup-

Table IV. Baraminic distance matrix listing the proportion (lower diagonal) and number (upper diagonal) of character mismatches.

	Ple	Pti	Ppa	Pon	Pun	Nne	Pma	Lru	Lca	
Ple	–	70/287	62/287	62/287	74/279	86/278	81/273	102/286	89/269	
Pti	0.244	–	49/287	44/287	53/279	55/278	57/273	70/286	57/269	
Ppa	0.216	0.171	–	34/287	41/279	57/278	57/273	70/286	56/269	
Pon	0.216	0.153	0.119	–	40/279	61/278	58/273	71/286	58/269	
Pun	0.265	0.190	0.147	0.143	–	51/275	60/271	62/279	52/264	
Nne	0.309	0.198	0.205	0.219	0.185	–	58/272	65/277	58/26	
Pma	0.297	0.209	0.209	0.213	0.221	0.213	–	42/273	42/263	
Lru	0.357	0.245	0.245	0.248	0.222	0.235	0.154	–	4/269	
Lca	0.331	0.212	0.208	0.216	0.197	0.219	0.160	0.015	–	
Cca	0.364	0.283	0.265	0.254	0.261	0.261	0.205	0.194	0.182	
Lse	0.343	0.261	0.247	0.226	0.235	0.261	0.177	0.166	0.168	
Pbe	0.327	0.278	0.264	0.257	0.250	0.236	0.167	0.184	0.192	
Pau	0.337	0.239	0.232	0.235	0.244	0.261	0.185	0.207	0.216	
Pte	0.351	0.235	0.239	0.235	0.218	0.242	0.168	0.188	0.192	
Aju	0.339	0.276	0.280	0.262	0.229	0.291	0.223	0.239	0.209	
Pco	0.322	0.241	0.234	0.231	0.245	0.256	0.191	0.225	0.208	
Lpa	0.352	0.244	0.226	0.247	0.229	0.219	0.183	0.196	0.186	
Ccr	0.453	0.379	0.398	0.359	0.406	0.429	0.406	0.418	0.392	
Ssu	0.588	0.525	0.510	0.510	0.512	0.547	0.496	0.490	0.490	
	Cca	Lse	Pbe	Pau	Pte	Aju	Pco	Lpa	Ccr	Ssu
	103/283	97/283	93/284	93/276	97/276	97/286	92/286	101/287	116/256	150/255
	80/283	74/283	79/284	66/276	65/276	79/286	69/286	70/287	97/256	134/255
	75/283	70/283	75/284	64/276	66/276	80/286	67/286	65/287	102/256	130/255
	72/283	64/283	73/284	65/276	65/276	75/286	66/286	71/287	92/256	130/255
	72/276	65/277	69/276	66/270	59/271	64/279	68/278	64/279	101/249	127/248
	72/276	72/276	65/275	71/272	66/273	81/278	71/277	61/278	106/247	135/247
	56/273	48/272	45/270	50/270	45/268	61/273	52/272	50/273	99/244	121/244
	55/283	47/283	52/283	57/276	52/276	68/285	64/285	56/286	107/256	125/255
	49/269	45/267	51/266	57/264	51/265	56/268	56/269	50/269	96/245	120/245
	–	54/281	61/280	40/276	62/275	78/282	68/282	61/283	104/254	127/254
	0.192	–	51/280	50/275	56/275	75/283	63/282	54/283	105/254	123/254
	0.218	0.182	–	58/276	57/276	70/283	53/283	44/284	102/253	117/252
	0.145	0.182	0.210	–	61/274	78/276	68/275	58/276	96/247	114/247
	0.226	0.204	0.207	0.223	–	70/276	61/276	54/276	101/246	125/246
	0.277	0.265	0.247	0.283	0.254	–	58/285	73/286	103/255	128/254
	0.241	0.223	0.187	0.247	0.221	0.203	–	57/286	106/255	132/254
	0.216	0.191	0.155	0.210	0.196	0.255	0.199	–	100/256	122/255
	0.409	0.413	0.403	0.389	0.411	0.404	0.416	0.391	–	124/255
	0.500	0.484	0.464	0.462	0.508	0.504	0.520	0.478	0.486	–

ported if more powerful data were available (Robinson and Cavanaugh, 1998).

The aeluroid correlation analyses provided evidence for both monobaraminic continuity uniting cats, and an apobaraminic division separating cats from outgroups. Thus, by definition these data identified a Felid holobaramin. Of all the aeluroid graphs presented in Figure 3 (Panels A, E, I, M, Q) a total of 850 correlation coefficients were noted (171 correlations per criteria, x 5 criteria, –5 correlations between the outgroups themselves). Most of the cat-cat correlations were skewed towards the right (633 positive, 47 negative), whereas most of the cat-outgroup correlations were skewed

towards the left (19 positive, 151 negative). A majority (64.8%) of the aeluroid correlations were statistically significant. Note the distinct bimodal distribution obtained from the correlations based on the combined (panel A), morphological (panel I), and molecular (panel Q) data. This pattern was not as obvious in the ecological (panel E) and chromosomal (panel M) data.

The felid correlation analyses further supported the unity of the three cat subgroups. Of the felid graphs presented in Figure 3 (Panels B, F, J, N, R) a total of 680 correlation coefficients were noted (136 correlations per criteria, x 5 criteria). Most of the intrasubgroup cat correlations were skewed

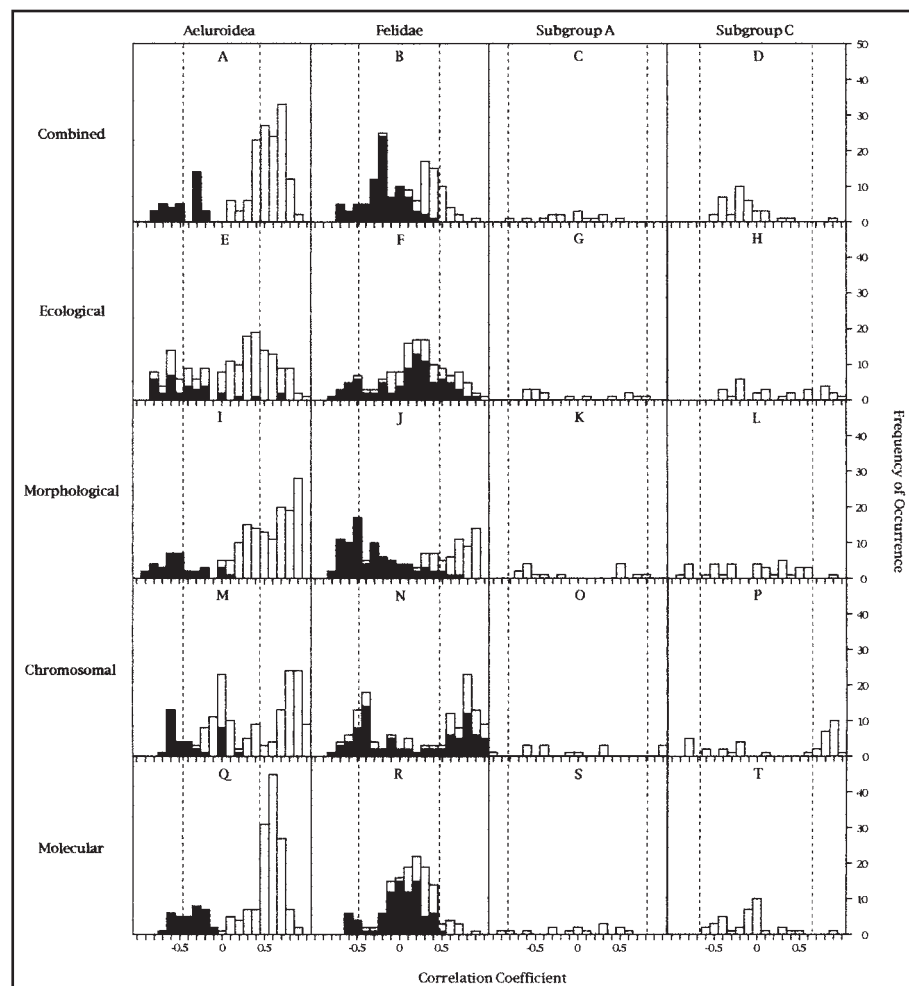


Figure 3. Exhaustive summary of the organismal correlation analyses based on different groups of taxa and different data sets. The dotted lines represent critical values for a 95% probability that the correlation is not zero (the values are: Aeluroidae ± 0.455 , Felidae ± 0.482 , Subgroup A ± 0.811 , Subgroup C ± 0.666). In the Aeluroidae graphs, black bars denote cat-outgroup comparisons, and white bars represent cat-cat comparisons. In the Felidae graphs, black bars denote intersubgroup comparisons, and white bars represent intrasubgroup comparisons.

towards the right (229 positive, 31 negative). However, the intersubgroup cat correlations were distributed evenly in the right and left directions (199 positive, 221 negative). The resolution of the felid correlations was poor because only

36.2% of the correlations were statistically significant.

A couple of points can be made from the correlation analyses of subgroups A and C in Figure 3 (Panels C, G, K, O, S and D, H, L, P, T respectively). These data sets were relatively small and represented comparisons among very similar species. The correlations are almost completely unresolved as only 9.3% and 24.4% of the correlations for subgroups A and C respectively were statistically significant. Moreover, these data detected negative correlations between species that are capable of hybridizing and producing fertile offspring; certainly not apobaraminic species. Our results showed that the greatest resolution was obtained with the largest data set (the aeluroids). As successively smaller data sets were examined more similar species were compared and the resolution diminished.

Hybridograms

The potential for interspecific hybridization provides an important data set for elucidating monobaramins. Five species included in this survey are known to hybridize: *Panthera leo* x *Panthera tigris*, *Panthera pardus*, *Panthera onca*; *Panthera tigris* x *Panthera pardus*; *Panthera pardus* x *Panthera onca*, *Puma concolor*; *Panthera onca* x *Puma concolor* (Gray, 1972; Van Gelder, 1977). Gene flow is also possible between *Lynx rufus* and *Prionailurus bengalensis* since both species are known to cross with *Felis domesticus* (Gray, 1972). Mapping the information obtained from the quantitative analyses onto a matrix of hybridization data (here called a hybridogram) resulted in a useful graphical method for identifying monobaramins (Figure 4). Eleven cat species contained pairwise

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Table V. Comparisons of intragroup with intergroup baraminic distance variation.

Criteria	Cat Species Within Genera	Average Baraminic Distance ($\pm 95\%$ C.I.)		
		Cats Within Subgroups	Cats Between Subgroups	Cats Versus Outgroups
Combined	0.175 (0.218, 0.132)	0.193 (0.201, 0.185)	0.252 (0.261, 0.243)	0.455 (0.484, 0.426)
Ecological	0.477 (0.629, 0.325)	0.391 (0.483, 0.299)	0.546 (0.598, 0.494)	0.789 (0.850, 0.728)
Morphological	0.145 (0.190, 0.100)	0.164 (0.183, 0.145)	0.306 (0.321, 0.291)	0.611 (0.653, 0.569)
Chromosomal	0.094 (0.183, 0.005)	0.298 (0.378, 0.218)	0.336 (0.389, 0.283)	0.831 (0.880, 0.782)
Molecular	0.178 (0.231, 0.125)	0.192 (0.203, 0.181)	0.221 (0.231, 0.211)	0.405 (0.421, 0.389)
n	12	40	84	34

Note: Subgroups are defined in Figure 2.

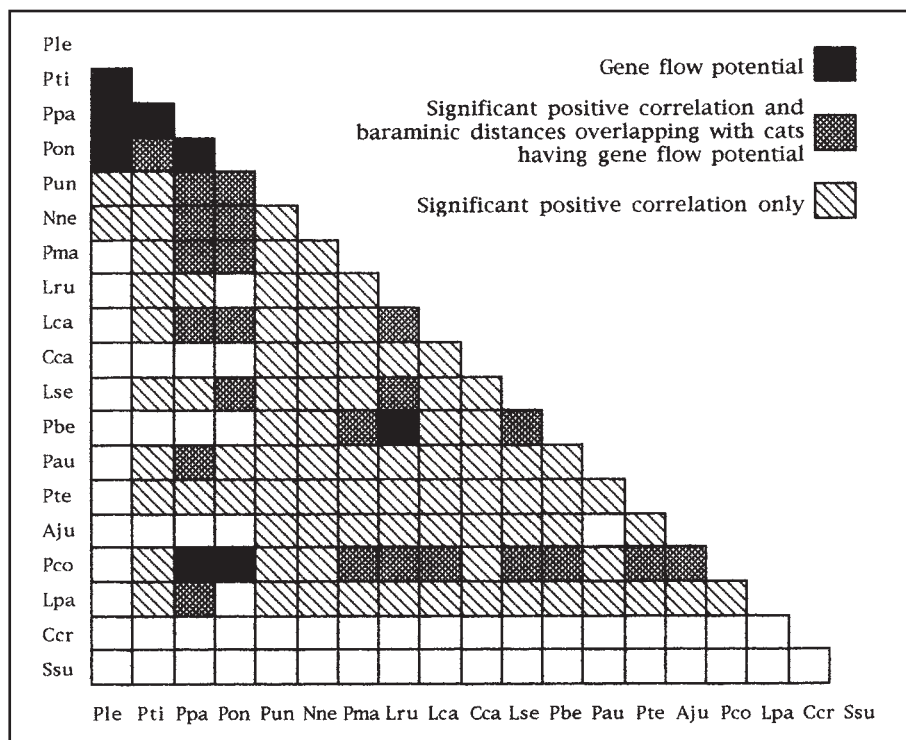


Figure 4. Hybridogram characterizing a single cat monobaramin on the basis of gene flow potential, overlap in pairwise baraminic distances, and significantly positive organismal correlations.

baraminic distances (the values tabulated in Table IV, not the confidence intervals estimated in Table V) that overlapped with those of hybridizing cats. The organismal correlations based on the combined aeluroid data set (Figure 3A) was more inclusive and grouped nearly all cats into a single monobaramin. All cat species within the range of baraminic distances of cats capable of gene flow were also significantly and positively correlated. There was no overlap of cats with outgroups.

Eaton (1974) noted that *Acionyx jubatus* displays an aggressive rather than copulative behavior towards dummies of *Panthera pardus*. Thus, a possible lack of gene flow between these species may partially explain the lack of correlation between their characters. Aggressive behavior may also partially explain the observation that large cats tended to be uncorrelated with the intermediate and smaller species. Indeed, based on the combined aeluroid data set 96% of the unresolved organismal correlations were comparisons of large cats with smaller species. The clouded and snow leopards being the smallest of the large cats provided an exception. The baraminic distances of these two species were correlated with the baraminic distances of the small cats, and aligned more closely on the dendrograms.

Evaluation of the Homoplasy Criterion

Characters that occur in disjoint branches of a cladogram are defined as homoplasies. Homoplasies could be potentially the result of a separate creative act by the Creator, parallel evolution, an error in diagnosing the character, an event that transfers the character between different lineages, or an event that expresses the character from a previously unexpressed state.

Roughly half of the characters included in this study were homoplasious for the Aeluroidae and Felidae (Table VI). With the exception of the ecological criterion the amount of homoplasy among the felids was slightly higher than among all aeluroids considered together. The amount of homoplasy within subgroup C was roughly twice as high as that found within subgroup A. Homoplasy indices were relatively high in this study. All carnivorans share a certain number of characters that allows them to fulfill their predatory function. Crompton (1993) noted that 15 of 19 chromosomes present in the Felidae are also present in the Hyaenidae and Viverridae. This much shared genomic information might lead to a number of different homoplasies. Furthermore, we know that the biology of carnivorous baramins has been altered at some point in their natural history (see Lambert, 1983; Stambaugh, 1991). It is tempting to speculate that this alteration either distributed new information for carnivoran characters across different carnivoran baramins or regulated the expression of already present carnivoran characters in a similar manner.

In a previous study the relationship between baraminic distance and homoplasy was relatively uniform; as the phenetic distance between two species increased so did the number of homoplasies (Robinson and Cavanaugh, 1998).

Table VI. Comparisons of homoplasy within the Aeluroidae, Felidae, and two felid subgroups.

Criteria	Aeluroidae		Felidae		Subgroup A		Subgroup C	
	Length	H.I.	Length	H.I.	Length	H.I.	Length	H.I.
Combined	737	0.488	562	0.505	192	0.214	256	0.387
Ecological	50	0.540	42	0.500	13	0.154	13	0.231
Morphological	187	0.476	147	0.490	40	0.025	52	0.442
Chromosomal	37	0.514	31	0.613	4	0.000	15	0.267
Molecular	503	0.527	385	0.558	130	0.254	176	0.392

Note: Subgroups are defined in Figure 2. Length refers to the total number of character changes required by the indicated cladogram and H.I. represents the homoplasy Index. The Felidae, Subgroup A, and Subgroup C values were obtained by pruning the necessary taxa from the five Aeluroidae cladograms.

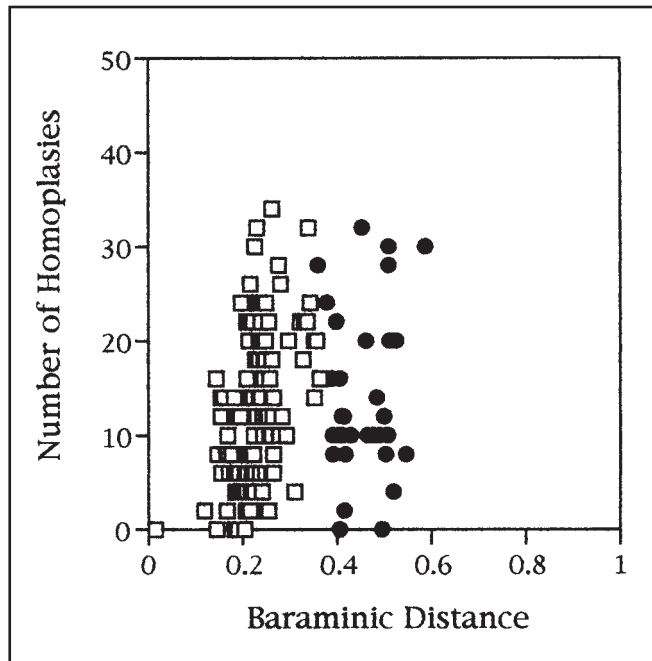


Figure 5. Plot of pairwise baraminic distances versus the number of pairwise homoplasies detected in the cladistic analysis. Black circles denote cat-outgroup comparisons, and white squares represent cat-cat comparisons.

In the present study the relationship between baraminic distance and homoplasy was spurious (Figure 5). The outgroups were phenetically distant from the cats, but the number of homoplasies shared between cats and outgroups was of the same magnitude as those shared between different cat species. Future studies of different taxonomic groups, especially carnivorans, are needed to help explain these observations.

Discussion

Baraminology of the Cats

Evidence for three major cat monobaramins has been presented. The cluster analyses suggested that the Felidae was composed of three major subgroups, although only two of these received bootstrap support. The baraminic distance variation and organismal correlation analyses confirmed the distinction of these groups. More importantly, the extensive overlap between subgroups as illustrated in the hybridogram strongly suggested all cats could be lumped into a larger monobaramin. Simpson (1945) classified living cats into the same three subgroups, although he placed the cougar into the genus *Felis* rather than *Acionyx*. It is encouraging to note that baraminology can yield practical classifications that have some conventional support.

In order to identify a group as a holobaramin it is necessary to identify both monobaraminic relationships uniting the group and apobaraminic divisions separating the group from other species. The clear separation of cats from out-

groups in the cluster analyses, large gaps in the baraminic distance variation of cats from different subgroups versus cats and outgroups, and predominantly negative correlation coefficients between cats and outgroups in the organismal correlation analyses all indicated the cats were distinct from the selected outgroups. Since the Hyaenidae and Viverridae resemble the Felidae more closely than other living families, comparisons of cats with additional carnivore families would be expected to yield even larger biological discontinuities. Mehler (1995) noted that fossil evidence for a macroevolutionary relationship uniting cats and other carnivores was lacking. Despite a century of research into the evolution of cats, no common ancestor uniting cats and other carnivores has been established (Hunt, 1987). The living cat family can therefore be confidently defined as a holobaramin, which is composed of phylogenetically related species and fully surrounded by a phyletic division (Figure 6).

The unity of large cats was one notable finding of this study. The lion was the most divergent cat and shared statistically significant similarities only with the other large cats. Species within a monobaraminic group that are difficult, if not impossible, to classify because of conflicting characters have been called aberrant (Scherer, 1993). *Neofelis nebulosa* is such an aberrant species whose taxonomic affinity traditionally has been puzzling. The current survey consistently placed the clouded leopard basally within the *Panthera* monobaramin. Werdelin (1983) demonstrated the clouded leopard was intermediate between the large and small cats for a variety of skull and dentition characters. The upper canine teeth of the clouded leopard were further noted to be similar in size to saber-toothed specimens. Incidentally, molecular evidence has allied the saber-toothed cat near the *Panthera* subgroup (Janczewski, Yuhki, Gilbert, Jefferson, and O'Brien, 1992), possibly within the range of sequence variation of hybridizing species. These data would challenge Mehler's (1995) contention that saber-toothed cats form a separate holobaramin, although a study should be conducted to formally test his hypothesis.

An accurate understanding of the potential for variability within the *Acionyx* monobaramin might be crucial to its preservation because the cheetah and cougar are endangered in all or parts of their range. Moderate bootstrap support in both the phenetic and cladistic cluster analyses indicated these species may form a natural group, a hypothesis strengthened by molecular (O'Brien et al., 1987; Collier and O'Brien, 1985) and morphological (see data of Herrington in Salles, 1992) evidence not included in this study. The *Felis trumani* specimen of North America has been offered as an intermediate between the cheetah and cougar (Adams, 1979). Cheetah fossils are also found among the lowest strata known for modern cats. It is therefore possible that the lineage leading to the cheetah and cougar represents an early monobaraminic radiation within the Felid holobaramin.

The high degree of morphological specialization exhibited by the cheetah has led systematists to postulate an early origin for this species. As noted by Scherer (1993) the process of specialization indicates the descendant population



Figure 6. Representative members of the Felid holobaramin and an aeluroid outgroup. The white bengal tiger (A) is classified along with other large cats into the *Panthera* monobaramin. The cheetah (B) is one of two living species within the *Acionyx* monobaramin. The fishing cat (C), *Prionailurus viverrina*, was not included in this study but is expected to be classified along with the leopard cat, *Prionailurus bengalensis*, into the *Felis* monobaramin. The meerkat (D), *Suricata suricatta*, was suggested to be unrelated to the cats. (Photographs by D. A. Robinson)

has lost variation potential when compared to the ancestral population. Indeed, modern cheetahs are noted for being genetically depauperate (O'Brien, Wildt, Goldman, Merrill, and Bush, 1983), suggesting the variation potential within this species has been diminished. Aggressive behavior (Eaton, 1974) and the propensity to inbreed (O'Brien, et al., 1983) may prevent the cheetah from hybridizing with other cat species (and thus tapping into a potentially rich pool of genetic information). The cougar qualifies as another aberrant species because it is morphologically similar to the small cats, yet produces viable offspring with the large cats (Van Gelder, 1977). This observation alone strongly supports the unity of all three felid subgroups.

The classification of small cats traditionally has proved enigmatic as witnessed by a profusion of generic names. Although the current survey was unable to resolve many of the relationships within this monobaramin, two pairs of taxa were supported in both the phenetic and cladistic cluster analyses; the African golden cat plus the caracal, and the two lynxes. The Asian golden cat and the caracal are especially

aberrant species that have been classified into a variety of genera. It is possible the data failed to support a particular arrangement of species within the *Felis* monobaramin because rapid microevolution has led to a tangled network of characters. The short internal branches and long terminal branches depicted in the phenetic dendrogram are supportive of this hypothesis.

Hybridization among a genetically rich ancestral population might promote such a burst of speciation (Scherer, 1993; Fehrer, 1996). Moreover, some characters of small cats may be better explained as a result of historical hybridization rather than selective pressure leading to the independent evolution of these characters. For example, both the caracal and the lynxes display conspicuous ear tufts, a character without any obvious selective advantage. Perhaps the relatively more gentle behavior of small cats has provided an increased opportunity for hybridization, and thus higher frequencies of character exchange. As rather weak support for this hypothesis we note that Gray (1972) recorded six species of small cats that hybridize, but only four

and one species respectively among the large and medium cats. Further support could be taken from the observation that the homoplasy indices for subgroup C were roughly twice as large as the homoplasy indices for subgroup A.

Two major radiations are often hypothesized to have occurred within the *Felis* monobaramin; one leading to a domestic cat lineage, the other leading to an ocelot lineage. It is noted that the domestic cats contain specific endogenous retroviral sequences within their genomes, an inheritable feature not present in other cat species. Ocelots, on the other hand, have a unique diploid number of 36 and a restricted South American distribution (O'Brien, 1986; Wayne, Benveniste, Janczewski and O'Brien, 1989).

Reliability of Criteria

In a previous study the ecological and morphological data were the most reliable for distinguishing humans from non-human primates (Robinson and Cavanaugh, 1998). In the present study the ecological data were the least reliable criterion, both in terms of overall resolving power and in specific terms of being able to distinguish cats from the aeluroid outgroups. Ecology may be an especially unstable baraminic membership criterion within carnivorous taxa such as the Aeluroidae. Support for this hypothesis comes from the observation that the criterial diversity of ecological characters was nearly twice as high as in other criteria, its baraminic signal was not statistically significant, plus ecology was the most homoplasious criterion among aeluroids. Moreover, only eight ecological characters (most of which were originally continuous variables) were sampled in this study, versus 18 in the previous study (Robinson and Cavanaugh, 1998).

The chromosomal data proved yet again to be a weak data set as witnessed by a low (but statistically significant) baraminic signal and relatively poor separation of distributions in the organismal correlation analyses. There may be simply too few chromosomal characters which can be collected to make a reliable chromosomal criterion. Chromosomal characters are often combined into morphological data sets in conventional biosystematics.

Our results have suggested that morphological and molecular characters could be of great value in baraminology research. The baraminic signal of these criteria was highly significant, and the organismal correlations based on these criteria produced a distinct and highly resolved pattern separating cats from outgroups. More detailed analyses of the molecular data suggested that non-protein coding genes may not be generally useful for examining discontinuity in terms of transition and transversion substitutional patterns. These data also confirmed previous observations that substantial levels of variation in non-protein coding genes often occur among taxonomic units higher than the holobaramin (Robinson, 1997; Robinson and Cavanaugh, 1998). Thus, non-protein coding genes may not be properly calibrated for identifying holobaramins. Future studies should examine the sequences of other molecules to determine the extent of these generalizations.

Epilogue

As suggested in a previous study (Robinson and Cavanaugh, 1998) the proper selection of characters may be the most important factor in baraminology studies. We have dealt pragmatically with character selection, mostly seeking to maximize criterial relevance (A). In other words, we selected characters that were available for a majority of the species included in the study, regardless of its historical use in the systematics of primates or cats. Some characters possibly should have been removed from our studies because of logical correlations such as the presence or absence of folivory and the percent foliage in the diet. Another reason for our pragmatic selection of characters is that we are neither primate nor cat experts. In order for baraminology to become a productive scientific discipline, it is necessary for numerous biologists in diverse subdisciplines to gain a curiosity about the baraminology of their particular organism of expertise. What is their natural history? What does their origin and microevolution suggest about other aspects of their biology? Nearly every biologist is an expert on some organism, and is therefore most qualified to decide which characters are taxonomically important for that organism. Finally, we can justify the relatively pragmatic selection of characters in our studies by pointing out that our main goal has been to introduce new tools for baraminology. If these methods were successful with pragmatically selected data, then it is possible they may perform even better with more carefully selected data.

We note that characters are given weight merely by their inclusion in a study. Natural weighting schemes, however, are not appreciated by all biosystematists. Sneath and Sokal (1973) present compelling arguments for not artificially weighting characters unless one has good reason to do so. Guidelines for weighting characters phenetically and cladistically have been published, and their use in studies of baraminology should be examined. We have presented a simple weighting scheme (Robinson and Cavanaugh, 1998). It might be useful for future studies to examine the effects of weighting transversal nucleotide substitutions higher than transitions. The predicted effect would be to highlight phylogenetic gaps because these mismatches tend to predominate between proposed apobaraminic species (this study and Robinson, 1997). Transversions are often weighted in conventional systematics because it is assumed these mutations accumulate more slowly.

We have classified biological characters into very broad baraminic membership criteria. Future studies might benefit from classifying characters into narrower criteria. For example, the ecological criterion might be separated into ethological (behavioral) and life history characters. Morphological characters might be divided into major anatomical systems (Wise, 1992). Molecular characters might be separated into protein and non-protein genes. A narrower categorization of characters may be important because different subsets of criteria will probably have different reliabilities for inferring baraminic relationships in different groups of organisms. For example, the morphology of mouthparts are

important taxonomic characters in the larvae of aquatic insects in the family Chironomidae, but are not as important for turtle taxonomy. Two cautions are advised when classifying characters into different baraminic membership criteria.

(1) It is possible to classify characters into too narrow a baraminic membership criterion, such that the data set is too weak to support any particular hypothesis. We believe that considering single characters such as the trophic status or habit of organisms as separate baraminic membership criteria is an example of a weak data set (and can lead to confusion, see Wise, 1992; Robinson, 1997; Robinson and Cavanaugh, 1998). In the context of quantitative baraminology, there is no real estimate on the minimum number of characters that should be used to form the basis of a reliable measure of resemblance. Sneath and Sokal (1973) have arbitrarily suggested 60 characters. The ecological criterion that separated humans from nonhuman primates was composed of only 18 characters. However, the more characters the better, as more information gives a more complete description of the species, and thus a better estimate of the differences between species.

(2) Our classification of characters into different criteria has been a largely subjective process. There is a school of thought in conventional biosystematics that argues that different classes of phylogenetic evidence do not exist, but are merely artifacts of tradition and technology (Miyamoto and Fitch, 1995). For example, molecular data are only separated from morphological data because the techniques for collecting and analyzing this data are more recent. At first glance, there is no rational basis for separating the data and attaching special importance to one or the other data sets. The decision to combine or separate data sets is often resolved by testing for a so-called process partition. A process partition is a division of characters into subsets that are subject to different evolutionary forces (Bull et al., 1993). The generation of conflicting but statistically supported dendrograms are grounds for separating the data sets. Otherwise, it is suggested that the data sets be combined and analyzed together.

Returning to the relevance of this issue for baraminology, if different data sets seem more useful for detecting phylogenetic discontinuity, then we need some rational basis for claiming that their evidence is superior to evidence that may not support phylogenetic discontinuity. For example, why was the ecological criterion reliable and the molecular criterion unreliable for distinguishing humans from nonhuman primates (Robinson and Cavanaugh, 1998), whereas the opposite result was found with cats and aeluroid outgroups? With primates the Scriptural criterion was used to interpret the different data sets. We suggested that the ecological and morphological criteria were most reliable simply because they most efficiently distinguished humans from nonhuman primates. These data sets were also the most highly correlated (Robinson and Cavanaugh, 1998). With cats there was no Scriptural criterion available for interpreting the results. We concluded, however, that the morphological and molecular criteria were more reliable because they had the

greatest resolving power. Interestingly, these two criteria provided the only correlated data sets. Will the most reliable criteria always be the most highly correlated? Data sets that yield congruent dendrograms would also be expected to yield significant criterial correlations. Thus, it is possible that the most reliable criteria for detecting phylogenetic discontinuity will be the ones that present no demonstrable process partition. In other words, the natural history of the most baraminically informative characters may be subject to the same microevolutionary forces. These issues raise fundamental questions about the nature of the holobaramin and the characters that can be used to identify them. We hope that baraminologists will give these questions thoughtful attention.

Appendix I

Ecological characters: activity pattern, vegetation, zonation, diet, social behavior, litter size, gestation length, age of maturity (Gittleman, 1985; 1986a; 1986b; 1991)

Morphological characters: body weight, body length, brain weight, birth weight, olfactory bulb height, olfactory bulb width, olfactory bulb length, anterior dentary, lower third deciduous premolar-second posterior accessory cusp, upper third premolar-parastyle, upper fourth premolar-protcone, upper canine-dorsoventral length, upper canine-lingual ridge, relative position of foramen rotundum to basicranial plane, external pterygoid fossa, palatine bones, occipital condyles, subarcuate fossa, internal auditory meatus-marginal surface, longitudinal ridge of auditory meatus, malleus-processus brevis, incus-inferior head with malleus, groove for stylomastoid foramen, frontal sinus-relative position on the skull, anterodorsal frontal sinus cavity, first caudal ethmoturbinate scroll-posterior position, frontal sinus volume, frontal bone-outer surface depression, frontal bone-lateral expansion, frontonasal region-dorsal profile, frontonasal region-dorsoventral compression, frontonasal region-ridge, rostral constriction, infraorbital foramen, maxilla expansion over infraorbital foramen, jugal and frontal postorbital processes, jugal anterior process, hyoid apparatus, fibula head, tendon for extensor digitorum longus, olecranon of ulna, caudal vertebrae, shape of ear, pencil hair of ear, interdigital webs of hind foot, digit tips of fore and hind feet, growth of neck fur, pupils, tongue, anterior palatine foramina, relative size of palatine, alisphenoid canal, auditory bulla-posterior carotid canal, external auditory meatal tube, caudal entotympanic, paraoccipital process, processus gracilis of malleus, major a2 arterial shunt, major a4 arterial shunt, major anastomosis Y, course of internal carotid, P1, p1, p2, M1, M2, m1, m2, hallux, anal glands (Salles, 1992; Wozencraft, 1989)

Chromosomal characters: diploid number, fundamental number, morphology of metacentric, acrocentric, and Y chromosomes, banding patterns of chromosomes B4, D2, E4, F1, and C3 (Modi and O'Brien, 1988; Wurster and Benirschke, 1968)

Molecular characters: 124 polymorphic sites for cytochrome *b*, 75 polymorphic sites for 12S-rRNA (Janczewski, Modi, Stephens, and O'Brien, 1995; Masuda, Yoshida, Shinyashiki and Bando, 1994).

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Book Review

***A Biologist Examines the Book of Mormon* by Thomas D. S. Key. 1995
Utah Missions, P.O. Box 348, Marlow, OK 73055. 1995. 59 pages. \$6 postpaid. (Paperback)
Reviewed by George F. Howe***

A copy of this book was given to me by my friend Edmund Gruss who is an historical researcher and an author of many books on Mormonism and on the Jehovah's Witness movement. The name Thomas D. S. Key immediately caught my eye because when I was a beginning instructor in biology, I received a beneficial boost in my own burgeoning creation studies from a fine chapter written about 40 years ago by this same author (Key, 1959, pp. 11-52) in a symposium volume which some readers may still remember—*Evolution and Christian Thought Today*.

But Key's 1995 book is not about creation or evolution. It is worth reviewing here, however, because most creationists like to check statements from the Bible and other religious writings against the facts of science. The Bible emerges from such comparisons smelling like a proverbial rose. Not so, says T. D. S. Key, with *The Book of Mormon*. Key raises no objections to the concept of miracles as such, but he has located many apparent scientific blunders in the discussions of both ordinary and miraculous events. He has not intended, he says, to offend Mormons (pp. 4-6) but wants to shed light on possible scientific discrepancies.

Key has organized his many arguments into 19 scientific sections which are arranged alphabetically from "Anatomical Problems" to "Zoological Problems," with "Geological Problems" somewhere in the middle. One of the anatomical glitches he reports is in *Mosiah* 3:7 (which Mormons date at about 124 B.C.). In a reference to Jesus' sufferings, it says

that "...blood cometh from every pore..." (p. 6); but skin pores were not described or even discovered, writes Key, until after microscopes were developed—many centuries later.

Flax is mentioned as being present in the Americas (I *Nephi* 13:7 refers to linen, an indirect but definite involvement of flax because linen is made only from processed flax stems), but native Americans had neither flax nor linen (p. 13). Under "Anthropological Problems" (p. 9) he notes that *The Book of Mormon* treats dark skin pigmentation as a definite curse while it can, in many climates, be a physiological blessing. A few of the other questions analyzed include: (1) whether or not Native Americans are descended from middle-eastern Hebrews, (2) did the animals called "cureloms" or "cummoms" have real counterparts in natural history, and (3) did horses exist in pre-Columbian America?

This brief but lucid book contains cartoons illustrating various purported errors. It concludes with Key's personal Christian testimony and a direct comparison between the Bible and Mormonism regarding the subject of eternal life. This booklet will interest all readers who want to discover whether or not the revered writings of Mormonism are replete with scientific errors. Key concludes that *The Book of Mormon* is "...definitely not fact but clearly fiction" (p. 56).

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A Preliminary Report on the Precambrian Pikes Peak Iron Formation Yavapai County, Arizona

Van Andel Creation Research Center Report Number 2

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Abstract

The Precambrian Yavapai Series contains the Pikes¹ Peak Iron Formation, dated to the Early Proterozoic, a uniformitarian age of 1.75 billion years old. The origin and development of iron bearing strata remain somewhat enigmatic within the uniformitarian model because no modern analogy of iron-rich deposition occurs on earth today. Various models have been proposed by uni-

formitarians in their attempt to explain its origin and occurrence. Based on our examination of several outcrops, we propose that the Precambrian Yavapai Series and the Pikes Peak Iron Formation formed during the earliest stages of the Flood (Lower Flood Event Division) in a volcanic setting (possibly including hydrothermal activity) under subaqueous conditions.

Introduction

Precambrian iron formations represent interesting problems for uniformitarian geologists. Their origin and possible depositional setting have not been conclusively resolved because no modern environment currently exists from which comparisons can be derived. However, several models have been proposed in an attempt to explain their origin and/or diagenetic development (e.g., Dimroth, 1979a, 1979b; Govett, 1966; Gross, 1965; Lepp and Goldich, 1964; Lewis and McConchie, 1994).

Within the continental United States there are only three areas where Precambrian iron formations are found: the Lake Superior region, the northern Rocky Mountains, and the desert southwest (Bayley and James, 1973). Within the southwestern United States, the best exposures of these iron-rich layers are found in the Pikes Peak Iron Formation of Arizona.

The Pikes Peak Iron Formation, within the Precambrian Yavapai Series, outcrops in several areas near the Creation

Research Society's Van Andel Creation Research Center (Figure 1). These rocks are exposed within the Transition Zone geomorphic province (Froede, Howe, Reed, Meyer, and Williams, 1997). We conducted a preliminary investigation of several outcrops of the Pikes Peak Iron Formation within this area. We propose that the Precambrian Yavapai Series (which contains the Pikes Peak Iron Formation) represents volcanically-derived sediments which were deposited during the early stages of the Flood. Because of burial, heat, pressure, volcanism (including hydrothermal activity), and tectonic activity associated with the Flood event, the original volcanoclastic sediments have been subsequently altered to form low to medium grade metamorphic rocks (Yavapai Series) containing lenses of iron-rich chert (i.e., Pikes Peak Iron Formation).

A glossary of terms is provided at the end of this article to aid the reader in understanding some of the geological terminology.

Precambrian Yavapai Series Pikes Peak Iron Formation

The Precambrian Yavapai Series strata are exposed across a broad area of Yavapai County and along northern portions of Maricopa, County, in central Arizona (Figure 1). Within these Precambrian rocks are a series of iron-rich chert layers identified as the Pikes Peak Iron Formation (dated as Early

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¹At this location, "Pikes" is spelled with no apostrophe.

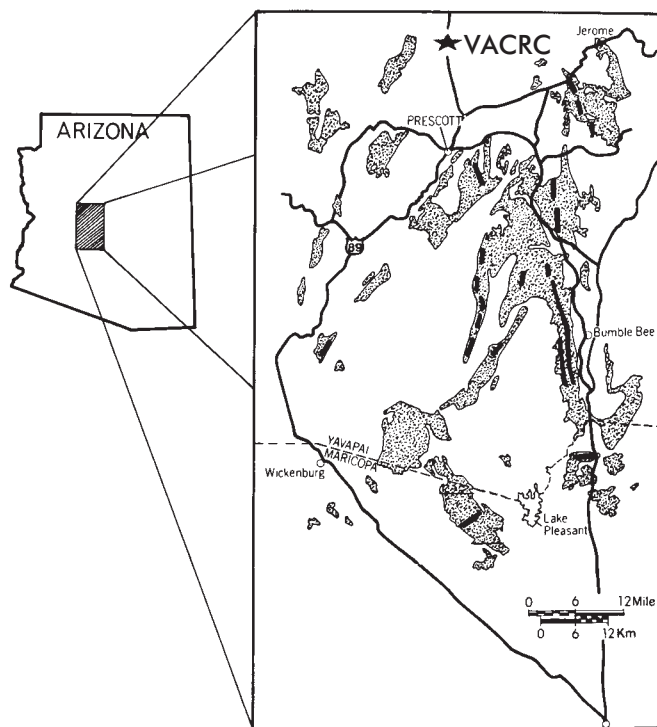


Figure 1. Generalized map showing the extent of the Precambrian Yavapai Series rocks as they are exposed across Yavapai and Maricopa Counties. The Yavapai Series (Precambrian) are shown stippled and the Pikes Peak BIF outcrops are shown as solid black lines. The Creation Research Society's Van Andel Creation Research Center is located to the north of Prescott, within close access to several locations from which the Pikes Peak BIF can be examined. Modified from Figure 1 in Slatt, Heintz, Lowry, and O'Hara, 1978.

Proterozoic—1.75 Ga (billion years old). Because the Pikes Peak Iron Formation exhibits distinct stratigraphic layering, it has the characteristics of a banded iron formation (BIF) [Figure 2], referred to hereafter as the Pikes Peak BIF.

According to Bayley and James (1973, pp. 955-956), the Yavapai Series of central Arizona is described as:

...a complex sequence of rocks, dominantly of volcanic origin, more than 20,000 feet thick. Flows and volcanic breccias range in composition from basaltic to rhyolitic, and interbedded sediments consist mainly of volcanic materials.

Presently no fossils have been identified within the Yavapai Series which would allow for biostratigraphic dating or paleoecological reconstruction. However, using its lateral position to fossil-bearing strata, combined with radiometric dating, the Yavapai Series has been estimated as forming 1.6 to 1.82 Ga before present (Anderson, Blacet, Silver, and Stern, 1971, p. C1; Lanphere, 1967, p. 757).

According to Slatt, Heintz, Lowry, and O'Hara (1978, p. 73) the Pikes Peak BIF:

...consists of a series of lenticular bodies of interlaminated chert and iron oxide which form an outcrop belt

about 6 km (4 miles) long by 700 m (2300 feet) wide within more areally extensive phyllites and associated meta-volcanic rocks. (parenthesis ours)

The Pikes Peak BIF has steeply dipping beds that strike N. 60 E. (Lindberg, 1989, p. 207). The tectonic event which resulted in the deformation of not only the Pikes Peak BIF, but the entire Yavapai Supergroup is called the Yavapai Orogeny (Nations and Stump, 1996, p. 116).

In our field work within this area we noticed a variability in the thickness and composition of the iron-rich layers, and in the adjacent phyllites and schists (Figure 3). The Pikes Peak BIF varied from brown to red jasper cherts which were interbedded with magnetite and hematite-rich layers and bounded by phyllites and schists (Figure 4). In many places the upturned iron-rich rocks formed ridges, because they are harder and erode at a slower rate than the surrounding strata (Figure 5).

It is noteworthy that the Pikes Peak BIF is physically similar to many of the other BIFs found across the globe (e.g., Blatt, Middleton, and Murray, 1972, p. 577).



Figure 2. Banded iron layers are exposed in a near vertical orientation due to the tectonic forces experienced following original deposition. The layering is alternating brown to red jasper cherts interbedded with magnetite and hematite-rich layers. Scale is in inches and centimeters.



Figure 3. An outcrop of Pikes Peak BIF bounded by phyllites and schists. Note person at left for scale.

Economic Significance

The Pikes Peak BIF is recognized as a possible economical source for iron. As part of an United States Bureau of Mines investigation, Farnham and Havens (1957, pp. 1–2) examined the potential reserves within a limited outcrop area of the Pikes Peak Iron Formation. They determined that the iron could be open-pit strip mined to a depth of 400 feet below grade with approximately 30 percent of the minable material providing iron ore. Although this report only addressed the Pikes Peak BIF for a limited area, it does provide an understanding of how and where the concentrated iron deposits lie both in outcrop as well as in the subsurface. Likely the iron lenses were at one time concentrated areas of iron-rich sediment, which reinforces our understanding of the original sediments probably being formed within a volcanic (possibly hydrothermal) environment.

Depositional Environment

Several depositional environments have been proposed within the uniformitarian model in an attempt to explain the occurrence of banded iron formations (e.g., Gross, 1980, 1983; Isley, 1995; James, 1954, 1992; Trendall, 1968). Gross (1965, p. 89) originally classified the world's iron formations into six different types. Bayley and James (1973, p. 936) have stated that the Pikes Peak BIF is most closely characterized by the "Algoma Type" of iron-rich strata.

Gross (1965, pp. 90-91) described the "Algoma Type" of Precambrian iron formation as:

...characteristically thin banded or laminated with interbands of ferruginous grey or jasper chert and hematite and magnetite. They are intimately associated with various volcanic rocks including pillowed

andesites, tuffs, pyroclastic rocks, or rhyolitic flows and with greywacke, grey-green slate, or black carbonaceous slate. Tuff and fine-grained clastic beds or ferruginous cherts are interbedded in the iron-formation and detailed stratigraphic successions show heterogeneous lithological assemblages. *The associated rocks indicate a eugeosynclinal environment for their formation and a close relationship in time and space to volcanic activity.* (emphasis ours)

Slatt et al. (1978, p. 81) have postulated the origin of the Pikes Peak BIF as:

...at least three cycles of deltaic sedimentation led to the development of the Pikes Peak deposit. Each cycle of sedimentation is represented by prodelta and delta front phyllites overlain by tidal flat cherty iron oxide. Chemical sedimentation in very shallow water might

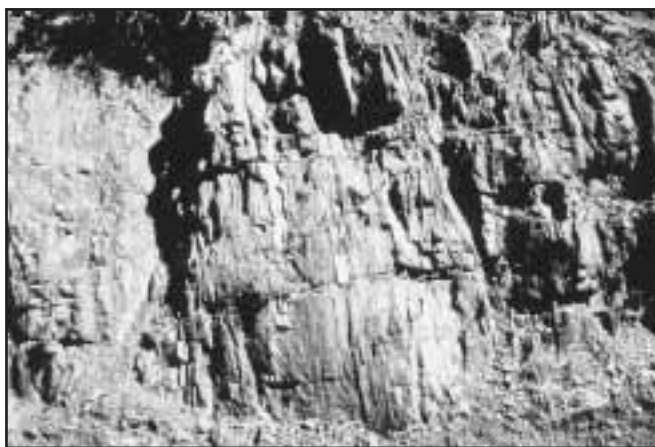


Figure 4. The Pikes Peak BIF is a massive series of iron-rich chert layers which exhibit the typical physical features of BIF found in many other places across the globe.



Figure 5. As a hardened chert layer, the Pikes Peak BIF resists erosion better than the surrounding phyllites and schists. Hence, in many places the BIF is typically exposed as a ridge or as in this case a wall.

indicate the iron was derived from terrestrial chemical weathering.

The proposal of a Precambrian prograding deltaic paleoenvironment implies millions of years of deposition, much volcanic activity, and iron containing volcanic sediments. However, this imagined iron-rich deltaic depositional environment does not exist anywhere on Earth today. Additionally, no deltaic environment (even within a volcanic setting) has ever been suggested as providing substantial iron deposits in any form—this is a first for the prograding delta model.¹

We propose a high-energy subaqueous volcanic setting from which both volcanic sediments and iron-rich layers were derived. Additionally, possible hydrothermal activity within this paleo-volcanic setting could also explain the formation of the iron-rich and chert layers. Interestingly, a recognized source of iron found within iron-rich sedimentary rocks has been attributed to volcanic sources. Pettijohn (1976, pp. 420-421) has stated:

The appeal to volcanism as a source of iron (and silica) arises from the presumed inadequacies of ordinary processes to supply and transport iron in sufficient quantities. *The evidence for a volcanic source is the presumed close association in time and space of iron sedimentation and volcanism.* (emphasis ours)

The Precambrian Yavapai Series is clearly derived from volcanic sources, thus it is logical to assume that the Pikes Peak BIF is also derived from volcanic sources. This is the most parsimonious approach to the interpretation of the

Precambrian Yavapai Series (and specifically, the Pikes Peak BIF). Note that Gross (1965) and Pettijohn (1976) both agreed that the occurrence of iron-rich rock is best explained within a volcanic environment, and Cloud (1983) has noted problems with the various non-volcanic BIF depositional models.

The close association of the Precambrian Yavapai Series/Pikes Peak BIF with volcanically derived sediments and stratigraphically adjacent massive sulfide deposits suggests a non-uniformitarian (i.e., catastrophic) approach to solving the origin of this strata. All of these strata reflect a former volcanic depositional environment which operated over a very short period of time.

Young-Earth Flood Model

The young-earth catastrophist must use the physical information and the framework provided by the biblical historical record to evaluate suggested uniformitarian interpretations. The position of strata within a Flood-based stratigraphic column may be established by reference to changing energy levels as inferred from geologic materials (Reed, Froede, and Bennett, 1996). This approach is one possible method of discussing the origin and development of strata within the framework of a creationist geological timescale (e.g., Froede, 1995; 1998; Walker, 1994).

This catastrophic method focusses on the energy conditions under which the sediments were deposited, rather than by the passage of time (the uniformitarian approach). It also eliminates uniformitarian paleo-depositional environments which are believed to have existed for millions of years. In summary, physical evidences (i.e., sedimentary deposits exhibited at various rock outcrops, as well logs, and as cores) are reinterpreted within the context of a biblical-catastrophic framework.

¹This interpretation clearly falls outside the realm of science, i.e., it is neither demonstrable nor does it correspond to a modern day analogy. This proposal illustrates the great lengths to which uniformitarian scientists will go in order to explain the physical evidences within their model!

There are several creationist proposals which explain how the Precambrian strata might fit within the Young-Earth Flood model. Snelling (1991) and Woodmorappe (1983) have suggested that any fossils/organic matter found within the Precambrian strata should relegate them to Flood deposits. Precambrian strata which do not contain any former evidences of life would then date to the creation week. Counter to this proposal, Wise (1992) and Austin and Wise (1994) have suggested that some types of fossil-containing Precambrian strata were formed before the Flood, and reflect the activities associated with the third day of the creation week (see Appendix A). Hunter (1992) proposed that all of the Precambrian, (based on petrology and lithology) should be considered Flood deposits.

Presently, there are no fossils or organic materials reported within the Precambrian Yavapai Series or specifically within the Pikes Peak BIF which might help us determine their time of deposition.² However, we believe that several factors help us to establish the timing for the formation of the Precambrian Yavapai Series as being derived during the earliest stages of the Flood (i.e., Lower Flood Event Division). Our interpretation is based on the high-energy levels required to account for the volcanic sediments, their burial under hundreds if not thousands of feet of additional sedimentary materials, followed by tectonic activity, and then tremendous erosion which must have followed to expose these rocks at the Earth's surface.

Within this same general area are Precambrian massive sulfide deposits which were emplaced under subaqueous conditions (Anderson and Creasey, 1958; Anderson and Nash, 1972; Bouley and Hodder, 1976; DeWitt, 1979). These sulfide deposits lie immediately adjacent to and sometimes include portions of the Precambrian Yavapai Series. Hence, these sulfide deposits reinforce our suggestion that the Pikes Peak BIF was emplaced in a subaqueous environment which would clearly fit within a Flood (i.e., Lower Flood Event Division) setting.

Conclusions

Our preliminary investigation of the Precambrian Pikes Peak BIF reveals a complex association of iron-rich rocks within the surrounding Yavapai Series phyllites and schists. These Precambrian deposits have undergone deformation and alteration via complex tectonic forces which have destroyed any pre-existing fossil information they might have contained. Therefore any interpretation is limited to sediment type, stratigraphic position, and alteration history.

We propose that the Pikes Peak BIF found within the Precambrian Yavapai Series was formed at the onset of the Flood Event. Volcanic and tectonic activity associated with

this high-energy event rapidly buried this area under a tremendous volume of rock; volcanic, then carbonate and clastic sediments transported from adjacent areas.³ Heat, pressure, and pore fluid chemistry could have then altered the Pikes Peak BIF to its present state. Later tectonic activity deformed the strata, and erosion (still associated with the Flood) removed much of the overburden and exposed the now upturned strata. All of this activity resulted in the exposure (within the Transition Zone Province) of tilted and hardened iron-rich chert (e.g., Pikes Peak BIF) with adjoining phyllites, schists, and massive sulfide deposits (i.e., Precambrian Yavapai Series strata).

This is not the only possible interpretation within the Young-Earth Flood model. As creationists conduct additional research into these rocks this interpretation could change. But it serves as a starting point. Only through additional field work will we better understand the variability of the Yavapai Series rocks, and the Pikes Peak Iron Formation.

Appendix A—Precambrian Strata and the pre-Flood/Flood Boundary

Although the authors have tentatively interpreted the Pikes Peak BIF genetically within the Genesis Flood event, other creationists have discussed the relationship of Precambrian rocks to the boundary separating initial Flood deposits from pre-existing (i.e., Creation Week) strata. Prominent among these are Austin (1994), Wise (1992), and Austin and Wise (1994), who considered several problems surrounding such a classification, and have proposed five criteria for defining a pre-Flood/Flood boundary. Although each of these criteria deserves much discussion, we focus on only one—the “Paleontological Discontinuity.”⁴ Austin and Wise (1994) define this boundary between strata as separating fossils of simple life forms (i.e., microfossils) from those containing fossils of more complex life forms (i.e., macrofossils).

Historical observation does allow broad classification of sedimentary units by fossil content: (1) those containing both microfossils and macrofossils, (2) those containing microfossils, but no macrofossils, (3) those containing neither (assuming observational knowledge and methods are adequate to justify the claim of a blanket negative), and (4) those containing macrofossils, but no microfossils (again, presuming on observational method). During the development of the uniformitarian geologic column, the existence of these observed classes of sedimentary rocks carried tremendous historical significance for naturalists, because the

³This area within the Transition Zone was probably once a part of a much broader Colorado Plateau; this proposal is based on similar strata (Froede, Howe, Reed, Meyer, and Williams, 1997).

⁴We focus on this particular discontinuity because it has the greatest bearing on this article. We do not support the uniformitarian age dates assigned to the Precambrian strata, but believe that most, if not all, of these “oldest” strata represent Flood deposits.

²In this case we do not propose using fossils in a biostratigraphic sense. Rather, we suggest that fossils could help us determine if the strata in question are Flood deposits in a manner suggested by both Snelling (1991) and Woodmorappe (1983).

transition from microfossils to macrofossils was thought to reflect a historical development (i.e., the rocks are evolutionary clocks). Under the uniformitarian framework, observed sequences of these strata (microfossils only to macrofossils and microfossils, or to macrofossils only) allowed correlation of the strata between widely spaced locations, based on the singularity of the historical evolutionary event.

If Austin and Wise (1994) are proposing a boundary to set the global “clock” (initial Flood event) based upon the same transition from microfossils to macrofossils, then the similarity of their proposed global model to that applied during the historical development of the uniformitarian geologic column is close enough as to require significant discussion to differentiate between an evolutionary and a non-evolutionary cause for the proposed transition. The similarities are twofold: both in the significance attached to the observed differences in the fossil content of various units; and in the use of those differences as an indicator of time presumed to apply globally. The difference would reside in the rejection (as advocated many times by both Austin and Wise) of the causal mechanism of naturalistic evolution as well as its implied context of long ages of uniformitarian history. However, because of the similarity of the method, the possibility exists for misunderstanding and misinterpreting their position. Therefore, the authors encourage Austin and Wise to continue to develop their differences vis a vis uniformitarian Precambrian constructs and the role of fossils as time indicators.

Based partly on the “Paleontological Discontinuity,” Austin and Wise (1994) associate the boundary between pre-Flood and Flood strata with the Great Unconformity at the Precambrian/Cambrian boundary in the Grand Canyon (dated at 570 million years). If their definition is valid, and if it can be correlated regionally following strata classified by the uniformitarian framework, then the authors’ classification of the Pikes Peak BIF (dated at 1.75 Ga) as Flood strata would obviously be in error. However, the first of these assumptions appears premature based partly upon the published work of Burdick (1974) [repeated by Howe et al. (1988), and discussed by Williams (1997)] that reported the presence of pollens in the Hakatai Shale (dated at 1.25 Ga)—which is well below the Austin/Wise (1994) proposed pre-Flood/Flood boundary. Austin (1994) does not believe that his model is consistent with those observations, and expresses doubt as to the nature of the pollen found in the Hakatai. He does admit the presence of pollen grains within the rock, but relates it to modern pollens infiltrating into pores within the shale (Austin, 1994, p. 137). If the conclusions of Austin (1994) and Burdick (1974) and Howe et al. (1988) exhaust the possibilities, then creationists are faced with a happy dilemma. Either Burdick (1974) and Howe et al. (1988) have demonstrated spectacular contrary evidence to the geologic timescale, or Austin has discovered a mecha-

nism that would not only cast doubt on the work of Burdick (1974) and Howe et al. (1988), but on any work ever done in similar conditions by any palynologist on any sedimentary unit. Within the uniformitarian framework of deposition, emergence, reburial, and re-emergence, could not many palynological discoveries (currently used as time index fossils) be unrelated to the original timing of deposition of a given unit? If the infiltration model can be tested and demonstrated, then Austin’s insight will require a significant re-evaluation of modern palynology. We hope to see publication of details of this model. Until that time, or until the observations of Burdick and Howe et al. have been rigorously refuted, we accept that work and the uncertainties it adds to the ubiquitous use of a “Paleontological Discontinuity,” and look for other means to falsify our tentative interpretation of the Pikes Peak BIF.

In response to the second assumption of the synchronous correlation of the strata from the Grand Canyon to the observed BIF outcrops, the authors encourage the use of interpolation rather than extrapolation in extending catastrophist stratigraphic boundaries from local to regional, or even global scales. The compressed timing of Flood events would imply correlating the rock record by similar events, which though similar in depositional style, could be non-synchronous across a broad area. In other words, the onset of the Flood event may leave similar evidence in the rock record, but the time factor must be reduced in significance from that applied in a uniformitarian context. For example, the deposition of marine carbonates may have been proceeding at a downdip location at the exact moment that underlying “shoreline” transgressive clastics were being laid down updip. We would encourage other creationists to work towards defining key boundaries and units locally at a variety of locations on the basis of depositional events, so as to provide a broader empirical basis in an interpretative framework more congenial to the Biblical record.

Glossary

Banded Iron Formation (BIF)—Iron formation that shows marked banding, generally of iron-rich minerals and chert or fined-grained quartz.

Diagenesis—All the chemical, physical, and biologic changes undergone by a sediment after its initial deposition, and during and after its lithification.

Eugeosyncline—A geosyncline (i.e., a basin on a continental landmass adjacent to an ocean) in which volcanism is associated with clastic sedimentation. From a plate tectonic perspective this would be a basin which develops between a volcanic fore-arc and a subduction zone. Volcanic sediments would mix within this setting with continental derived clastic deposits. Somehow all of these deposits result in the formation of BIF.

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Errata

CRSQ 34(4), March 1998, page 219. The lowest section was omitted from Table II.

Table II. Regional Stratigraphy of Western Colorado, adapted from Lohman (1965), Prather (1982), and Young (1984).

Uniformitarian term for time periods	Thickness in feet	Rock layers exposed in Grand Mesa-Uncompahgre area
Miocene	100	Basalt cap
Eocene	1000	Green River Formation
Paleocene	1,700	Wasatch Formation
<i>Unconformity</i>		
Late Cretaceous	1,500	Mesa Verde Formation
Late Cretaceous	3,800	Mancos Shale
Late Cretaceous	150	Dakota Formation
Late Cretaceous	60	Burro Canyon Formation
Early Cretaceous	600	Morrison Formation
Late Jurassic	54	Summerville Formation
Late Jurassic	150	Entrada Sandstone
<i>Unconformity inferred</i>		
Late Triassic	45-80	Kayenta Formation
Triassic	530	Wingate Sandstone
Triassic	80-100	Chinle Formation
<i>Unconformity</i>		
Precambrian		crystalline rocks

CRSQ 34(4), March 1998, page 218. In the abstract, "steam" should be "stream."

CRSQ 34(4), March 1998, page 248. In "Tasso's Creation" the next to last line in the first paragraph should be "God" instead of "Cod."

CRSQ 34(4), March 1998, page 258. The book review author's address was omitted:

Richard Overman
Creation Education Resources
P.O. Box 1853
Orange Park, FL 32067-1853

CRSQ 34(4), March 1998, page 256. Line 8 from the bottom of the first column should read, "Thanh, a family relative from Vietnam who is a practicing civil engineer with..."

CRSQ 34(4), March 1998, page 256. Line 17 of the second column should read, "Dr. Imai-zumi, now quite aged, is also not known to have changed his views (Kasuya, 1997)." Line 23 has an erroneous repeat of the original line.

CRSQ 34(4), March 1998, page 256. Line 21 from the bottom of the second column should read "decomposing sharks, was that what they had caught was indeed very different and unusual."

CRSQ 34(4), March 1998, page 257. Line 2 from the end should read "was" instead of "has."

The Angular Size of the Moon and Other Planetary Satellites An Argument for Design

Danny R. Faulkner

Abstract

It previously has been argued that the circumstances of total solar eclipses for the earth-moon system are unique in the solar system and that this suggests design. This is reexamined using the latest data on the many satellites now known to exist

in the solar system. This argument is shown to be stronger than ever. Some comments about the design argument in astronomy are made. It is suggested that discussion of the definition and application of the design argument be pursued.

Introduction

While the sun is about 400 times larger than the moon, the moon is also approximately 400 times closer to the earth, so that both objects extend nearly identical angular sizes of about $\frac{1}{2}$ degree. This causes a total solar eclipse to be a very remarkable event, one of the most beautiful and awe-inspiring experiences in nature, as anyone who has seen one can attest. If the moon were slightly farther away or smaller (or the sun closer or larger in size), total solar eclipses would not be possible. If the situation were reversed, many of the startling features of a total solar eclipse, such as the diamond ring effect, Bailey's beads, and prominences near the sun's limb, would not be as readily visible. Total solar eclipses also would be more common, making them less thrilling phenomena that they are now.

As beautiful as total solar eclipses are, perhaps more importantly they offer an opportunity for scientific study of certain solar phenomenon that would be difficult or impossible to do otherwise. For instance, the sun's chromosphere is briefly visible at the instants when totality begins and ends. Almost all of the energy that we receive from the sun comes from the portion of the sun's atmosphere called the photosphere. The chromosphere is a thin, cooler, more rarefied region of the sun's atmosphere lying just above the photosphere. Its feeble light is usually overpowered by the photosphere, except when the photosphere is blocked during a total eclipse. Historically the chromosphere's emission spectrum has been studied when it is revealed as a flash spectrum that briefly appears around the onset and end of totality.

Lying above the chromosphere is the solar corona, which extends a few solar diameters into space. Only visible during totality, the pearly white corona is very rarefied, but is at a high temperature (between one and two million °K). How this high temperature is maintained has remained a mystery

for some time, and some recent creationists have used its high temperature as evidence of its recent formation. Magnetic field lines are clearly visible in the corona, and the size and shape of the corona changes from sun spot minimum to sun spot maximum. So the observations of the corona during total solar eclipses provides clues to the complex magnetic interactions taking place in the sun.

One of the first confirmations of general relativity was the bending of star light by the sun's mass, which could be observed only during a total solar eclipse when the images of stars were visible near the sun's edge. Total (or near total) solar eclipses give us a unique opportunity to gauge the relative sizes of the sun and moon. This provides data in deciding the question of whether the sun is shrinking, another argument that is used for the sun's recent origin. Historical data on the locations of eclipses have allowed us to determine the rate at which the earth's rotation is slowing because of tidal braking. This too places an upper limit on the age of the earth-moon system.

For generations astronomers have traveled to exotic locations to observe total solar eclipses because total solar eclipses are such rare events. On average a total solar eclipse is visible from any location only once every few centuries. Therefore without planning it is unlikely that a typical person will ever view a total solar eclipse, let alone more than one. Whitcomb and DeYoung (1978, p. 132-136) and Mendillo and Hart (1974) have previously called attention to the interesting circumstance necessary for total solar eclipses as an argument for design in the earth-moon-sun system. More recently Englin and Howe concluded that the unique geometry of the earth-moon system that gives us total eclipses is no accident. No other moon in the solar system has such a close balance between the rarity and stark beauty of eclipses. Many have no eclipses at all. In the two decades since the work of Whitcomb and DeYoung the number of known satellites in the solar system has nearly doubled. At the same time the orbital parameters and measured sizes of most of the others have been greatly improved. Let us examine the latest values to determine how unique our moon is in this respect.

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Calculation of Ratios

Table I lists the 61 satellites known at the time of the writing of this article. It is possible that additional ones may be discovered or confirmed by the time that this goes to press, but, as it will be argued later, any of those would be unlikely to alter the conclusion given here. All data were taken from the 1997 *Astronomical Almanac*. The first two columns give the names of the satellites. The third column lists the angular size, in degrees, of the sun at the distance of the planet from the sun. The fourth column gives the angular size, in degrees, that each satellite has as seen from the planet about which the satellite orbits. The angular sizes were calculated using the average distance (semi-major axis) of each orbit (epoch February 1, 1997). For ease in comparison, it was decided to express each number as a simple decimal rather than in scientific notation. The precision of each number reflects the precision of the satellite parameters, with the uncertainty usually dominated by uncertainties in satellite diameters. Some of the satellites are

known to be oblong rather than spherical in shape. In those cases the largest diameters were used.

Because the orbits of the planets and the major satellites are nearly circular, these calculated average angular diameters are a good starting approximation. If any satellites were discovered to have nearly the same angular diameter as the sun, then they could be further investigated as to the conditions of eclipse. The orbits of some of the smaller satellites are appreciably elliptical, and so these could be further investigated as well if it appears that eclipses could be possible near the extremes of the orbits.

The best way to evaluate the possibility, rarity, and beauty of a particular satellite's eclipses is to compare the sizes of the apparent solar and satellite diameters. For instance, the ratio of the moon's apparent diameter to that of the sun is 0.9719. This means that a typical centerline eclipse tends to be annular rather than total. An annular eclipse is one in which the moon is too small to completely cover the sun, so that a thin ring, or annulus, of the sun's photosphere remains visible at mid eclipse. This is particu-

Table I. Planets and their satellites with their relationships to the sun and to each other.

Planet	Satellite	Solar Diameter	Satellite Diameter
Earth I	Moon	0.5331	0.5181
Mars I	Phobos	0.3499	0.165
Mars II	Deimos	0.3499	0.037
Jupiter I	Io	0.1025	0.493
Jupiter II	Europa	0.1025	0.268
Jupiter III	Ganymede	0.1025	0.2818
Jupiter IV	Callisto	0.1025	0.1461
Jupiter V	Amalthea	0.1025	0.0855
Jupiter VI	Himalia	0.1025	0.00093
Jupiter VII	Elara	0.1025	0.00037
Jupiter VIII	Pasiphae	0.1025	0.00012
Jupiter IX	Sinope	0.1025	0.000087
Jupiter X	Lysithea	0.1025	0.00018
Jupiter XI	Carme	0.1025	0.00010
Jupiter XII	Ananke	0.1025	0.000081
Jupiter XIII	Leda	0.1025	0.00008
Jupiter XIV	Thebe	0.1025	0.028
Jupiter XV	Adrastea	0.1025	0.011
Jupiter XVI	Metis	0.1025	0.018
Saturn I	Mimas	0.05573	0.121
Saturn II	Enceladus	0.05573	0.120
Saturn III	Tethys	0.05573	0.206
Saturn IV	Dione	0.05573	0.170
Saturn V	Rhea	0.05573	0.166
Saturn VI	Titan	0.05573	0.2415
Saturn VII	Hyperion	0.05573	0.0159
Saturn VIII	Iapetus	0.05573	0.0235
Saturn IX	Phoebe	0.05573	0.000973
Saturn X	Janus	0.05573	0.083
Saturn XI	Epimetheus	0.05573	0.053
Saturn XII	Helene	0.05573	0.0055

Planet	Satellite	Solar Diameter	Satellite Diameter
Saturn XIII	Telesto	0.05573	0.0066
Saturn XIV	Calypso	0.05573	0.0066
Saturn XV	Atlas	0.05573	0.017
Saturn XVI	Prometheus	0.05573	0.058
Saturn XVII	Pandora	0.05573	0.044
Saturn XVIII	Pan	0.05573	0.0086
Uranus I	Ariel	0.02762	0.347
Uranus II	Umbriel	0.02762	0.252
Uranus III	Titania	0.02762	0.208
Uranus IV	Oberon	0.02762	0.150
Uranus V	Miranda	0.02762	0.213
Uranus VI	Cordelia	0.02762	0.030
Uranus VII	Ophelia	0.02762	0.032
Uranus VIII	Bianca	0.02762	0.041
Uranus IX	Cressida	0.02762	0.058
Uranus X	Desdemona	0.02762	0.049
Uranus XI	Juliet	0.02762	0.075
Uranus XII	Portia	0.02762	0.094
Uranus XIII	Rosalind	0.02762	0.044
Uranus XIV	Belinda	0.02762	0.050
Uranus XV	Puck	0.02762	0.10
Neptune I	Triton	0.01761	0.4370
Neptune II	Nereid	0.01761	0.00353
Neptune III	Naiad	0.01761	0.069
Neptune IV	Thalassa	0.01761	0.092
Neptune V	Despina	0.01761	0.16
Neptune VI	Galatea	0.01761	0.15
Neptune VII	Larissa	0.01761	0.162
Neptune VIII	Proteus	0.01761	0.212
Pluto I	Charon	0.01344	3.47

larly true when an eclipse occurs near the moon's apogee or the earth's perihelion. This also effects the duration of an eclipse. The longest totalities, about seven minutes, occur at noon in the tropics, with the earth at aphelion and the moon at perigee.

We can conclude that if the ratio of the angular diameter of a satellite to that of the sun is much less than one, then no total eclipse would be possible. On the other hand, a ratio much larger than one would cause eclipses to be very total and very frequent. As described above, both of these effects would tend to detract from the wonder of a total eclipse, though gross over totality would have the greater effect. Much of the beauty of a total solar eclipse derives from the appearance of the inner corona and the very colorful prominences, both of which are visible near the limb (edge) of the sun. Because of the near match in angular diameters of the moon and sun, these are visible all around the sun's limb. For a overly total eclipse, these would only be briefly visible near the points of second and third contact (defined below), the points where totality begins and ends.

Table II displays the ratios of the angular diameters (satellite/solar) for the 34 satellites for which the ratio exceeds 0.9. It can be assumed that the other 37 satellites fail to produce any total solar eclipses. As can be seen from the second table, the ratios show that most satellites that produce total eclipses produce ones that are overly total. The most extreme is Pluto's moon, which has a ratio of 258. The best candidates for total eclipses are Saturn XI(0.95), Saturn XVI(1.02), and Uranus VI (1.08)

Saturn XI and Saturn XVI are not spherical, but are elongated, and as stated above, the longest diameter was used to find the angular size. Most of the satellites of the solar system are believed to follow synchronous orbits, that is, they orbit the planets with one face toward the parent body at all times. This is caused by a tidal interaction, and is expected to be especially true of the small, elongated satellites. For a particular satellite this would result in the longest diameter pointing toward the planet, and so a smaller diameter would be the diameter needed to calculate the angular diameter of the moon. Therefore it is unlikely that total eclipses would occur for these two small moons. Using the largest satellite diameter, the angular diameter of the sun, and the satellite's orbital period, the duration of eclipse can be calculated. The duration of an eclipse can best be expressed in terms of the times of first, second, third, and fourth contacts. First contact is defined as the instant when the eclipsing body first begins to block the sun's disk, and is generally considered the beginning of the eclipse. Second contact is the instant when the sun's disk is completely blocked, and thus marks the onset of totality. Third contact is the end of totality, while fourth contact is the end of the eclipse. The time from second to third contacts is the duration of totality, and the length of the entire eclipse is the time difference between first and fourth contacts.

For Saturn XI the duration of eclipse is 19 seconds, while Saturn XVI has duration of 17 seconds. These durations are for the entire eclipses from first to fourth contacts, including the partial phases before and after any totality (or annu-

Table II. Satellites with satellite/solar ratios exceeding 0.9.

Name	Ratio	Name	Ratio
Jupiter I	4.81	Jupiter II	2.61
Jupiter III	2.750	Jupiter IV	1.425
Saturn I	2.17	Saturn II	2.16
Saturn III	3.70	Saturn IV	3.05
Saturn V	2.98	Saturn VI	4.333
Saturn XI	0.95	Saturn XVI	1.03
Uranus I	12.6	Uranus II	9.13
Uranus III	7.52	Uranus IV	5.42
Uranus V	7.70	Uranus VI	1.08
Uranus VII	1.16	Uranus VIII	1.47
Uranus IX	2.1	Uranus X	1.8
Uranus XI	2.7	Uranus XII	3.4
Uranus XIII	1.6	Uranus XIV	1.8
Uranus XV	3.7	Neptune I	24.82
Neptune III	3.9	Neptune IV	5.2
Neptune V	9.2	Neptune VI	8.3
Neptune VII	9.20	Neptune VIII	12.1
Pluto I	258		

larity). The length of totality is impossible to calculate with the current knowledge of the diameters of these two satellites, but it would likely be less than one second. Such eclipse would be almost unnoticeable, let alone enjoyable or useful for scientific study. An even worse situation prevails for Uranus VI, with a ratio of 1.08. It is not known if it is elongated, but given its small size, it probably is. Eclipse duration from first to fourth contact would be less than five seconds, causing any totality to be far less than a second.

It is obvious that the smaller satellites of the solar system do not provide a good opportunity for total solar eclipses, because their small sizes and rapid motion combine to produce very short duration eclipses. It then becomes obvious that the only hope of producing awe-inspiring eclipses is to look to the larger satellites. Most of the larger moons produce very overly total eclipses, but the most promising one is Jupiter IV (Callisto) with a ratio of 1.425. Calculation shows that Callisto produces eclipses having first to fourth contact duration of 16.6 minutes, with totality lasting 2.9 minutes. At first look this appears to fulfill our requirements established for rare, beautiful events. But the over totality means that the inner corona and the prominences can only be glimpsed at narrow ranges near the points of second and third contact. The author personally noted that while watching the February 26, 1979 total solar eclipse in Arborg, Manitoba with two minutes, 50 seconds of totality, prominences were best visible on the east limb of the sun early in totality and on the west end late in totality. This was caused by the moon's proximity to perigee at the time, giving it a slightly larger apparent size, covering those features first on the west limb, and then on the east limb. The rapid motion of Callisto, combined with the more over total nature of its eclipses, would greatly shorten the length of time that these features would be visible.

This leads to a very subtle effect that is hiding in these calculations. Note that for the planets closer to the sun, total

eclipses are quite rare, while for the more distant ones, they are quite common. For instance, only the four larger (Galilean) of the 16 satellites of Jupiter produce total eclipses, all the satellites of Uranus and all but one of Neptune do. This is because the angular diameter of the sun is progressively smaller as one gets farther from the sun. This has three effects. First, it lowers the requirement for totality. Second, it causes the eclipses to be very over total. Third, the decreasing angular diameter diminishes the visual effect of the eclipses. For instance, Jupiter being more than five times more distant from the sun causes the features of the corona and prominences to be more that five times smaller as seen from the earth. From Saturn and beyond it is doubtful that the appearance of the sun with its photosphere eclipsed would be that impressive or that the eclipses would be very noticeable.

Conclusion

The doubling of the number of planetary satellites in the past two decades has not undermined the prior conclusion of Whitcomb and DeYoung and Mendillo and Hart that the earth-moon system produces uniquely beautiful total eclipses. To the contrary, the calculations presented here demonstrate that their conclusion is more sound than ever. Additional consideration shows that overly total eclipses are not expected to be as spectacular as the ones produced by our moon. Furthermore the greatly diminished apparent size of the sun at the distances of the larger planets means that any total solar eclipse there would lack the visual effect as seen from the earth. The earth-moon system combines three aspects that enhances the beauty and wonder of total solar eclipses:

- A large angular size of the sun, which produces high visual resolution of features only seen during total solar eclipses
- Optimal duration of totality of up to seven minutes that allows for maximum enjoyment
- Frequency that makes total solar eclipses uncommonly rare, yet occur often enough to be enjoyed by many

For some time this author has been concerned with the design argument in astronomy. In discussing biological systems, the design argument can be very powerful. For instance, if gross properties of the earth, such as atmospheric composition or gravity were altered, life would be impossible. If the sun's size and temperature or the earth's orbit were different, life would again be endangered. The same

can be said for atomic properties of matter, such as the many bonds that carbon can form, or the status of water as the universal solvent, or the unique property of water expanding upon freezing. In short, the design argument is a demonstration that nature must be as it is, or else life as we know could not exist. Even evolutionary scientists have recognized this fact and have coined the term the "anthropic principle" to describe it (Barrow and Tipler, 1986).

Creationists often attempt to extend this very powerful design argument to astronomical topics as discussed here. But the design argument for the earth-moon system presented here is a much weaker one than is usually presented for biological systems. If the earth-moon system were not unique, or if total solar eclipses did not occur, life would not be imperiled. In other words, while the earth-moon system may demonstrate the Creator's imagination and concern for our enjoyment, it must not be thus for our existence.

Just as Barrow and Tipler define weak and strong anthropic principles, perhaps creationists should adopt the terms weak and strong in discussing design arguments. Many of the astronomical design arguments, including the one discussed here, would be of the weak variety. Even more basic would be a definition of design and a methodology in consistently applying the design argument. At this time it appears that this definition and methodology do not exist, because most people assume that design is readily recognized. If this is the case, then two criticisms readily come to mind. First, many may see design where none actually exists. Second, a sort of circular reasoning may develop where people see design because they know that it must exist, while others of the different persuasion fail to see the evidence.

It is hoped that other creationists join in the discussion to define and refine the design argument.

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The religion that is married to science today will be a widow tomorrow. The sciences in their multiple theories and forms come and go. Biology in the year 2050 may be as different from the biology of today as the religion of today is from the religion of 1850. But the religion that is divorced from science today will leave no offspring tomorrow (p. vii).

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The Critically Important Plants Called Mosses

Jerry Bergman*

Abstract

Mosses were assumed for years to play a minor role in ecology, but we now know they play a critical role in the earth's complex biomass ecosystem. Without mosses and their relatives life probably could not exist on our planet unless the Creator supplied another means to carry out their functions. What was once regarded as an independent class of plants is now recognized as a part of a complex interrelated ecosystem. If any one part is too

seriously disrupted, then the whole is threatened. These tiny plants have design features they share with the rest of the Kingdom Plantae, as well as unique characteristics of their own. Mosses exist in the lowest parts of the fossil record and are not much different today. The lack of evidence for moss evolution is common to most plants and poses a significant problem for evolutionary naturalism.

Introduction

Mosses are probably most well known as the plants that can help persons who are lost in the woods find their way home. One of the first lessons many children used to learn is that moss grows on the north side of trees for the reason that this side is damp and shady. Many types of moss must have moist conditions in order to grow and excessive sunlight is harmful (Raven, Evert and Eichorn, 1986). Moss need at least a damp environment to survive and for this reason bryophytic plants are said to straddle the boundary between aquatic and terrestrial existence (Audesirk and Audesirk, 1996, p. 444). The word *moss* refers to the very small, green, *bryophytic* plants that are classified with the liverworts and hornworts in the phylum Bryophyta (Klein and Klein, 1988, p. 13). *Bryophyte* means "moss plant," *bryon* means moss and *phyton* means plant (Hutchins, 1966, p. 118). They grow in a velvety cluster on rocks, trees, and other moist places.

Mosses are small tree-like plants that do not produce either flowers or seeds but reproduce by means of spores that are spread by the wind (Figure 1). Spores are similar to the seeds of higher plants, but are usually far smaller: so small that a mass of spores actually looks like a dust cloud. In the tips of many "female" moss plants grow *archegonia* in which the eggs develop; in the male plant grow structures called *antheridia* in which sperm develops (Dodd, 1978).

When a film of water, such as from the morning dew, covers the plant, the sperm use their hair-like appendages called *cilia* to swim from the antheridia over to the archegonia. Some of those sperm that make it to the female moss plant then fertilize an egg cell there. From a fertilized cell grows a thin green stalk structure. This structure grows in the top of the archegonial plant where the egg first developed. On the top of this stalk develops a capsule covered by

a lid which contains spores. When the capsule (which functions like a womb) is ready, its lid opens and the ejected spores are then scattered about by the wind. Some types release their spores explosively, others are slowly jostled out by the wind. A spore which falls to Earth in a warm, moist, fertile place develops into a protonema, completing the moss life cycle. This structure produces buds which grow into a small leafy moss plant.

The Gametophyte

Botanists call the green, leafy plant that produces the gametes the *gametophyte*, meaning "the plant body bearing the sex cells." The second stage of the life cycle, the plant that bears the spore case, is the *sporophyte* or "the spore plant." This system by which a plant produces sex cells (the gametophytes) in one generation and then diploid spores (the sporophyte generation) in the next is referred to as *alternation of generations* reproduction. Both ferns and liverworts use a similar life cycle system to reproduce.

The Huge Moss Family

So far, over 16,000 species of mosses have been identified by botanists (Audesirk and Audesirk, 1996). They have been found in almost every part of the world in every kind of habitat, from the Arctic to the Antarctic and even in deserts. Most kinds grow in moist, shaded places. The two main divisions of mosses are the *sphagnum*, often called peat moss, and the *true mosses*.

All mosses lack defined vascular systems to carry fluids to their cells. Instead of tubes, they have spongy structures that use diffusion to move water and nutrients throughout the plant. Sphagnum moss, because it absorbs liquids rapidly, makes an ideal surgical dressing. It also is used for

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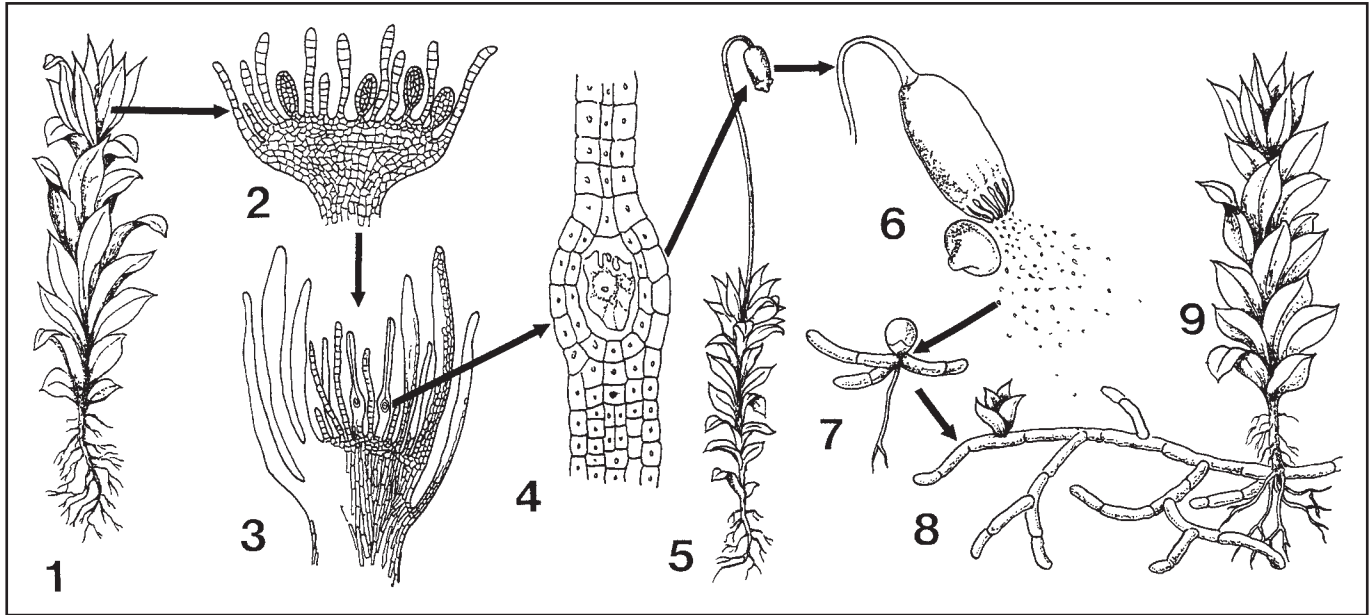


Figure 1. The Life Cycle of the Moss Plant

A typical moss gametophyte plant (1) has at the top either antheridia (2), which produce sperm, or archegonia (3), which produce eggs. The sperm swim through a film of water to the archegonia and fertilize the eggs. The new embryo (4) develops into a moss sporophyte plant, which spends its life attached to the top of the female gametophyte (5). The sporophyte reproduces by asexual spores formed in the capsule (6), and they are dispersed by the wind after the lid of the capsule drops off. Spores that land in a suitable location germinate (7) into a protonema (8). A new gametophyte plant (9) then develops from the protonema (adapted by Rich Geer from Compton's Pictured Encyclopedia, 1987, University of Chicago Press).

packaging plants which must be kept moist during shipping. It grows in large patches in damp meadows, bogs, and swamps. When sphagnum moss grows along the shores of a lake or pond, it often gradually fills up the whole pond with its spongy growth. Growth of sphagnum that has accumulated for thousands of years slowly decomposes and settles to the bottom, forming huge peat deposits. Major peat deposits can be found in England, Ireland and many other countries.

Moss Types and Their Look-alikes

One of the best known true mosses is the haircap moss which grows erect to a height of several inches. Another true moss, the pincushion moss, grows in a dense, round clump. Yet another type, plume moss, resembles a green ostrich plume. The fern moss looks like a tiny fern, but with a heavy spore-bearing stalk.

Mosses are similar to, and thus are sometimes confused with *liverworts*, which also grow in damp places and are of the same green color. Liverworts have thicker leaves that are softer and fleshier than mosses, which usually lie flat on the ground. These leaves have little hair like rootlets on their under surface. Other similar looking plants, although often called mosses, are not classified as mosses by biologists today, include the Irish moss, which is actually a type of seaweed. Other moss look-alikes are the club mosses. They are

related to ferns and are vascular plants, thus classified as *tracheophyta*. Likewise, Iceland moss and reindeer moss are not mosses either but are *lichens* which are symbiotic units of fungi and algae.

The Critical Importance of Mosses

Many people assume that mosses are, at best, a useless member of the plant kingdom or, at worst, a gardener's bother. This is a totally incorrect view of these plants. Without the Mosses and their cousins, the earth's surface would probably be largely solid rock like most of the known planets. They are called pioneer plants because they help to prepare the Earth's surface for higher level plant and animal habitation ("Moss," 1987, p. 502). Microorganisms help initial soil development by slowly decomposing organic matter and forming weak acids that dissolve rock much faster than pure water. Mosses are also among the first colonizers of burned-over forests and grassland, flood, or lava covered land (Nadakavukaren and McCracken, 1985, p. 355).

The very first plants to grow on rocks are often crust-like lichens (Donahue, Miller and Shickluna, 1985). Lichens can grow on solid rock because they need only sunlight, water and a few minerals which they obtain from dissolving the rock they grow on with their acid secretions.

Algae and fungi also soon carpet rock near water or damp areas, and in time they break up the rock enough so that the

mosses are able to follow. As moss plants grow they are held on decaying wood or on rock surfaces by small roots called *rhizoids* which absorb water and minerals. From these simple materials, the mosses manufacture complex organic compounds that allow other plants to grow (Klein and Klein, 1988, p. 16). In this way they serve a critical role in the chain of life. The dead bodies of these plants slowly accumulate, building up "soil," especially in the rock cracks. The process of one plant starting to make soil, and then another taking the process a step farther is called *succession*. Each step makes the soil rich enough for the next higher plant types in the succession process. The mosses and the higher plants together form a material which is fertile enough to support other vegetation. Eventually the plant life can support vegetarian forms of animal life.

Today mosses still function as part of the cycle that produces fertile soil from barren rock. After land is stripped bare of plant life by volcanic eruptions, floods or fire, moss is often a major player in preparing the land for vascular plants again. As Audesirk and Audesirk note:

Succession on dry land takes two major forms: primary and secondary. During *primary succession*, an ecosystem is forged from bare rock, sand, or a clear glacial pool where there is no trace of a previous community.... Bare rock, such as that exposed by a retreating glacier, begins to liberate nutrients such as minerals by weathering. Cracks form as the rock alternately freezes and thaws, contracting and expanding. For lichens (symbiotic associations of fungi and algae), the weathered rock provides a place to attach where there are no competitors and plenty of sunlight. Lichens can photosynthesize, and they obtain minerals by dissolving some of the rock with an acid they secrete. As the pioneering lichens spread over the rock, drought-resistant, sun-loving mosses begin growing in the cracks. Fortified by nutrients liberated by the lichens, the moss forms a dense mat that traps dust, tiny rock particles, and bits of organic debris. The death of some of the moss adds to a growing nutrient base, while the moss mat itself acts as a sponge, trapping moisture. Within the moss, seeds of larger plants germinate. Eventually, their bodies contribute to a growing layer of soil. As woody shrubs such as blueberry and juniper take advantage of the newly formed soil, the moss and lichens may be shaded out and buried by decaying leaves and vegetation (Audesirk and Audesirk, 1997, p. 589).

If an area becomes dry, mosses become shriveled and brown. When water is again available "their tissues quickly absorb it, and they seem miraculously to come to life" (Klein and Klein, 1988, p. 16). Mosses are also important in reducing wind and water erosion (Bold and LaClaire, 1987, p. 83). The peat mosses form peat bogs that are a "conspicuous feature of cold and temperature regions throughout the world." Their importance is indicated by the fact that peat bogs cover "an enormous area equivalent to that of half of the United States." (Raven et al., 1986, p. 298).

Evidence for the Evolution of Mosses

No fossil evidence exists for moss, hornwort or liverwort evolution and consequently theories of phylogeny are based on comparative morphology of living plants (Bold and LaClaire, 1987). Hutchins notes that they have been around since ancient times and have changed little since then (1966, p. 111). In his words they "got in an evolutionary rut and remained there" (1966, p. 111). Beck, in a summary of the literature, notes that they appear very early in the fossil record and have not changed since they first appeared (Beck, 1976).

Little agreement even exists on the general path of evolution that mosses may have traveled. Some believe that they formed a link between water-living plants, others argue that they developed from a vascular plant such as Rhyniophyta by reduction (Bold and LaClaire, 1987, p. 80). Others concluded that they likely evolved from algae and land ferns, but others that it is more likely mosses evolved directly from algae (Hutchins, 1966, p. 118). Yet other researchers argue their origin was either from a monobiontic haploid or dibiontic green algae ancestor.

The reason for the enormous amount of disagreement is that all these views are based on pure speculation, not evidence. This lack of evidence for evolution is not only true of mosses; little evidence exists as to the origin of any land plants. Delevoryas calls green algae "possible ancestors of mosses" but cites no evidence except biochemical similarities of the plant life that he has examined (1966, p. 49). He recognizes that the problems of the evolution of water plants to land life are enormous and we have few clues as to how this did or even could have occurred.

Mosses and liverworts lack a water conducting system, and are for this reason speculated to be a "bridge" between water and land plants. The problem with this explanation is that mosses and liverworts are small and grow in moist places, and consequently do not need a fluid conducting system such as the xylem and phloem of vascular systems found in larger plants. No evidence of evolving vascular systems has been found, only systems designed to meet the individual plants needs. Since mosses are classified as primitive plants and are found very early in the fossil record, the question what they evolved into is also of major concern. On this point Nadakavukaren and McCracken conclude:

The bryophytes appear to represent an evolutionary dead end although the adaptations that developed in this group were sufficiently successful that the bryophytes have survived to this day. For some reason, however, mutations that would have led to the development of more efficient conducting tissue, roots, and cuticle did not appear in the genetic information of the bryophytes, thus limiting them in size and distribution. Modern and fossil species are very similar, indicating lack of change within the group. In fact, the habitat of the group has not really changed from that of the ancestral bryophyte: terrestrial regions with constant or periodically high moisture levels (1985, p. 362).

It is not only the evolution of mosses which has stymied evolutionists, but the evidence for the origin of *almost all plant groups* is totally lacking. Even the evidence for the evolution of the major plant groups is totally lacking. Cronquist concluded that “the origin of angiosperms was an ‘abominable mystery’ to Charles Darwin, and it remains scarcely less so to modern students of evolution” (1968, p. 35). Duddington said “The carnivorous plants are a remarkable. . . group that defeats the imagination when one speculates on how they have evolved” (1974, p. 234). This problem prompted Briggs and Walters to conclude that the evidence for evolution lies primarily in variations within kinds:

Since 1859... with the publication of *On the Origin of Species*, all such studies have been made in the light of Darwin’s profound generalization of evolution by natural selection. Even though this theory has not always been accepted by biologists, it could never be ignored. It is too easy for this generation to forget the tremendous impact made upon biology by Darwin’s work. The fact of evolution is taken for granted, in part because of the wealth of evidence assembled by Darwin and other scientists. There is often at the same time an uncritical acceptance of the theory—it must be true, for it is in all the books. Implicit in Darwin’s ideas is the assumption that evolution is still taking place. Thus in this book we shall not only look at the problems of species and patterns of variation, but also indicate evidence for evolution, particularly evidence, in part experimental, for evolution on a small scale, which is often called ‘microevolution’ (1969, p. 16).

Conclusions

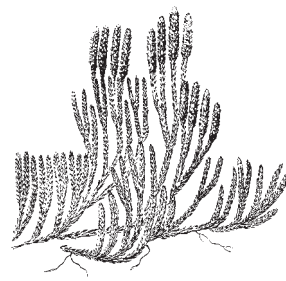
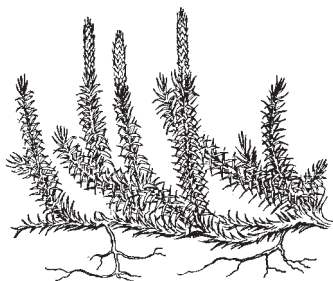
Scientific research on the moss plant family supports the understanding that the earth consists of a complex biomass which has many parts, each one which is critical and without them all life as we know it would be threatened. Evolution must explain the existence of these separately evolving parts. How can it be that each part plays a role in the whole and yet the whole cannot exist without each part. If natural selection selected for the fittest of each type, we would not expect the extensive complex interconnections that exist everywhere in the natural world.

Nor would we expect the enormous variety seen in the moss family unless each variety filled an ecological niche. The variety in the case of moss is due to the enormous gene pools that each created kind possesses. This gene pool allows

certain aspects of the moss phenotype to be maximized or sometimes new traits can be caused to appear by breeding (Moore, 1967, p. 12). This interdependency problem is the same as exists for the animal and plant cell—each part is useless without the whole and each part manifests irreducible complexity. The law of irreducible complexity argues that life could not have evolved because each part of the organism and the ecosystem as well could not exist until all parts were in place and developed to the extent necessary for propagation of life.

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Fossil Wood From Big Bend National Park, Texas (Dawson Creek Region)

Part V—Origin and Diagenesis of Clays

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Abstract

Petrified and charcoalfied woods were collected from the Dawson Creek region of Big Bend National Park. The results of the various tests conducted on the fossils were reported in Parts I–IV of this series along with a creationist interpretation of petrification and charcoalfication. Samples of the clays, in which the fossil woods were located, were gathered with permission of the Park Service.

Tests were performed on the clays to determine their origin and the nature of diagenetic processes acting upon them. The clays are believed to be of volcanic origin. The original volcanic ash was altered to form bentonitic clays. This alteration probably occurred in the late stages of the Flood or soon thereafter in a post-Flood temperate climate in Trans-Pecos Texas.

Introduction

Fossil wood was collected from the Dawson Creek region of Big Bend National Park, Texas (Figure 1) in order to study the material chemically and to examine the structure of the wood. The history of the field work as well as the geologic setting in which the fossils were located was discussed in Williams and Howe (1993). The mechanism of silicification, the possibility of rapid petrification, and an authochthonous vs. allochthonous origin for the fossils were presented (Williams, 1993a). The data obtained from chemical analysis of the charcoalfied and petrified (silicified) wood specimens were reported and then explanations for these phenomena were presented in Part III of the series (Williams, Matzko, Howe, White and Stark, 1993). Throughout the papers, all chemical data and collecting site studies were interpreted within a young earth/Flood model. The fossil wood was examined by optical microscopy and scanning electron microscopy (Williams, Howe, Matzko, White and Stark, 1995). The lack of growth rings in the specimens was noted and explanations were suggested. Also the possibility of a post-Flood climate change was explored and its effect on the silicification of the buried wood was examined.

The investigation of the clays in which the charcoalfied and petrified wood is buried is discussed in this report. We

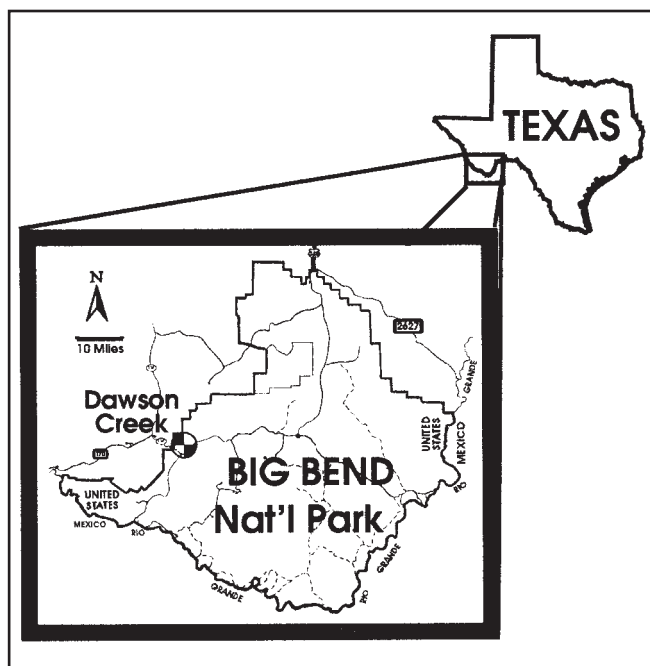


Figure 1. The location of the Dawson Creek region of Big Bend National Park, Texas where the field work in this report was conducted.

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could find no analyses of these clays in the literature, thus we conducted the various tests discussed in later sections to determine the type of clay and its properties. We suggest mechanisms for the origin of the clays to possibly determine the conditions under which the wood was preserved. A glossary of certain geological terms used in this paper is provided after the acknowledgments.

Table I. Clay Collection Sites.

Clay Mound Designation	Wood Type at Locale	Geologic Formation	Reference to Past Reports (See also Part IV of series)
M1 (Figure 3)	charcoalified wood (Figure 4)	Aguja	Part III (Figures 1 and 2)
M2 (Figure 5)	“dark stained” petrified wood (Figure 7)	Aguja	Part III (Figures 5 and 6) Specimen 19
M4 (Figure 8)	“light stained” petrified wood (Figure 9)	Javelina	Part III (Figures 11 and 12) Specimen 25

of the unweathered clay and petrified wood found within the mound are in Table II.

pH Measurements

pH measurements were performed according to ASTM specification D4972-89, Standard Test Method for pH of Soils. The tests were conducted using a HANNA HI9219 microprocessor bench pH/°C meter.

Field Work

Three specific sites in the Dawson Creek region of Big Bend National Park (Figure 2) were chosen from which to collect the clay samples. These locations yielded either charcoalified or petrified (silicified) wood. The type of fossil wood found at each location is given in Table I.

Samples of weathered and unweathered clay were gathered at clay mounds M1, M2, and M4 (Figures 3, 5, and 8 respectively). Two of the mounds (M1 and M4) evidenced colored bands on their exterior surfaces. However, digging into the mounds revealed that all of the unweathered clay in a particular mound was uniformly the same color. The exterior colored bands originated from weathering. This situation is similar to what was experienced by McBride (1974), who attributed the color of certain rocks in northeast Mexico to weathering. Various minerals and organic material present in the rocks determined the color, but the pigmentation was enhanced by weathering processes. Appendix I has an extended quotation from the McBride article.

Materials and Methods

Clay Samples

Weathered samples were gathered from the exterior surface of a mound. Unweathered material was collected at depths of 6 to 12 inches below the weathered surface layer. A LaMotte model EP soil sampling tube was employed in removing the clay specimens.

Clay Color

Color determinations were done using Munsell soil color charts. The colors

Table II. Clay and Petrified Wood Coloration.

Clay Mound	Clay Color	Petrified Wood Coloration
M1	10YR 5/2 (U)* (grayish brown)	None at location
M2	10YR 5/6 (U) (yellowish brown)	3/ (very dark gray) 4/ (dark gray) 10YR 5/2 (grayish brown) 10YR 3/1 (very dark gray)
M4	10YR 7/4 (W) (very pale brown)	10YR 8/2 (very pale brown) 10YR 8/3 (very pale brown) 2.5YR 8/2 (pale yellow)

*U—unweathered
W—weathered

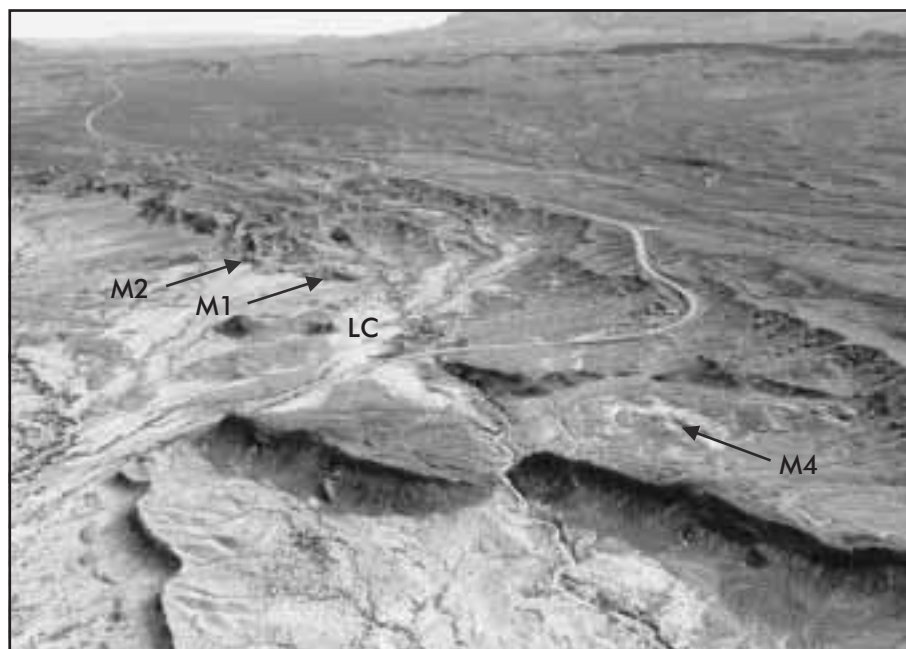


Figure 2 Aerial view of Dawson Creek study area, Park road winds eastward (top of photograph) toward Panther Junction and westward (lower left of photograph) toward Study Butte, Texas. Base of Chisos Mountains can be seen at the upper right of photograph. Dawson Creek, an intermittent stream “flows” from the left center to the lower right of the photograph. The stream bed is normally dry until the runoff from a local thundershower fills it. Clay mounds designated M1, M2 and M4, LC—lone column. Photograph by Robert Goette.

Energy Dispersive X-Ray Analysis (EDX)

EDX measurements were conducted on as-received clay samples per Vaughan (1989).

X-Ray Diffraction of Clays

Where necessary, clay samples were pretreated with 30% H_2O_2 in order to remove any organic material. Each sample then was placed in a separate 500 ml beaker to which 20 ml of 10% sodium hexametaphosphate was added. After standing overnight, the sample was disaggregated in a soil stirrer for five minutes. The sample was then placed in a 1200 ml hydrometer and distilled water was added to bring the volume to 1000 ml. After agitation, the sample was allowed to stand for 20 hours. The upper 10 cm was poured off and the clay fraction flocculated by the addition of 10 ml of 10% MgCl_2 . The magnesium-saturated samples were then concentrated by centrifuging, and slides were made from the resulting slurry. A quantity of 1:3 glycerine-water was added to a portion of the slurry. Slides were also made from the glycerine-treated slurry. Each slide was scanned in a Scintag PAD 2000 x-ray diffractometer equipped with a single crystal graphite monochromator and copper $\text{K}\alpha$ radiation. Identification of the clay mineral phases and their approximate quantization was made employing procedures described in Brindley and Brown (1980) and Pierce and Siegel (1969).



Figure 4. Small piece of charcoalified wood typical of the fossil wood found in mound M1. Photograph by Robert Goette.



Figure 3. Mound M1 as seen from the desert pavement. Dark bands, colored by organic material, in the mound developed by weathering processes. Photograph by Robert Goette.

Test Results

pH of Clays and EDX Spectra

The pH values of the clay samples vary between 3.17 and 8.30. When the clays with low pH values (acid) are compared to the EDX results from the same samples, low pH correlates with the abundance of sulfur in the clay (Figure 10). Likely the sulfur peak on the EDX spectrum indicates that sulfates are present in the clays with a low pH (3.17–4.66).¹ The clays with no detectible sulfur have a weakly basic pH (7.63–8.30) which may be caused by the presence of CaCO_3 in these samples. In examining the EDX spectra of weathered clays, it was noted that the sulfur peak was either weak or nonexistent. Possibly as the clay on the surface of the mound is exposed to the infrequent precipitation in the Big Bend region, the sulfates are dissolved in the rainwater and leached from the clays thus increasing the pH of the weathered material.

X-Ray Diffraction Analysis

Three clay mineral phases were observed in each of the samples (Table III). These included a smectite group mineral (montmorillonite), illite (clay mica) and kaolinite. Quartz was also present in each of the samples. The percentages of each component are semi-quantitative only and in-

¹When collecting either fossil wood or unweathered clay samples during the heat of the day, if the acidic clay comes into contact with a person's hands, blisters can form on the hand because of the acid burn.



Figure 5. Mound M2 as seen from the desert pavement. Photograph by Robert Goette.

dicate the relative abundance of each phase. A typical x-ray diffraction pattern of a clay is shown in Figure 11.

Sample M2 was collected adjacent to the petrified log in Figure 6. The high quartz content may be caused by thermal spalling of quartz particles (Figure 12) from the surface of the log due to weathering processes. Another possibility is that SiO_2 has an affinity for organic material (see Williams, 1993a, p. 107) and a large amount of silica precipitated around the wood as it was petrifying.

Discussion of Results

The clay mounds we investigated are part of the badlands in the Dawson Creek region of the Park. Badlands usually consist of bentonite whose major component is montmorillonite (Mason and Berry, 1959, p. 447). Bentonite originates from altered volcanic ash and has the unusual property of expanding several times its original volume when placed in water (Klein and Hurlbut, 1985, p. 429). Thus when exposed to rainfall, the surface clay particles expand considerably so that none of the water penetrates into the interior of the clay. With no moisture available below the surface, plants are unable to grow successfully in the clay. Thus the term, badlands, is used to describe the barren region.



Figure 6. View of an 18-inch diameter petrified log within mound M2. Clay sample was collected next to the log about 12 inches into the mound. Photograph by Robert Goette.

Table III. Mineral Phases in the Clay Samples.

Clay Sample	Percent Smectite	Percent Illite	Percent Kaolinite	Percent Quartz
M1 (U)*	59	1	1	39
M2 (U)	24	6	12	57
M4 (W)	65	1	3	31

*U—unweathered clay

W—weathered clay

There has been considerable volcanic activity in the Big Bend region (Williams and Howe, 1993, p. 50; Williams, 1993b; Froede, 1995a, c; Froede, 1996; Henry, et al., 1988; Price and Henry, 1988; Henry and Price, 1989; Henry, Price, Parker and Wolff, 1989; Henry, Price, Duex and James, 1992; Henry and Muehlberger, 1996) which evidently generated many regional ash falls.

Next we address the question of whether the volcanic ash, from which the smectite developed, was deposited sub-aerially or subaqueously. Consider the following remarks on this subject by Chamley (1989, p. 411):

The term bentonite originally refers to smectite-rich beds mostly derived from tephra deposits. Bentonites usually correspond to subaqueous, mainly marine, smectite horizons,...



Figure 7. Typical "dark stained" petrified wood found in clay mound M2. Some surfaces of this wood were likely charred before petrification. Six-inch scale is shown. Photograph by Robert Goette.

Christidis, Scott and Marcopoulos (1995, p. 63) listed three possible processes for the transformation of volcanic, mainly glass rocks, to bentonite:

- ...a) *in situ* alteration of volcanic glass in aqueous environment
- b) hydrothermal alteration of igneous rocks and
- c) deuteric alteration of igneous material involving reactions of vapours and gases with igneous mass.

They further commented that many well-known bentonite formations, such as at Sucker Creek, Oregon, Clay Spur bed in Wyoming and Montana and the English fuller's earth deposits, formed "by means of *in situ* alteration of airborne and water transported volcanic ash in relatively shallow lacustrine and sea water respectively (p. 63). Chamley (1989, p. 174) claimed that "Volcanic rocks weather preferentially into smectite, regardless of climatic conditions if there is sufficient water to allow hydrolytic process."



Figure 9. Typical "light stained" petrified wood found in mound M4. Photograph by Robert Goette.

Pollastro and Bohor (1993, p. 22) noted that "Smectite...commonly forms from the alteration of glass in saline or brackish environments (e.g., bentonites)." However Weaver (1989, pp. 153-154) explained that

Montmorillonite can form by the alteration (transformation) of volcanic glass, feldspars, micas, various FeMg silicates and silication of detrital phyllosilicates... Commonly it is difficult to determine if the montmorillonite is detrital or if it altered in place from transported volcanic material. If it is detrital, as in the Mississippi Delta, then the problem is to determine if it formed under continental conditions, soil and lacustrine, or was derived from older rocks. Even for the recent Mississippi Delta deposits it is difficult to determine the



Figure 8. Clay mound M4 as seen from the desert pavement. This mound consists mainly of claystone. Photograph by Robert Goette.

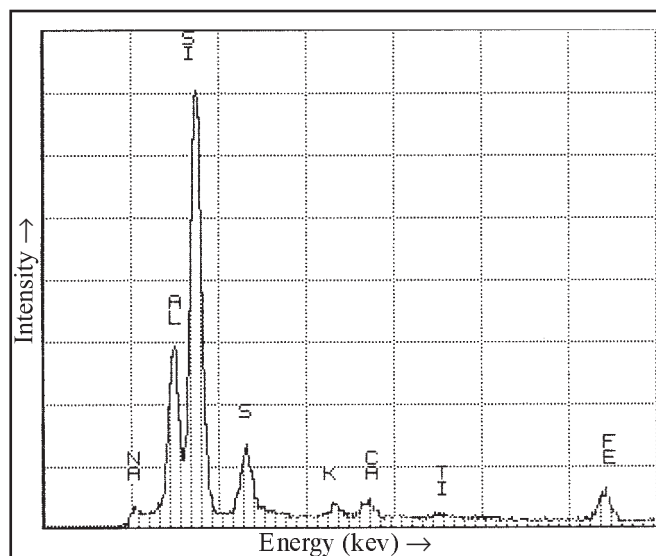


Figure 10. EDX spectrum of unweathered clay sample from mound M2. Note the presence of sulfur peak. Sample has a pH of 3.42.

original source of the montmorillonite. Presumably the ultimate source was primarily volcanic debris created by the extensive Cretaceous to recent volcanic activity in the western United States. This volcanic material was altered to montmorillonite under both continental and marine conditions and tens of millions of years later transported to the delta.

Also Weaver (1989, p. 378), in discussing the large quantity of fresh glass in marine sediments, noted that the volcanic glasses that have been altered to smectite "...are more likely to be from submarine explosions." He suggested that "It now appears that these ash beds, particularly the more acid types, were probably buried to a considerable depth" (p. 378).

Obviously there are many possibilities for the formation of smectite from volcanic ash. To compound the problem, there has been considerable erosion in the Dawson Creek region which has washed away much of the volcanic material that was deposited there in the past. As for the origin of the clays, we suggest the following:

1. The clay in mound M2 was once a deposit of volcanic ash that was transported from a subaqueous eruption in the Cretaceous seaway (actually retreating Floodwater) [see Williams and Howe, 1993, pp. 50-52; Froede, 1995b] to Dawson Creek and the surrounding region. Waterlogged trees, logs and limbs were buried in this deposit and rapidly petrified. The continual retreat of Floodwater from the North American continent eroded the majority of this altered ash.

2. Later a subaerial eruption in the last stages of the Flood (the final retreat of Floodwater) deposited large quantities of hot volcanic ash over beached and waterlogged trees and other woody material that had not been petrified, baking the wood and converting it to fossil charcoal. This ash weathered to form the clay in mound M1. Severe erosion continued during this period as considerable rainfall pro-

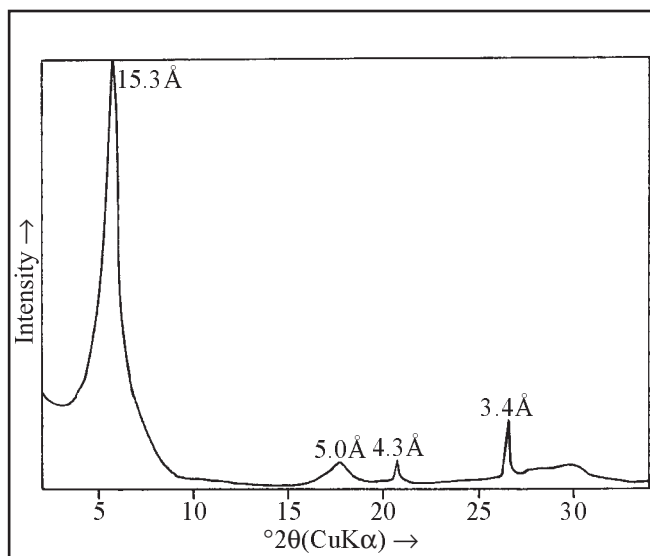


Figure 11. X-ray diffraction pattern of Mg-saturated sample from mound M4: diffraction of x-rays follow the Bragg equation $n\lambda = 2d \sin\theta$ where $n = 1, 2, 3$, etc., λ = wavelength of incident radiation, d = crystal lattice spacing and θ = diffraction angle.

vided ample flowing water to remove much of the newly deposited sediments.

3. Following the withdrawal of Floodwater, the volcanic ash in mound M4 from another subaerial eruption was deposited and altered to smectite in a shallow lacustrine envi-



Figure 12 Scanning electron micrograph of unweathered sample from mound M2. The sharp-cornered particles are quartz shards. Micrograph by William Stark. Magnification 40X.

ronment during the temperate post-Flood era (Williams, Howe, Matzko, White and Stark, 1995, pp. 228-229) in Trans-Pecos Texas. The ash would have covered much of the post-Flood vegetation growing in the Dawson Creek region as well as pre-Flood wood that was deposited in the lake. The Big Bend country likely contained several lakes during this time (Williams and Howe, 1996, pp. 92-94) and both pre- and post-Flood wood would have been petrified under the altered ash.

Erosion along Dawson Creek continues into the present time exposing considerable petrified and charcoaled wood. Thundershower activity activates most of the erosion processes now experienced in the area we investigated.

The sequence of events for the postulated formation of clays is thought to have occurred quickly within a limited time period of possibly several decades. (See Appendix II) The authors realize that the actual conditions that developed in Trans-Pecos Texas late in the Flood and immediately afterward are much more complex than the simple model of clay formation and preservation of fossil wood proposed in this paper. These conjectures are considered a first step in describing the events that may have occurred in one of the most fascinating National Parks in the United States. More field work must be conducted to refine or reject these suggestions.

Acknowledgments

The authors thank the many donors to the Creation Research Society Research Fund, interest from which financed a portion of these studies. Appreciation is expressed to personnel of Big Bend National Park for allowing us to collect the clay samples. The opinions expressed in this paper remain solely those of the authors. We are grateful to Carl R. Froede, Jr. for his help and interest in this project.

Glossary

Claystone: an indurated clay having the same mineralogy and composition of shale but lacking its fabric.

Deuteric: refers to reactions between primary magmatic minerals and water solutions that separate from the same body of magma at a late stage in its cooling history.

Kaolinite: a common clay mineral of the kaolin group: $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$.

Montmorillonite: a dioctahedral clay mineral of the smectite group: $\text{Na}_{0.33}\text{Al}_{1.67}\text{Mg}_{0.33}\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$.

Physil: an abbreviation form of phyllosilicate proposed to apply to all sheet silicate minerals regardless of grain size.

Smectite: a group of expanding-lattice clay minerals of general formula $\text{R}_{0.33}\text{Al}_2\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$ where R includes one or more of cations Na^+ , K^+ , Mg^{+2} , Ca^{+2} and possibly others. The smectite minerals are the chief constituents of bentonite and fuller's earth.

Tephra: volcanic ejecta.

Appendix I

Quotation from McBride, 1974. [p. 760]

Varicolored rocks of the Difunta Group...are composed of detritus derived from a relatively uniform terrane of volcanic rocks and deposited in fluvial, deltaic, and shelf environments. Red, green and purple rocks are restricted to delta-plain facies, whereas the dark colors are present in all facies.

The color of claystone is a function of color mixing of red hematite, green illite and chlorite, and black organic matter; and possibly of grain size of hematite (purple color). Red and purple rocks owe their color to pervasive hematite grain coatings and crystals intergrown with clay; brown rocks owe their color to faint or localized iron-oxide grain coatings; and gray rocks to organic matter and authigenic iron sulfides. Green rocks owe their color to chlorite and illite and to the absence of hematite, organic matter and sulfides. Olive and yellow claystone colors are imparted by color mixing of green clay and black organic matter.

Field relations and petrographic studies indicate that red and purple colors originated through postdepositional reddening of sediment, in part in soil zones on the delta plain, in a sub-humid to semi-arid climate that had seasonal wet and dry periods. Reddening occurred both by aging of hydrous ferric oxide plus staining of grains by hematite pigment formed by oxidation of detrital iron oxide and mafic grains. Some brown siltstone beds were pigmented in a manner similar to red beds, but other siltstone beds developed brown color upon weathering. Green beds formed by bleaching of red (or proto-red) beds by interstitial percolation of reducing water derived largely from fluvial channels overlying the green beds. Olive and gray claystone are predominate in marine facies that contain abundant organic matter and in some delta-plain facies where destruction of organic matter was incomplete.

Appendix II

Rapid Weathering and Hydrolysis of Volcanic Ash

We postulate that the weathering of volcanic ash into clay occurred quickly in the Dawson Creek region of Big Bend National Park. We believe that the original ash was ejected from explosive volcanic eruptions during the waning phase of the Flood or soon thereafter. Thus there was ample water and atmospheric moisture available for hydrolytic processes to operate on the ash.

Weathering progresses faster on volcanic material than on other types of rocks (Chamley, 1989, p. 38). The particle size of ash ejected from volcanic explosions is generally quite small and this increased surface area per unit volume would encourage rapid hydrolysis. Since volcanic ash weathers preferentially into smectite if there is sufficient water to allow hydrolytic processes (Chamley, 1989, p. 174), the availability of water and the fine particle size of the ash would result in rapid alteration. It has been observed that well-crystallized smectite forms on volcanic material as soon

as weathering commences in temperate warm and subarid climates (Chamley, 1989, p. 39). The Big Bend region likely had a warm, and temperate climate soon after the Flood.

Time itself may not be a factor in the alteration of volcanic ash. For instance, glass shards from volcanic activity found in a Mesozoic sediment often were unaltered whereas much of a similar volcanic debris in Quaternary deposits was transformed into smectite (Chamley, 1989, p. 352). We do not accept the uniformitarian time table, but if time is the sole factor in the alteration of volcanic material into clay, then the (older) Mesozoic shards should be in an advanced state of alteration compared to the (younger) Quaternary debris which is not the case.

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Notes from the Panorama of Science

A Study of the Erosion Rates of Several Kinds of Rock

Introduction

Erosion on the surface of the earth is a widespread and pervasive phenomenon. Therefore, the rates of erosion of various rock types are of importance for the understanding of geologic processes. The rates are noticeably slow for most types of rocks, as can be witnessed from the weathering of historical monuments and buildings over hundreds or thousands of years. Some gravestones have become unreadable in just a few centuries. Rephotography of scenes can provide a baseline of over a century for evaluating the minor shrinkage of some rock surfaces. The surfaces of some road and railroad cuts through rock show noticeable weathering in decades. The generally slow rates of erosion of most rock types has been used by uniformitarians to justify their rejection of the young-earth scenario. If the rocks in ancient Greek and Roman buildings have lost only a few percent of their mass in a time period approaching half way back to the Flood, then how can entire mountain ranges be destroyed in less than millions of years under conditions similar to those of today.

While such historical indicators of weathering provide long baselines of time, compared to the elapsed time from the Flood, initial measurements of rock mass and dimensions are generally not available. Therefore estimates of the rates of erosion may be of limited accuracy. Laboratory measurements over time spans comparable to a year can be of high accuracy, but the changes may be so small that extrapolation to long time periods may be risky.

In order to directly assess the shrinkage of rocks the author conducted two experiments. The several rock samples used in these experiments came from local lumber yards and from donations. I assume that typical river beds contain one or more of these common rock types. In one experiment, eight rock types (five samples each) were tumbled with mud, sand and water for eight hours in a cement mixer, simulating what might be happening in a gravel stream bed of a swift river. After eight hours of tumbling, the 40 samples were rinsed with clean water and air dried for over one week. The samples were individually weighed and photographed. Another eight-hour run was performed on the samples. This process was repeated consecutively for 24 hours. The results together with mathematical analysis were published in the *Creation Ex Nihilo Technical Journal* Volume 11 (Part 3), 1997, pp. 335-343.

Two drawbacks were noted in the tumbling experiment: The rock samples were forced to erode by tumbling and the measuring balance is only accurate to the nearest gram. A new experiment was designed to correct the two apparent deficiencies. In this experiment a falling stream of water was directed at a container of the eight rock types (four samples

each) that were weighed to the nearest 0.01 gram. Exposure times amounted to only two days. Yet shrinkage of each rock sample was detectable in the experiment.

Tumbling Experiment

To simulate a fast running stream, eight types of rock, listed in Table I, were tumbled together with mud, sand, and filtered tap water in a cement mixer operated at about 60 cm/sec. About every eight hours the rocks were rinsed, air dried for two to three weeks, photographed and weighed to the nearest gram. The weights of the stones were observed to decrease either linearly or exponentially. Table I lists the fractional weight losses per day and the calculated number of days for the rocks to turn to sand or mud.

Table I. Summary of the erosion of rocks using a cement mixer.

Rock Type	Average % Losses in One Day	Days to Turn to Sand/Mud	Curve Fitting Correlation Coefficient
Norco Granite	24.14	6.25	0.956183
San Bernardino Mountain Granite	28.86	5.00	0.898027
Box Springs Granite	42.14	6.83	0.882341
Mexican Beach Rock (Metasediment)	12.48	12.08	0.982708
White Calcite Rock (limestone)	94.37	1.08	0.940019
California Desert Rock (ironstone)	30.83	6.21	0.976187
Lava Rock (scoria)	46.50	3.58	0.774597
Sandstone	40.60	3.50	0.979796

If exponential decay curve fittings were taken, then the number of days to turn into mud or sand will be about four times that given for the linear curve fittings.

These results show that an environment rich in energy can degrade rocks to small detritus in a short time, in a matter of weeks or years, far shorter than evolutionists would like to think. If the rainy season persists for a couple of months each year, then the tumbling experiment could simulate the actual fast running streams. This may be one reason why practically all pebbles are somewhat rounded. Since I still see a myriad of pebbles in all streams, the time span from their formation to the present could not be millions of years. Some evolutionists claim that the rate of erosion equals the rate of uplift (Fiero, 1986, p. 55). If this is so, then deep gorges or canyons should be found in the upper sections of every river!

Falling Water Experiment

Four cobbles of each of eight rock types were exposed to a stream of falling water. The samples were placed in the plastic container having an 8.3 cm diameter opening, as shown in Figure 1. Water from a hose fell into the container from a vertical and horizontal distances of 176 and 50 cm, respectively, as illustrated in Figure 2. The diameter of the stream was about 1 cm at its midpoint. Simple physics indicates that the water should have a speed of 5.9 m/s as it hits the rocks after a fall time of 0.6 s. The speed of 5.9 m/s corresponds to the lower speed of a typical fast running stream (Leet and Judson, 1965, p. 136). Brief changes in water pressure and wind speed sometimes caused the stream to miss the rock container. Therefore, the results are a minimal result.

The rocks were stacked in the plastic container with the softest rocks on the bottom and the hardest on top. After each eight-hour period, for a total of 48 hours of exposure, the rocks were air dried for two to three weeks, and then individually weighed. The scale used in this experiment was made by Ohaus (Scout Electronic Balances Model No. SC2020). Its electronic measurement had an accuracy of 0.01 g up to a 200 g capacity. Individual rocks were identified by their weights. Two types of rock, the California desert rock and the sandstone, gained weight from the soaking, so the drying time had to be a week or two. In fact, they were weighed consecutively for three weeks before another run took place. The rocks were photographed before and after each eight-hour exposure. Figure 3 shows the rocks after 40 hours of exposure to the falling water. Shrinkages were not detectable photographically.

Table II gives the average fractional mass loss after a total of 48 hours of exposure for the four samples of each rock type. Extrapolating linearly that loss at the same rate to a year's time and inverting, the approximate number of years to consume the rocks is given in the right column. If exponential decay curve fittings are employed, then the number of years will be approximately four times longer than what are listed below.

Though the extrapolation from two days to years is not very sound, it at least shows that individual cobbles can have a limited life span in an environment of water flows at a

Table II. Summary of the erosion of rocks using falling water.

Rock Type	Average % Losses in 48 hours	Years to Turn to Sand/Mud
Norco Granite	0.32	1.7
San Bernardino Mountain Granite	0.26	2.1
Box Springs Granite	0.29	1.9
Mexican Beach Rock (Metasediment)	0.09	6.1
White Calcite Rock (limestone)	1.28	0.4
California Desert Rock (ironstone)	0.46	1.2
Lava Rock (scoria)	3.03	0.2
Sandstone	0.53	1.0



Figure 1. Eight types of rock samples in the plastic container.



Figure 2. Experimental setup. The vertical and horizontal distances are 176 and 50 cm, respectively.



Figure 3. Rock samples after 40 hours of erosion using the apparatus of Figure 2.

magnitude similar to this experiment. But if the water currents cause the rocks to roll on the bottom of the river, then considerable less time would be needed to disintegrate the rocks.

Implications

These two experiments have shown that detectable erosion of rock cobbles can be measured after days of treatment by tumbling or impaction of a stream of water. Total consumption of the rocks, according to an extrapolation of the rates of erosion ranges from days to years. Though such extrapolations are crude, they indicate that rocks will not last thousands or millions of years under such conditions. The more energetic conditions during the Flood and on through the Ice Age would have enhanced the deterioration of rocks

in fluvial conditions. These simple results suggest that more sophisticated erosion experiments should help demonstrate that there are rapid geologic processes that are more consistent with a young earth: thousands rather than billions of years old.

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Panola Mountain, Georgia: Exfoliation Evidence in Support of Flood Exposure

Introduction

The Southern Appalachian Mountains have undergone at least one major mountain-building cycle. Tectonism during this period is believed to have created heat conditions sufficient to melt buried sedimentary and metamorphic rocks forming granitic magma. The erosion of the overlying rocks resulted in the eventual exposure of the granitic pluton. Uniformitarians suggest that all of this activity occurred over the course of millions of years. However, we suggest that this process was of short duration and associated with the Flood (Froede, 1995a, 1997). An examination of the exfoliation and weathering of one of the exposed granitic domes, Panola Mountain, helps us test this hypothesis.

Panola Mountain, Georgia

Panola Mountain, located in Dekalb County, Georgia, is one of many granitic plutons (e.g., Stone Mountain, Davidson-Arabia Mountain, Little Stone Mountain) found within close proximity to Atlanta, Georgia. It rises 200 feet above the surrounding topography (Figure 1). This granitic pluton is believed to be similar to nearby Stone Mountain in terms of its origin, emplacement, and subsequent exposure (Atkins and Griffin, 1977). Froede (1995a) has previously presented a creationist interpretation for the origin and

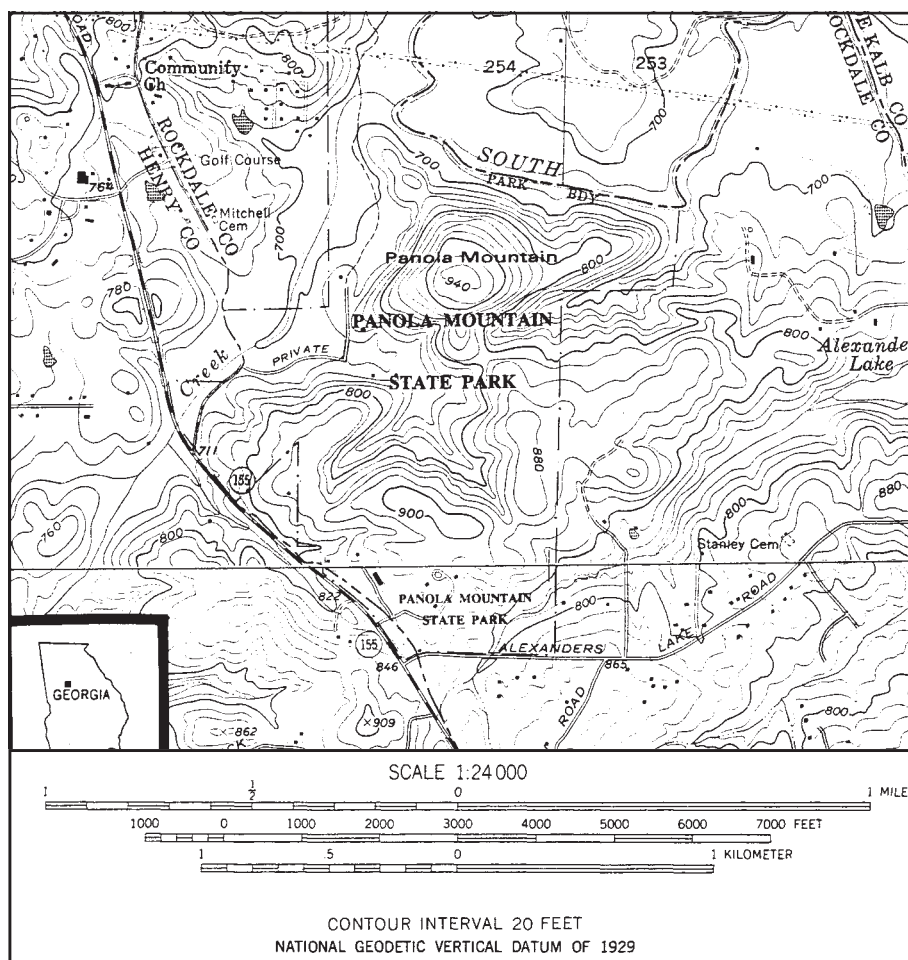


Figure 1. Composite U.S. Geological Survey topographic map showing elevation and features of the Panola Mountain location. The site is located approximately 15 miles southeast of Atlanta, Georgia. The base of the geomorphic feature known as Panola Mountain is defined by the 820 foot contour. However, the Panola Mountain Granite is found across a much broader area.

Figure 2. Graphic representation of the steps postulated for the creation of Panola Mountain.

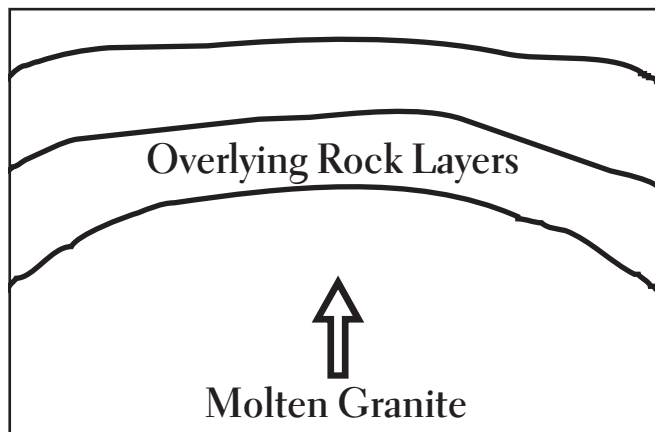


Figure 2A. The granitic magma is both created and emplaced during the Flood due to tectonic activity. Overlying layers impeded the upward movement of the magma.

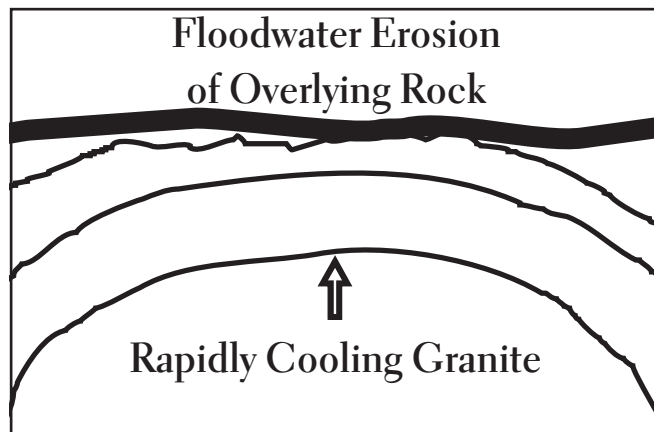


Figure 2B. Erosion of the overlying rocks reduces the confining pressure of the rapidly cooling granite. This allows the expansion of the granite to begin in the direction of the released confining pressure (note arrow direction).

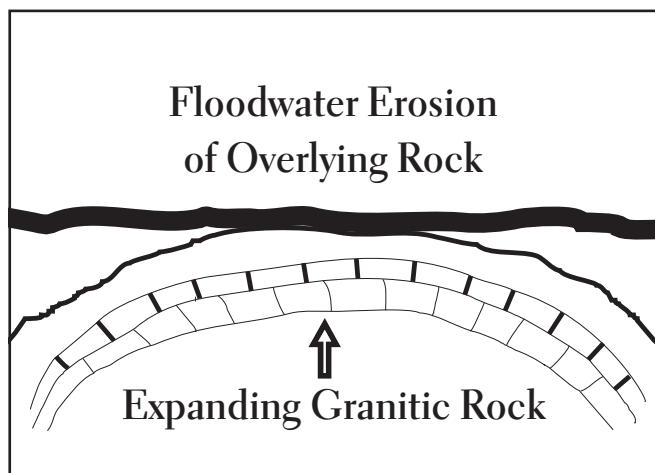


Figure 2C. As the granite continues to cool and crystallize it also continues to expand. This results in the formation of joints and fractures in the granite. Joints are displayed as thin lines and fractures as heavy lines. Eventually the rock will separate along joints and this results in exfoliation.

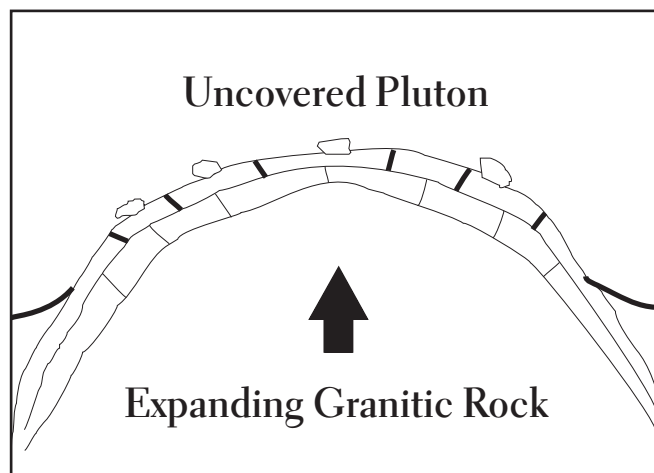


Figure 2D. Today's conditions at Panola Mountain. Individual exfoliation sheets and blocks found sporadically across the mountain suggest that there is much missing material. This missing talus is not found around the base of the mountain—where is it? We suggest that Floodwater removed it.

emplacement of nearby Stone Mountain.

Panola Mountain is one of many isolated granitic plutons (i.e., monadnocks) exposed within the inner piedmont of the Southern Appalachians. One major difference between Panola and the other granitic plutons is in its granitic texture and composition. The Panola Mountain Granite is regarded as biotite rich. Hermann (1954, p. 96) described the Panola Mountain Granite as:

... a coarse-grained, porphyritic biotite granite with microcline and biotite phenocrysts up to one-eighth of an inch in diameter. A small amount of magnetite is

scattered throughout the rock. The stone is poor quality for quarrying because of the many fractures filled with epidote and chlorite.

This difference in composition and texture between the Panola Mountain Granite and other granitic plutons in the area is attributed to a difference in the original source materials. Panola Mountain Granite is believed to have been emplaced at a greater depth, and was mixed with significant amounts of rock materials from mafic (iron-rich) sources when compared to the other granitic plutons, such as Stone Mountain.

Exfoliation

The emplacement of the original granitic magma into the overlying rocks required great pressure. However, this pressure was not sufficient to result in a volcanic eruption. Uniformitarians propose that following emplacement, the magma slowly cooled in place. The removal of the overburden served to release the confining pressure on the granitic mass, and allowed it to expand in the direction of the released confining pressure. Such expansion has been noted and documented at Stone Mountain (Dale, 1923, p. 30). The expansion of the granite results in the formation of joints and fractures in the rock which later serve as planes of exfoliation (Figure 2). Further jointing and fracturing of the

granitic mass results in its breaking into sheets and blocks. Under the influence of gravity these broken rock layers slide toward the base of the mountain.

There are only a few large blocks/sheets of exfoliated granite found around the base of the Panola Mountain outcrop (Figures 3, 4, 5, and 6). One explanation that might be suggested to account for the "missing" granitic rock could be that it was removed for use in local construction (Note: This granite is not of high quality, and would not likely be used for construction or ornamentation). If it were removed for use this type of use we would still expect to see some of the larger blocks/sheets which could not have been moved. Few were noted. What has happened to the expected but missing exfoliation sheets and large blocks?



Figure 3. Small area of exfoliation blocks near the top of the mountain. Note people on right for scale. These blocks are eroding in place - they are not moving in any measurable manner. The adjacent blocks associated with this layer are missing.



Figure 4. Large sheet slowly moving down the side of the mountain. If the millions of years of unroofing have occurred as the uniformitarians have postulated then the mountain should be covered with these sheets (see Figure 2C). Instead we find isolated individual sheets/blocks scattered across the mountain.



Figure 5. Large block of granite. This block is actually broken into three separate pieces and is hundreds of feet away from any other exfoliation layer. Where is the adjacent rock layer that this block was once a part of? Likely it has been removed from Panola Mountain by catastrophic force.



Figure 6. Large sheet of granite which has weathered from rocks at a higher elevation on the mountain. This sheet has moved to lower elevations and is now proceeding to weather into sand and clay, in place. Again, if millions of years have passed since its unroofing then we would/should expect to see far more exfoliation sheets/blocks than were observed.

Discussion

The Panola Mountain pluton provides us with a place to test a portion of the uniformitarian model for granitic pluton exposure and erosion. In following the uniformitarian history, the outer surface of the mountain should reflect many millions of years of weathering. We would also expect to observe the mountain surface and base covered with exfoliation sheets/blocks due to extensive long term weathering. Instead we find isolated granitic sheets/blocks resting on the mountain surface with no hint as to where the adjacent missing layers have gone. Uniformitarian scientists cannot explain why there is so much missing talus. We have attended lectures held by a uniformitarian geologist who is an authority on Panola Mountain. He has commented on the fact that there should be more granitic debris at the base of the mountain, than is presently observed. He offered no possible solutions to this enigma.

The Young-Earth Flood model requires the origin, emplacement, unroofing, and exposure of granitic plutons such as Panola Mountain within short time frames (e.g., Walker, 1994, Froede, 1995b). We propose that tectonic processes associated with the Flood generated a granitic magma in the shallow subsurface. This magma was then forced upward into the overlying rocks. Following this, the granitic mass cooled quickly (see Snelling, 1996). The submerged ground surface within this same area experienced rapid erosion by moving Floodwater. This erosion removed the overburden that covered the rapidly-cooling granite, and exposed it to the overlying Floodwater. This caused even greater cooling and resulted in jointing and fracturing. During this time expansion and related exfoliation of the granite caused much of the outer layer(s) to be broken apart and washed away. With eventual Floodwater withdrawal, the granitic mass was subject to the wet weather conditions associated with the Ice Age (Oard, 1990), causing continued exfoliation. These weathering processes have continued at ever decreasing rates (Reed, Froede, and Bennett, 1996) in the moist temperate climate of north-central Georgia resulting in further (albeit minor) exfoliation.

Due to the postulated short period in which all of this occurred, we would expect to observe fewer exfoliated sheets/blocks across and around the mountain (Figure 2D). Most of the exfoliated layers/blocks are missing due to Floodwater removal.² Because of the recent exposure of the outer granitic surface (within the Young-Earth Flood model), Panola Mountain shows only the ravages of four to six thousand years of weathering.

²This setting should be repeated at every exosed granitic pluton if they were unroofed, and the outer exfoliated layers were removed during the Flood. This could be one way of dating the unroofing of the granitic pluton(s) to the Flood-Event Timeframe (as opposed to a pre-Flood or post-Flood setting). Additional investigations are required to validate this concept.

Glossary

- Monadnock:** An upstanding rock, hill, or mountain of circumdenudation rising conspicuously above the general level of a peneplain in a temperate climate, representing an isolated remnant of a former erosion cycle in a mountain region that has been largely beveled to its base level.
- Phenocryst:** A term suggested for a relatively large, conspicuous crystal in a porphyritic rock.
- Pluton:** An igneous intrusion—the term implies a deep-seated body of granitoid texture.
- Porphyritic:** The texture of an igneous rock in which larger crystals (phenocrysts) are set in a finer-grained ground-mass.
- Tectonism:** Synonymous with diastrophism. A general term for all movement of the crust produced by tectonic processes, including the formation of ocean basins, continents, plateaus, and mountain ranges.

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Letters to the Editor

Did Certain Members of the Order Marsupialia Lay Eggs?

Marsupials go through a stage in their development in which a horny shell covers the egg. This shell persists until about the last third of pregnancy. An egg tooth and a caruncle are also present in Marsupial embryos. Hill and De Beer (1950, p. 526) describe a shell membrane of marsupials which increases in thickness in the uterus as is the case with the Monotremes or egg-laying mammals.

Lillegraven (1979, pp. 262-263) points out these same features. On page 265 Lillegraven also draws attention to the fact that Marsupials are born with a reptile-like articular-quadrant jaw joint.

In reply to these arguments for embryonic recapitulation and macroevolution, I note that all these features occur in the reproductive development of modern Monotremes. The only thing that is missing in the Marsupials seems to be the last third of the egg shell development. By way of analogy certain reptiles are born in a sac and therefore lack an egg shell and certain frogs are born looking like miniature forms of the adult. This demonstrates that some changes in reproduction can occur and yet those creatures (reptiles or frogs) are still within their respective created kinds.

My view of a Genesis kind is that it is the basic plan and that it does not consistently conform to any particular hierarchical level in the taxonomic system. It often says in Genesis that God created them according to their kinds and I believe this means He created them according to various plans or designs. Reproduction is a secondary factor. When certain races of leopard frogs mate, for example, no offspring is produced and yet they are only races, not even species. Clearly reproduction will not necessarily happen between all members of the same "kind." This is because the kind is the plan so that the absence of reproduction between two forms does not necessarily mean they are evolving apart from one another or that they are of different kinds (Joy of Knowledge, 1990, p. 599).

The same negative outcome occurs when two very similar forms of hawk moth are mated—no offspring arise from the cross (Leakey, 1979, p. 33). On the other hand, offspring are produced when camels of two quite distinct species mate or in the recent case where offspring arose from a cross be-

tween a camel and a llama (Ingham, 1998, p. 15). The females from the mating were fertile and the males infertile. Clearly the physical differences between camel and llama did not prevent the basic plan from being produced. God could have created all the various forms of camel and llama at the start or He may have formed one (or only a few) of them from which the others arose later. I believe most of this variation came by means of adaptation after the first creation of the camel group.

Getting back to Marsupials, however, my point is that extinct members of the Marsupialia order could have laid eggs without having gone beyond their kind. I am not saying for certain that they did, but that if certain fossil Marsupialia did lay eggs, this would do no violence to the concept of creation "after their kinds." I invite further comment on these issues and I believe they warrant further research by creationists.

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The Mere Creationists

A new organization, the Mere Creationists, held its first conference in November, 1996, at Biola University in La Mirada, California. They are considered the "upper tier" among creationists, others being less scholarly and not as accurate in their research. They are anti-Darwinists in the sense that they recognize the structures and functions of living things are too complex and intricate to have come about by Darwinian natural selection.

Perhaps the most renowned of the participants at the conference was Professor Michael Behe. He discussed the almost unbelievable mechanism that rotates a flagellum of a bacterium. He calls it a complete outboard motor with a driveshaft, stator, bushing, and other necessary features. If any one of the parts is missing or imperfect, the flagellum could not operate. It is inconceivable that the parts could have come about one at a time by mutations and natural se-

lection. Yet Professor Behe himself sets the record straight on page five of his popular book, *Darwin's Black Box*, that he is an outright and complete evolutionist.

Another outstanding speaker, Professor Philip Johnson, author of *Darwin on Trial*, said he recommends putting Biblical issues aside when discussing the creation/evolution issue.

Most of the Mere Creationists are old-earthers and many of them are members of the American Scientific Affiliation. Judging by the tapes of the lectures, they are starting out with an acceptance of evolution which it took the ASA about 15 years to reach. The idea of a statement of faith was

rejected. One person in the audience identified himself as a "non-theist."

And Dr. Hugh Ross, with all his scientific errors and theological heresies, is one of them! He encouraged the scientists in their effort to create life and told them they have only about five million years in which to accomplish this. One thing seems certain—he is not expecting the soon return of the Lord.

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The Heat Issue Within Catastrophic Plate Tectonics

Catastrophic Plate Tectonics and Supporting Evidence

Several years ago a group of creation scientists (Austin, Baumgardner, Humphreys, Snelling, Vardiman, and Wise, 1994) proposed that creationists could transfer many concepts of uniformitarian Plate Tectonics (PT) to a young-earth approach identified as Catastrophic Plate Tectonics (CPT). This theory is based on extensive computer modeling (Baumgardner, 1986, 1990, 1994a, 1994b) coupled with information gathered and processed through the framework of evolutionary PT theory (Austin, et al., 1994, p. 610). Since its proposal, very little evidence has been offered by this group to support this complex catastrophic tectonic theory (e.g., Austin et al., 1996; Snelling, 1995a).

Uniformitarian PT is tightly intertwined with evolution and vast periods of time. The CPT theory cannot build on this same evolution-supported model/dataset without fully integrating it into the framework of the Biblical record (Froede, 1995; Reed, 1996a, 1996b; Reed and Froede, 1997; Reed, Froede, and Bennett, 1996).

What Happened to the Generated Heat?

CPT appears to be obtaining considerable acceptance by creationists (e.g., Humphreys, 1997; Lester, 1997; Snelling, 1995b), even though as a theory it has not yet addressed any serious issues. For example, CPT proposes that all of the modern oceanic basins were formed during the Flood. What happened to the heat generated during this period?

PT theory does not have a problem with heat generated at mid-oceanic spreading ridges. It is simply absorbed by thousands of feet of overlying seawater over the purported millions of years of slow sea-floor spreading. PT theory proposes that basalt which is erupted (i.e., extruded) along the Earth's mid-oceanic ridges forms the floors of the various ocean basins. Typically, basalt is extruded along these ridges at temperatures ranging from 1000 to 1200°C (1832 to 2192°F). CPT proposes that the present ocean floor formed quite rapidly and the extruded basalt might actually have attained temperatures up to 3600°C (6512°F), depending on the depth from which it originated in the mantle.¹ This

freshly-extruded basalt ocean floor covering slightly more than 75 percent of the earth's surface, would generate intense heat, perhaps sufficient to vaporize the overlying Floodwater. It would be beneficial for the proponents of CPT to model the heat transfer required to cool the CPT oceanic crust.

Conclusion

A significance difference between the PT and CPT theories is in the management of heat generated as a result of sea-floor spreading. The tremendous loss of heat generated as a result of sea-floor spreading during the Flood remains poorly modeled and explained within CPT theory. Until additional information is provided to make clear these types of differences between the models, I suggest that we maintain a position of balanced skepticism. Creationists should continue to investigate CPT and other tectonic options/models (global or otherwise) in an effort to explain these types of forces in effect during and following the Flood.

Acknowledgements

I thank Dr. E. L. Williams and Dr. J. K. Reed for their review and comment on this letter. Any mistakes which remain are my own. My wife Susan deserves special thanks for allowing me the time to write this letter. Glory to God in the highest (Proverbs 3:5-6).

¹This temperature range is based on the differences believed to occur within the upper and lower sections of the mantle. If the basalt was derived from even deeper levels (i.e., molten outer core) then the temperature could have even approached 4200°C (7592°F). Temperatures are taken from Decker and Decker (1997, p. 35). CPT computer modeling appears to suggest that basalt could have been derived from deeper sections of the mantle due to the displacement caused by the former plates being subducted to the outer core. However, PT proposes that mid-oceanic ridge basalt is only derived from the upper mantle (Another unresolved issue within CPT).

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Editor's Comment

In 1990, the Quarterly published an article by Dr. John Baumgardner (The imperative of non-stationary natural law in relation to Noah's Flood. *CRSQ* 27: 98-100). The article discussed the evidence for plate tectonics and pointed out "...the problem of how to cool the mantle by that much in the brief period of time since the Flood." Hence, Mr. Froede's letter does not point out a new problem, but nevertheless one which needs attention.

Invasion of Siberian Crabs

Northern Norway has been invaded by Siberian immigrants. According to a *News of Norway* article ("Norway invaded by crabs," 1997), the Alaska King Crab, known in Europe as the Kamchatka Crab, has expanded its range into the fjords of Finnmark fylke from Russia's Kola Peninsula over the past decade, a distance of approximately 500 km (300 miles), having originated in the Russian Far East approximately 8,000 km (5,000 miles) distant. When *Paralithodes camtschatica* reached the Kola Peninsula is not known. It is reported that individual crabs return to the same breeding grounds from year to year, resulting in little mixing of stocks (Browning, 1974, p. 21). The Associated Press re-

port cited in *News of Norway* said the Kamchatka Crab is called the Red King Crab in Alaska, while Alaskan fisherman describe three types: red, blue, and golden or deepwater. Only the red and blue are classified as *Paralithodes camtschatica*. It is not clear from the report whether only the red phenotype has appeared in the waters around Nordkapp. The Norwegian report describes the crabs as reaching 15 pounds and three feet claw-to-claw, while Alaska fishing reports indicate much larger crabs being taken. It may be that one figure is a mean, the other a maximum.

It is remarkable that an expansion in range has occurred at all. *Paralithodes camtschatica* dwells at a depth of approxi-

mately 100 fathoms (200 m), and since a significant migration has apparently occurred along the Arctic coast over the past several decades, a coast along which human activity has largely been limited to pollution, the range expansion does not appear to be induced by human activity. The rate of range expansion is also remarkable considering the crab's relatively slow locomotion and inflexible feeding and breeding habits.

The range expansion exhibited by this overgrown crustacean intimates several interesting implications. The first is the lack of equilibrium in Arctic marine faunal populations. The Arctic Ocean is probably one of the least disturbed environments one could study, yet marine populations are dynamic. Is this what one would expect if these creatures had inhabited these regions for many thousands of years? Climate change does not appear to be a factor, since this increase in range does not coincide with any change approaching the warm period 1000 years ago or the "Little Ice Age" that followed, let alone the end of the "Pleistocene" ice age. To what extent should paleoecological and paleogeographical theories be accepted when they are dependent on the fossil record? Could any fossil sequence that may exist record such sudden biogeographic changes as this? Evolutionists often envision rapid genetic changes and increase in genetic information (i.e. biological evolution) occurring in small, isolated populations. Is this reasonable? One might envision islands serving this purpose for land vertebrates, but what of the oceans? Would giant crabs evolve in isolated pools? What of whales?

Some research has been conducted on the genetics and distribution of land vertebrates in the postdiluvian period, e.g. that of Woodmorappe (1993). Has any similar work been done on postdiluvian marine biogeography? This is no doubt more complex, since polytypic baramins could be common. Do the red and blue phenotypes of *Paralithodes camtschatica* represent normal variation within a relatively homogeneous population or a postdiluvian development resulting from reduced genetic variability in isolated stocks? Is the golden or deepwater king a member of the same baramin? What does the rapid expansion of the range of the king crab imply for other migratory creatures such as salmon and birds? How quickly after the Deluge could these migration routes and breeding grounds have become established?

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Reply to P. V. Vorpahl's Article "Predators and Paradise, One More Time"

Vorpahl's article in the September 1997 issue of the Quarterly made two statements I agree with, "...the Scripture has absolute integrity," and, "There may indeed seem to be a tension between the created order with its obviously vegetarian diet and the 'real' world which we occupy." But I disagree with his statement concerning Adam and Eve that, "There is no scriptural basis for their ever having spent a single night within the confines of the Garden."

At the end of creation day six God looked at what he had made and pronounced it "very good." How could God have said that if Adam and Eve had already sinned? Therefore I believe they spent the night after the sixth day in the Garden.

Then we are told that "on the seventh day God ended his work which he had made; and he rested on the seventh day." What kind of rest might God have had if the ones whom he had created in his own image had already sinned? Chapter three of Genesis relates the story of Adam's and Eve's Fall. On that day, whenever it was, God worked. Thus, the Fall could not have happened on the seventh day. Therefore I believe they spent the seventh night also in the Garden. Thus it appears there is a "scriptural basis" for spending an unknown number of nights in the Garden.

Vorpahl also wrote, "...so an abbreviated time span between Creation and the Fall would allow animals physically and mentally equipped for a carnivorous lifestyle to capture and consume the prey with which they were matched... without the necessity of... ingesting food for which their digestive tracts were simply never designed."

Genesis 1:29-30, "And God said, Behold, I have given you every herb bearing seed, which live upon the face of all the earth, and every tree, in the which is the fruit of a tree yielding seed; to you it shall be for meat. And to every beast of the earth, and to every fowl of the air, and to every thing that creepeth upon the earth, wherein there is life, I have given every green herb for meat: and it was so."

When we believe Vorpahl's statement that, "the Scripture has absolute integrity," we must conclude that if God's creation was very good, then when He laid out the diet for every creature, He also must have "physically and mentally equipped" them for the diet he gave them. Their digestive system had to be designed to handle vegetation.

A time is coming when, "The wolf and the lamb shall feed together, and the lion shall eat straw like the bullock." (Isaiah 65:25) At Creation, God made the lion and gave him a vegetarian diet Scripture is very clear on that. Lions now

eat meat. And the quote above tells us that the lion will one day revert to the original vegetarian diet. The problem Vorpahl is trying to solve is his supposition that the lion's digestive track needs alteration when the diet is changed. But does it?

Man's original diet was also vegetarian. But after the Flood God added meat to his diet Did God have to alter his digestive system to accommodate meat or was it created to handle both diets? Also, will man's diet return to vegetarian when the lion's diet does?

As part of this discussion I would like to bring up the idea of genetics and instincts. There are a couple places where we are told that after Creation was finished God made some changes in genetic and instinctive makeup of His creation. After man sinned God "cursed the ground" and said that, "Thorns also and thistles shall it bring forth." (Genesis 3:17-19) That "curse" made a lot of changes and what they all were we cannot know. Whether carnivorous animals ever had their digestive tracts changed we do not know. If they did then God will have to change them back in the days the lion eats vegetation.

God made another change after Creation was finished in the days of Noah when He told him that "The fear of you

and the dread of you shall be upon every beast of the earth, and upon every fowl of the air, upon all that moveth upon the earth, and upon all the fishes of the sea; into your hand are they delivered. Every moving thing that liveth shall be meat for you; even as the green herb have I given you all things. (Genesis 9:2-3)

Animal behavior is dictated by the instincts God placed within them. Man also had some instincts besides his Free Will. After the Flood God changed animal instincts so that they feared and dreaded man. Instincts also determined their diet. Before this every creature was a vegetarian. (Genesis 1:29-30) Now the creatures that we call carnivorous were given instincts to seek flesh to eat. Some still eat vegetation.

Man also had his instincts changed at this point because now he had a desire to eat meat along with the vegetation. Did adding meat to man's and some animals' diets necessitate any genetic change in both man and animals? Or were they given that ability at creation but never used it because their instincts never led them to it? I favor the second idea.

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More Comments on "Predators and Paradise: One More Time"

In an article in the September, 1997, *Quarterly* entitled "Predators and Paradise, One More Time," P.V. Vorpahl proposed a biblically defensible explanation for specialized structures in predatory animals. This is a laudatory effort, for predation is an issue that must be addressed in formulating and defending a biblical worldview. Vorpahl's thesis is that God designed carnivores in preparation for the Fall, and that their original vegetarian diet was simply a brief, initial means of subsistence. That most carnivores are actually omnivorous and that modern carnivores can subsist for considerable periods of time on a vegetarian diet has been documented (Woodmorappe, 1996).

But was that actually the method God probably used? Vorpahl's case is unconvincing. He states that "Eve was not even named until after her disobedience (Vorpahl, p.84)." This is false or partly false. She was first named "Woman" (Genesis 2:23). Vorpahl claims Adam and Eve may not have spent a single night in the Garden, yet man was created on the sixth day, God rested on the seventh day, and Satan fell after the seventh day (Genesis 1:26-2:3). The implication from this and Genesis 3:8 seems to be that God was in the habit of strolling with Adam in the "cool of the day," and that his behavior this particularly day was rather odd. Vorpahl goes on to say, "Coupling these facts with human nature as we know it . . ." (emphasis mine), and invokes Jeremiah 17:9, a verse only applying to human nature after the Fall. All that we can be certain of regarding the time of the Fall is what the Scripture itself tells us. From Genesis 5:3 we see that Adam was 130 at the birth of Seth. Seth was born

after Cain murdered Abel. Cain and Abel, presumably two of the first children born to Adam and Eve, were born after the Fall. So the Fall could not have been much over a century after the Creation.

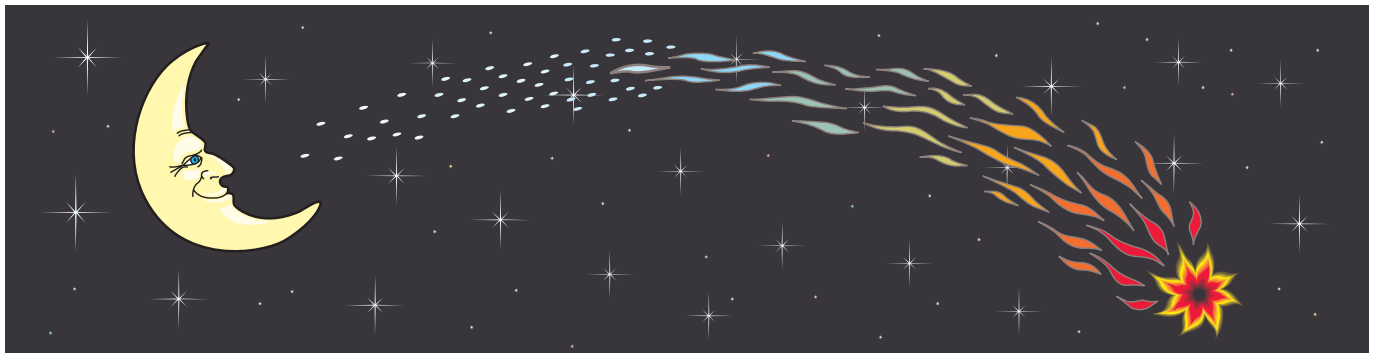
Although God's creative activity ceased with the seventh day of creation, an argument can be made that creation has since occurred in the form of miracles, including sustenance of the widow of Zarephath, the incarnation and the miracles of Christ. Genesis 3:17,18 seem to clearly indicate that genetic alteration of plants occurred at the Fall. That is one of the key problems with Vorpahl's thesis: looking at predation as we know it, when the ecology of the original creation is at best obscure. This same problem has arisen often in Christians' descriptions of primordial vegetarianism, as if plants simply are not "life" in the biblical sense, failing to see that there is a sharp distinction between the original design and the present function of creation. A simple illustration is the American Elm beside my house. It was ordered cut down several years ago because of Dutch Elm disease, and has now returned as a 15 foot stump sprout. The disease is a result of the Curse, but the tree could supply leaves and seeds for food and even its trunk for lumber without any death involved. Excess foliage and enlarged fruits that are of no direct value to the plants are obviously God's original provision, but diseases and predators are as clearly not. We have no way of knowing what manner of plants may have existed in the primordial world to feed the ancestors of modern carnivores, or what the protocarnivores may have been like.

It is important that we avoid falling into the trap of attributing the creation of evil to God Himself, a thesis both illogical and blasphemous. Vorpahl does a good job of emphasizing God's plan of redemption, but we do well to remember that redemption was only necessary because we chose to sin, and that predation only became necessary because we chose to sin. How the universe could have functioned without the present balances of energy/information degradation, death and predation is difficult for us to understand, but someday we will (Revelation 21:1).

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Book Review

The Whole Shebang by Timothy Ferris

Simon and Schuster, New York. 1997. 393 pages. \$14.

Reviewed by Don B. DeYoung *

This is the tenth book by astronomer Timothy Ferris. He has an obvious gift for explaining science concepts in a clear, interesting manner. Chapters concern the big bang, nucleosynthesis of elements, cosmic strings, and quantum theory. Ferris is not as caustic toward the creation view as was Carl Sagan, but the unfriendly treatment is familiar. Ferris falsely claims that science is under attack by religious fundamentalists (p. 13). Creationists are said to argue that "God made the geologic strata look as if the earth were old" (p. 67). At the other extreme, Christianity is complimented for promoting the concept that the universe and time had a beginning (p. 172). Ferris describes himself as a strong agnostic. He means by this not only that he does not know if God exists, but that he cannot know. He is wrong, of course, as his career in astronomy should have taught him by now. Ferris believes that the closest we can get to the concept of God is by human kindness and scientific truth.

The book subtitle is "A State-of-the-Universe(s) Report." The plural of universe illustrates a current movement in astronomy toward multiple or parallel universes (Rees, 1997). The idea is promoted to solve the problems of the big bang singularity and also the Anthropic Principle. Instead of a single big bang explosion, our observable universe is but one "among many bubbles that continue to nucleate more bub-

bles as they go..." (p. 263). Cosmologist Andrei Linde calls it an "eternally self-reproducing universe" (p. 264). This view, if widely accepted, cancels any apologetic value of the big bang as promoted by old-earth creationists. The steady state model of cosmology has returned. Since there are assumed to be an infinite number of universes on an infinite time scale, anthropic design arguments also disappear. Other universes exist with every possible value for constants, nuclear force strength, etc.

The plural universe concept is also favored by some quantum theorists. This many-worlds or many-histories view proposes that the entire universe splits into two or more separate universes with every physical measurement made. This irrational, unprovable idea solves certain paradoxes in quantum theory. It was first proposed by Hugh Everett of Princeton University in 1957.

Ferris has written a helpful book for those seeking an update on modern physics. Unfortunately his biology treatment remains weak. Ferris promotes the long-discredited recapitulation theory, and falsely describes gills on human embryos (p. 197). The book offers a full index, glossary, and many fascinating end notes.

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Creation Research Society

History—The Creation Research Society was organized in 1963, with Dr. Walter E. Lammerts as first president and editor of a quarterly publication. Initially started as an informal committee of 10 scientists, it has grown rapidly, evidently filling a need for an association devoted to research and publication in the field of scientific creation, with a current membership of over 600 voting members (graduate degrees in science) and about 1000 non-voting members. The *Creation Research Society Quarterly* has been gradually enlarged and improved and now is recognized as the outstanding publication in the field. In 1996 the CRSQ was joined by the newsletter *Creation Matters* as a source of information of interest to creationists.

Activities—The society is solely a research and publication society. It does not hold meetings or engage in other promotional activities, and has no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund is maintained to assist in such projects. Contributions to the research fund for these purposes are tax deductible. As part of its vigorous research and field study programs, the Society operates The Van Andel Creation Research Center in Chino Valley, Arizona.

Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the Statement of Belief.

Statement of Belief—Members of the Creation Research Society, which include research scientists representing various fields of scientific inquiry, are committed to full belief in the Biblical record of creation and early history, and thus to a concept of dynamic special creation (as opposed to evolution) both of the universe and the earth with its complexity of living forms. We propose to re-evaluate science from this viewpoint, and since 1964 have published a quarterly of research articles in this field. All members of the Society subscribe to the following statement of belief:

1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.

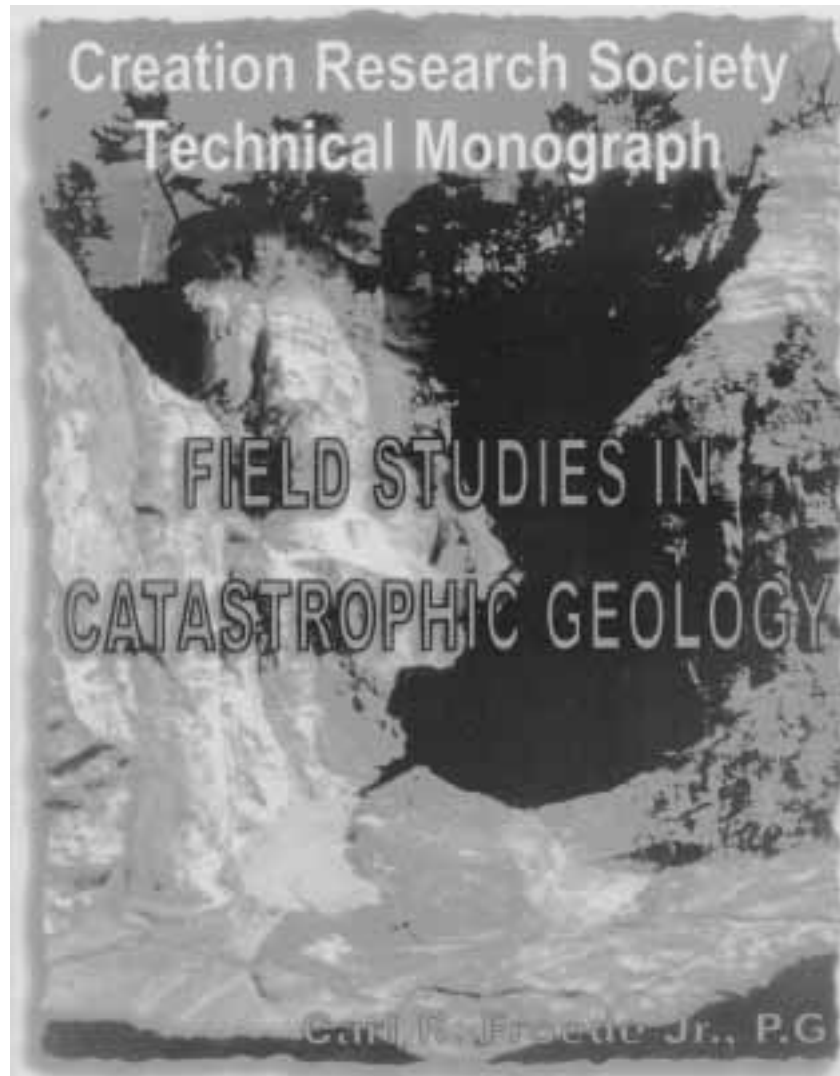
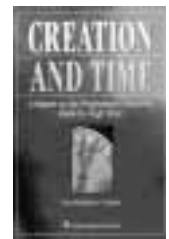
2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.

3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.

4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.

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This effort is directed toward scientists who are not geologists but have an interest in the subject. Accordingly, I have attempted to keep the use of