ARTICLES

SOME QUESTIONS ABOUT GEOCHRONOLOGY

Ariel A. Roth
Geoscience Research Institute

WHAT THIS ARTICLE IS ABOUT

The presently accepted geochronological time scale for the earth proposes an age of about 4600 Ma (4600 million years). Sedimentary layers found on the continents of the earth contain evidences of past life (fossils) dated from very recent to several thousand million years. Evolution of life is assumed to have taken place during that time. This scenario contrasts dramatically with the biblical creation account which proposes that life on earth has existed for only a few thousand years.

The geochronological time scale of thousands of millions of years is based mainly on radiometric dating — a dating system which has both strengths and weaknesses. On the other hand, some other time-dependent processes change at rates which challenge generally accepted geochronology. Examples include:

1. *The present rate of erosion of the land surface of the earth would level the continents several hundred times over in 4600 Ma.*
2. *Rivers carry sediment to the ocean at a rate that would fill the oceans at least 19× over in 3500 Ma, yet oceans are still very empty. Attempts to explain this by recycling sediments into the crust of the earth by various mechanisms are not very satisfactory.*
3. *Present rates of sediment formation indicate that there should be 14-23× as much as is found. Intermittent action is used as an explanation.*
4. *Mountains are rising at rates of 100 km in 100 Ma. Intermittent action is again used to explain the discrepancy.*
5. *In 3500 Ma, the present production rate of volcanic ejecta would produce 20-80× more than is now found.*
6. *The human population grows so rapidly that its present size could have been reached in less than 1% (3200 years) of the minimum time assumed (½ million years) for man on the basis of radiometric dating. Also supporting a recent existence for man are the historical and archaeological data which are abundant but very recent. It does not seem that man (Homo sapiens) has been on this planet for ½ million years.*
7. *On the other hand, the 4600 Ma assumed for the age of the earth is many orders of magnitude too short to account for the highly improbable events postulated for the evolutionary development of life.*

It appears that quite a number of independent factors disagree with the presently accepted view of 4600 Ma for the development of the present earth

system and the life contained therein. While the factors noted (except Factor 6) do not point to a few thousand years as indicated by the Bible, it is significant that the worldwide flood described in Genesis has the potential to cause Factors 1-5 to change more rapidly than at present and thus fit into the context of a few thousand years since creation. Creation itself has the potential to resolve any difficulty over the time required for evolutionary development (Factor 7).

All extrapolations of present phenomena into the past must be approached with caution. A number of explanations have been proposed in the scientific literature for reconciliation of the discrepancies noted above with standard geochronology. These explanations propose that present geologic processes do not represent long-term averages. While this may be true in some instances, it is difficult to accept that all these various rates would be wrong. It appears that standard geochronological interpretations face some significant unresolved problems.

INTRODUCTION

One of the more significant differences between the concepts of creation and evolution is the amount of time required for the history of life on earth. Evolution proposes thousands of millions of years for the development of life to advanced forms. The biblical creation model proposes that life has existed for only a few thousand years.

Estimates of the age of the earth and the subsequent assumed time for the development of life have increased considerably during this century. Early concepts of ages of less than 100 Ma (100 million years) have gradually given way to figures more than 40× as long (Engel 1969). Recent views are based on radiometric dating which is presently the most accepted method of determining geologic ages. It is sometimes called “absolute dating” — a term that expresses the high regard given to this method. Based on the rate of disintegration of long-lived isotopes, estimates up to 6000 Ma (6,000,000,000 years) have been proposed for the age of the earth. Major agreement has been reached on an age of around 4600 Ma (Engel 1969). Within this time frame, there is general agreement that a major part of the continents (Kröner 1985) and oceans have existed for 3500 Ma. These latter long time concepts (4600 and 3500 Ma) will be designated in this essay as “standard geochronology.”

Radiometric age measurements sometimes disagree with one another and with other dating techniques. Damon & Kulp (l958), Brown (1983) and Taylor et al. (1985) refer to many examples. Disagreements are explained — sometimes with convincing argumentation — on the basis of inherited characteristics and/or subsequent geochemical disturbances in the rocks. However, the radiometric dates that provide the basis for the standard geologic time scale present a significant sequence. In addition to methods based upon radiometric dating, the slow rate of presently observed geologic changes also suggests that a great deal of time would be involved in the formation of some of the major features of Earth's crust, including the thick accumulations of fossil-bearing (evidence of past life) sedimentary layers found therein.

On the other hand, those who believe in creation as described in the Bible envision a short period of a few thousand years for the existence of life on our planet. This model includes a worldwide catastrophe — the Genesis flood — responsible for the rapid deposition of fossil-bearing sedimentary layers. This view is supported by the evidence of past catastrophic activity found in the sediments as well as the scarcity of evidence, especially in the main part of the geologic column, of the consequences that should have developed over long periods of time. Examples include the paucity of soils or preserved mature plant ecosystems. Deep erosional features such as buried canyons and cliffs should be much more abundant throughout the sedimentary layers, if these layers had been part of a sedimentary cycle existing over thousands of millions of years.

Each of the considerations listed above could be the subject of an extended discussion. This short survey will be limited to processes which, according to presently observed rates of change, appear to be in disagreement with the standard geochronological time scale of 4600 Ma.

Unfortunately, pertinent information dealing with this topic is not always firm. In many cases an undesirable, but unavoidable, degree of imprecision, conjecture and uncertainty is present. Nevertheless, the incongruities between some contemporary observations and standard geochronology are significant enough to suggest a reassessment of the currently accepted framework for geologic time.

1. RATE OF EROSION OF THE CONTINENTS

By noting the rates at which the surfaces of the continents are eroded and carried away by rivers to the oceans (see Section 2 for specific values), one can calculate the length of time required to remove a given thickness of the continents. Judson & Ritter (1964) have estimated that for the United States the rate of erosion averages 6.1 cm/1000 yr. At this rate of denudation the continents, which average 623 m above sea level, would be eroded to sea level in a mere 10.2 Ma. In other words, at this rate the present continents would be eroded over 340× in the 3500 Ma assumed for the age of the continents. The observation by the famous geologist Powell that "mountains cannot long remain mountains" certainly seems appropriate. The estimate of 10 Ma given above has been a well-accepted figure (Schumm 1963) and has subsequently been referred to in a number of publications including Dott & Batten (1971, p 136) and Garrels & Mackenzie (1971, p 114-115). Earlier, Dole & Stabler (1909) gave figures indicating that it would take about twice as long. Judson (1968), while correcting for human activity, suggests 34 Ma for complete erosion of the continents. None of these figures does much to alleviate the discrepancy which is especially significant when one considers mountain ranges such as the Caledonides of western Europe and the Appalachians of North America which are assumed to be several hundred Ma old. Why are these ranges here today if they are so old?

Rates of erosion are greater in high mountains and lower in regions of less relief (Ahnert 1970, Bloom 1971, Ruxton & McDougall 1967, Schumm 1963). Ruxton & McDougall (1967) report erosion rates of 8 cm/1000 yr near sea level and 52 cm/1000 yr at an altitude of 975 m in the Hydrographers Range in Papua. Rates of 92 cm/1000 yr are reported for the Guatemala-Mexico Border Mountains (Corbel 1959), 100 cm/1000 yr for the Himalayas (Menard 1961), and in the Mt. Rainier region of Washington Mills (1976) documents erosion rates of up to 800 cm/1000 yr. Probably the highest recorded regional rate is 1900 cm/1000 yr from a volcano in New Guinea (Ollier & Brown 1971).

It has been suggested that mountains still exist because they are constantly being renewed by uplift from below. However, this process of uplift could not go through even one complete cycle of erosion and uplift without eradicating the layers of the geologic column found in them. Present erosion rates would tend to rapidly eradicate evidence of older sediments; yet these sediments are still very well-represented, both in mountains and elsewhere.

Other attempts to reconcile average present erosion rates to geologic time include suggestions that man's activities, especially agricultural practices, have increased the rate of erosion, making present rates uncharacteristically rapid. Such an explanation seems inadequate to account for a several hundred-fold discrepancy. Gilluly et al. (1968, p 79) propose that farming may have increased average erosion rates by a factor of less than 2, while Judson (1968) suggests about 2½×. Others have suggested that the climate of the past may have been more dry or the relief flatter, resulting in slower erosion rates. We now have some interior basins such as central Australia where there is no drainage and no removal of sediment, but these are exceptions. The lush vegetation evident in significant sections of the fossil record suggests at least some wetter conditions in the past. Characteristically, current erosion rates in hot, dry lowlands with gradients 0.001 or less, are not sufficiently slower. Corbel (1959) indicates rates of

1.2 cm/1000 yr for the hot dry plains of the Mediterranean region and New Mexico. The lowest rates found in a study of 20 river basins (Ahnert 1970) was 1.6 cm/1000 yr for basins in Texas and England. These slower rates do not solve a discrepancy of several hundred-fold, and one would have to postulate different past conditions for a major area of the earth during a significant proportion of earth history to provide a resolution to the problem.

A different context can serve to emphasize the question of rates of erosion. If it is assumed that 2.5 km of continents have been eroded in the past (our present continents average about one fourth that thickness above sea level) and if it is assumed that erosion proceeds at the rate of 3 cm/1000 yr (half of the presently observed rate to correct for the effects of modern agricultural pursuits), then it would take about 83 Ma to erode a 2.5 km thickness of continental crust. In other words, at present rates of erosion, continents 2.5 km thick could have been eroded 42× during the assumed 3500 Ma age for the continents, or continents 106 km thick would have been eroded once. There is little question that there is some difficulty in reconciling present erosion rates with standard geochronology.

2. SEDIMENTS CARRIED TO THE OCEAN

Rivers and glaciers carry sediments and dissolved chemicals to the ocean, ocean waves erode the continental coastlines, and wind carries some fine sediment to the ocean. All these factors, along with submarine volcanism, contribute to the sediments that accumulate in the ocean. The observed rate of transfer of sediments from the continents to the ocean seems too rapid to be readily reconciled with standard geochronology. Most of the sediment going into the ocean is transported by rivers. Estimates of sediment transport to the ocean for the world (Table 1) vary from 8000-58,000 million metric tons/yr (Holmes 1965, p 511; Holeman 1968; Jansen & Painter 1974; Milliman & Meade 1983). Many of the estimates do not take into account the bedload which represents the sediments that are rolled or pushed along the bed of a river and which is not readily observed at river gauging stations. Sometimes the bedload is arbitrarily estimated at 10%, because it is so difficult to measure (Blatt et al. 1980, p 23; Schumm 1963). Jansen & Painter (1974) suggest that 26,700 million tons/yr for global denudation “is likely to be an underestimate.” Gilluly (1955) estimates that 13.6 km^3 of solid material are carried to the world oceans every year. This corresponds to about 31,000 million tons/yr. At this rate the ocean basins (including their present sediments), which have a total volume of 1550 million km^3, should be filled in just 114 Ma. Using a more conservative estimate of river transport

TABLE 1
Some Estimates of the Rate at which Sediments Reach the Ocean*

Author (Date)	Thousand Million Metric Tons/Year
Fournier (1960)	58,100
Gilluly (1955)	31,800
Holeman (1968)	18,300
Holmes (1965)	8,000
Jansen & Painter (1974)	26,700
Kuenen (1950)	32,500
Lopatin (1952)	12,700
Milliman & Meade (1983)	15,500
Pechinov (1959)	24,200
Schumm (1963)	20,500

*Based on publications of Holmes 1965, p 511; Holeman 1968; Jansen & Painter 1974; and Milliman & Meade 1983.

of sediment to the ocean of 20,000 million tons/yr, it would still take only 178 Ma to fill these ocean basins with sediment. In other words, the present rate of transport of sediment by rivers could fill the oceans 19× in 3500 Ma. Of course, the oceans, which average 3.8 km in depth of water, are not at all full of sediment; and in much of the deep oceanic abyssal plains, sediment thickness averages only a few hundred meters. It would take about 50 Ma to produce the generous estimate of 435 million km^3 (Ronov & Yaroshevsky 1969) of sediment now found on the ocean and continental margins. One could argue that the continents were smaller in the past and produced less sediment. Such an argument would not resolve this discrepancy unless the continents were extremely small, and there is broad, but not unanimous, agreement that they have been near present size for the past 2500 Ma (Kröner 1985; Taylor & McLennan 1985, p 234).

On the other hand, three scenarios suggested within the standard geochronological paradigm may help alleviate some of the time discrepancy: a) the sediments are subducted into the earth at the deep trenches along the plate margins, as proposed by the plate-tectonics model, b) the sediments which originally came from the granitic continental crust are recycled again to form new continental crust by accretion or rifting processes, c) the river sediment which accumulates at the margins of the continents is recycled into other sediments again to be eroded. None of these scenarios provides a satisfactory explanation. They will be discussed in the order listed.

a) It is sometimes proposed that the reason there is so little sediment in the oceans is that the oceanic crust is too young, the older ocean floor and sediment having been subducted into the mantle of the earth. However, subduction of sediments is not going on at a rate that would keep up with the supply given by rivers (Karig & Kay 1981, Kay 1980, Veizer & Jansen 1979). Li (1972) has estimated the subduction rate to be at 2500 million tons/yr, in contrast to present river delivery of 20,000-30,000 million tons/yr. Lisitsyn et al. (1982) estimate subduction at about 3000 million tons/yr, while Howell & Murray (1986) propose that only 21% of the sediment load of rivers ends in the oceanic trenches where subduction occurs. Furthermore, one must take into account that the major repositories of sediments from big rivers on the floor of the ocean are geographically unrelated to subduction zones (Potter 1978; Taylor & McLennan 1985, p 240-241).

b) Probably the most serious problem faced by those who propose a recycling of sediments into the thick "granitic" crust forming the continents is the mismatch between the chemical composition of sedimentary and of igneous-metamorphic (granitic) rocks. The original granitic rocks are assumed to have been the parent source of the sediments which in turn are changed from sediment back to the igneous-metamorphic rocks forming new continental crust. The main mismatch is with sedimentary limestones which have a proportion of elements that is different from the proportion in the supposed parent-daughter igneous-metamorphic rocks (Garrels & Mackenzie 1971, p 237). The difference is emphasized by the fact that one finds more than twice as much limestone in the sedimentary rocks as would be expected if they were derived from igneous rocks. The average of 5 studies (Pettijohn 1975, p 21-22) involving direct measurement indicates 20% limestone, while the average of 4 studies utilizing calculations from the composition of igneous rocks indicates only 8% limestone. Also, the average igneous rock has more than 3× as much sodium as the average sedimentary rock (Garrels & Mackenzie 1971, p 237). The latter authors also indicate that carbon, which forms several percent (4.7% — compared as oxide) of sedimentary rocks, is present only as a trace in igneous rocks. It is sometimes assumed that carbon had to come originally from a degassing process from the planet's mantle. The general picture is that there are some significant differences in the elemental composition of sedimentary and igneous rocks. The kinds of minerals found in the two are very different. Mention should be made of Garrels & Mackenzie's (1971, p 248) effort to resolve the question of the origin of limestone from igneous rocks by proposing that limestone could be derived in part from very large quantities of Precambrian volcanic sediments.

c) If only sediments at the continental margins are involved in the recycling process, the rate of discharge of sediments from rivers is so great that very rapid recycling would be required. These rates seem too high to have preserved the older sediments that still exist. Ronov & Yaroshevsky (1969) estimate the volume of sediments on the continental margins to be 190 million km^3, equivalent to 8×10^{17} tons. One can conservatively assume that before the development of agriculture the rivers carried an estimated 10,000 million tons annually to the ocean, and 20% of this went to the deep trenches. According to the recycling of sediments model, the remaining 8,000 million tons/year must be recycled into other sediments near the continental margins. At this rate the 8×10^{17} tons would be recycled on an average once every 100 Ma (8×10^{17} divided by 8×10^{9}). Yet major parts of the geologic column considered much older than this are found on the continental margins and on areas considered to have been continental margins, including unique abundant Paleozoic and significant Precambrian limestone deposits. There are major deposits of Precambrian sediment older than their putative 600 Ma age in many regions of the world. Estimates of the proportion of sediments that are Precambrian vary from $^1/_5$ to $^1/_2$ (Garrels & Mackenzie 1971, p 249). It does not seem that if there was general recycling at the rate of once every 100 Ma, there would be very much of these ancient sedimentary deposits still preserved. One would also expect considerable recycling of fossils which usually appear in their primary unique position of burial in the geologic column. Furthermore, it does not seem satisfactory to suggest that rapid recycling has taken place only within very limited parts of the geologic column. That does not appear to be occurring now. Usually major sections of the geologic column are exposed and eroded in our river basins. Both young and old sediments are involved in much of the erosion now observed. Restricted recycling is not normative to our present earth.

It appears that the rivers carry sediments to the ocean at a rate that is too rapid to easily accommodate the long periods of time proposed by standard geochronology.

3. RATE OF SEDIMENT ACCUMULATION

{6 Jan 2000 note by author: this section may need updating}

Around the turn of the century a number of studies compared observed rates of accumulation of sediments with the maximum thickness obtainable from the various individual parts of the geologic column (e.g., Figure 1) over the world. These maxima sometimes totaled more than 100,000 m in thickness. While the results obtained are highly variable, present rates of deposition of sediments are so rapid that they all point to a younger age than that of standard geochronology. Eicher (1976, p 14) gives a summary of 19 such studies which average 246 Ma, or $^1/_{14}$ of the 3500 Ma of standard geochronology.

FIGURE 1. Deep sedimentary layers found on the east end of the Grand Canyon of the Colorado River in Arizona. Sediments are quite abundant in many localities, but much less is present than would be expected over thousands of millions of years.

Other more recent studies also support a paucity of sediments when compared to long geologic time. Gregor (1968) attributes to episodism (i.e., various episodes with differing rates of activity) the discrepancy between the relatively small amount of sediment present and the thousands of millions of years for sediment production. Assuming a rate of denudation to produce sediments at the rate of 3 cm/1000 yr, he suggests that in 3500 Ma, 23× as much sediment as now exists should be present. At this assumed rate the present sediments would have been produced in about 152 Ma.

A number of studies (see Gilluly 1949 for listing) have shown the intriguing relationship that younger sediments show greater thickness per equivalent unit of time than older ones. In other words, the rates of deposition appear more rapid for more recent deposits. Conversely, one could also interpret this as meaning that the time assumed for the deposition of older sediments is inordinately long. Newell (1972) gives a set of examples starting with slow rates of 0.6 to 6 cm/1000 yr (Kay 1955) for average deposition since the Precambrian and ending with Rusnak's (1967) estimate of a current rate of 100 to 200 cm/1000 yr for bays, estuaries, and lagoons. Much more rapid rates are observed in exceptional cases such as the Mississippi delta (30,000 cm/1000 yr), but these exceptions have limited significance for the general picture. The comprehensive data of Sadler (1981) based on 25,000 samples emphasizes the reality of the general picture presented above, and there is general agreement that present rates of sediment accumulation appear faster than can be easily extrapolated to the past.

Several explanations have been proposed. It is commonly suggested that we are in a period of rapid sedimentation. In the past the mountains were lower, hence erosion and deposition was slower (see Gilluly 1949 for review). Incidentally, a low topography for the past fits well with several models of the Genesis flood presently under study. Another explanation is that the farther back one goes in time, the more incomplete the record is (Gilluly 1949, Sadler 1981). The argument is that the more time there is, the greater the opportunity for periods of non-deposition to occur. If episodism is a highly random factor, such an explanation seems plausible. Still others propose that recycling of sediments has transferred older sediments into younger ones (Garrels & Mackenzie 1971, Veizer & Jansen 1979), hence the scarcity of the older sediments. In Section 2 we discussed some of the problems with recycling. On the other hand, the observed general decrease in the volume of sediments through time (as one goes down the geologic column) agrees with recycling. This observation might also be interpreted as a phenomena of basin infilling where the older (lower) sediment would have smaller volumes due to greater restriction in the lower regions of depositional basins. Regardless, the general decrease in sediment volume as one goes back in geochronological time is quite erratic (see figs. 10.1 and 10.9 in Garrels & Mackenzie 1971). It is irregular enough that Gregor (1968, 1970) proposes two cycles of sediment building instead of the usual one within the Phanerozoic. One can also consider the possibility that the reason for the scarcity of sediments in the past is not slower rates of accumulation but a shorter time for accumulation. Regardless of interpretation, there is an incongruity between present sediment rate production and the amount expected over the time proposed by standard geochronology.

One might wonder whether erosion of the continents is so rapid (Section 1) that we would not expect to see much sediment anyway. Erosion both produces and transports sediment, but the sediment must be deposited somewhere, and we should find it, unless it has been recycled. However, as shown in Section 2, recycling is not an easy answer.

4. RATES OF UPLIFT OF MOUNTAINS

Our “solid earth” is not as firm as we usually surmise. When careful measurements are made, we find that some areas of the continents are slowly rising, while others are subsiding. Current rates at which these changes are occurring are too rapid to represent long geologic processes over many millions of years.

There are two main methods of establishing the rate of orogeny (uplift) of mountains. One is by direct precise measurements noting accurately the altitude of a mountain at a given time and remeasuring its height a few years later. This gives the observed rate of uplift. The other is by indirect "geologic studies" comparing the height of a mountain with the time assumed for uplift based on standard geological and geochronological interpretations. This latter method gives average assumed rates. Measured rates of uplift are more rapid than those based on indirect geochronology. For instance, current uplift of the eastern and central part of the Alps of Switzerland (Figure 2) is about 100-150 cm/1000 yr (Mueller 1983) when measured directly. Using indirect geological studies gives a rate of only 3 cm/1000 yr (Zeuner 1958, p 360), or 3% of the present measured rate.

Schumm (1963) states that "Rates of orogeny being measured at the present instant of geologic time [direct precise measurement] are far in excess of the minimum values obtained by geologic studies." Schumm reviews some of the literature dealing with present rates of orogeny and

FIGURE 2. View looking southwest into the central Alps as seen from Gornergrat, Switzerland. Precise measurements show that this region is rising at the rate of about 1 mm/yr. This rate, if extended over 100 Ma, would raise the region by 100 km. Three glaciers are evident across the valley.

concludes that mountains form at a rate approaching 760 cm/1000 yr. The same rates are found in southern California hills (Schumm 1963) and the southern Appalachians (Hand, quoted in Press & Siever 1982, p 484) where there has been no glaciation that might induce some orogeny due to ice removal. In Japan Tsuboi (1933) measured rates as high as 7200 cm/ 1000 yr. Blatt et al. (1980, p 30) state that "rates of uplift of mountains are fast," ranging from 300-1000 cm/1000 yr. Hand (quoted in Press & Siever 1982, p 484) reports present-day regional uplift in the Rocky Mountain region of 100-1000 cm/1000 yr, and 0-1000 cm/1000 yr are indicated for the Appalachian region. On the other hand, areas such as parts of the east and southern coast of the United States are subsiding at comparable rates. Senftl & Exner (l973) report orogeny of 100 cm/1000 yr for the Hohen Tauern of the Austrian Alps. Precise direct measurements are not available for the Himalayas; however, on the basis of geomorphic evidence, also the finding of recent tropical plant and rhinoceros fossils which appear uplifted 5000 m, and on the basis of tilted beds, an estimate of a present uplift rate of 500 cm/1000 yr is proposed (Gansser 1983). It also appears that Tibet has been uplifted at a similar rate. On the basis of geomorphic and erosion data, the same author estimates an uplift rate of about 300 cm/ 1000 yr for the central Andes.

The rate of 760 cm/1000 yr proposed by Schumm (1963) would yield an uplift of 7.6 km in 1 Ma. Using a more conservative rate of 100 cm/1000 yr still suggests that the process could not continue over very long periods of time at the present measured rates, for at this rate the height of mountains could theoretically reach 100 km in 100 Ma. To explain the discrepancy a special case is proposed where mountains rise with "'pulses' of rapid uplift" (Blatt et al. 1980, p 30). Schumm (1963) also suggests that these data support rapid uplift with little time for erosion before uplift is completed. Recognizing that the present rate of uplift cannot be extended throughout standard geochronology, these authors explain the difference by episodism. The present is assumed to be in a period of rapid orogeny.

It should be noted that the rapid rates of erosion presently occurring are too slow to keep up with the rates of uplift noted in mountain formation. Schumm (1963) points out that modern rates of orogeny of 760 cm/ 1000 yr are about "8 times greater than the average maximum rate of denudation." Blatt et al. (1980, p 30) illustrate the same point by referring to the fact noted above that erosion is more rapid in high mountains and gradually decreases toward lower elevations. Using the data of Ahnert (1970), they estimate that for erosion to keep up with a "'typical' rate of mountain uplift" of 1000 cm/1000 yr, a mountain would have to be in the order of 45 km high. The present rate of uplift of mountains is too rapid to fit directly into standard geochronology.

One might ask if the rapid rate of uplift of mountains now observed does not negate the first point presented earlier that the continents including their mountains should have been eroded several hundred times over in the thousands of millions of years of their proposed existence. The challenge to standard geochronology is that if mountains have been uplifting at current rates or even much slower, the lower parts of the geologic column which are many hundreds to thousands of millions of years old should have been uplifted and eroded away long ago. Yet these older sections are very well-represented in our mountain ranges, as cursory field study or examination of geologic maps will reveal.

5. EMISSION OF VOLCANIC EJECTA

Gregor (1968), while proposing episodism, has indicated that on the basis of an estimated 1 km^3 of volcanic ejecta/yr on the earth, there should be an average layer of volcanic deposits 7 km deep in 3500 Ma. Gregor's figure of 1 km^3/yr seems supported by recent volcanic activity. Izett (1981) lists the volume of some of the more notable ash beds formed from volcanic activity: Tambora (Indonesia, 1815) — 100-300 km^3, Krakatoa (Indonesia, 1883) — 6-18 km^3, Katmai (Alaska, 1912) — 20 km^3, Mt. St. Helens (Washington, 1980) — 1 km^3. Mt. St. Helens ejected a significant volume of other volcanic products in addition to the ash considered above. To be added to this list are the numerous smaller volcanic events over the surface of the earth, such as occur periodically in Hawaii, Indonesia, Central and South America, Iceland, Italy, etc. All of this should average quite a bit more than 1 km^3/yr. Decker & Decker (1982, p 47) suggest an average volcanic output of about 4 km^3/yr. Estimates of the quantity of volcanic products now found on the earth are difficult to determine because of the problem of identification and because of mixing with other sediments. Garrels & Mackenzie (1971, p 249) suggest that 25% of the volume of sediments are volcanic in origin. One can obtain an estimate of the volume of volcanic products by applying this proportion to the total sediment volume of the earth. Pettijohn (1975, p 20) lists 8 estimates of the total volume of sediment. They average 683 million km^3. If 25% of this is volcanic, we get a figure of 170 million km^3 of volcanic ejecta on the earth. If we use the estimate of Gregor (1968) of volcanic production of 1 km^3/yr, we would get 3500 million km^3 in 3500 Ma, which is 20× as much as appears to be present. If we use the estimate of Decker & Decker (1982, p 47) of production rate of 4 km^3/yr, we would expect 80× as much as now appears present.

The simplest way to solve the discrepancy within a standard geochronological paradigm is to suggest episodism (Gregor 1968) and assume that we are in a much more active period of volcanic production. Another way is to recycle past production into the earth. Some of the problems of recycling were considered in Section 2. If one excludes these alternatives, a present rate of production by volcanoes of 4 km^3/yr when extended over 3500 Ma would exceed the total volume of the crust of the earth.

6. HUMAN POPULATION GROWTH RATES

It does not take much reflection for us to realize that mankind is a growing and ubiquitous entity on the face of the earth. Overcrowding is a serious and all-too-common problem. World population is growing exponentially, doubling every 35-40 years (Information Please Almanac 1986, p 132). Calculating backwards from the present (in reverse) at this rate, one would come to two individuals (necessary to start a population) in a mere 1100 or 1200 years. Data based on growth from the middle of the 17th century to the present suggest a slower rate of growth according to which the present world population would have been produced in about 3200 years. To account for the ½ Ma assumed for the existence of man according to radiometric inference, it is suggested that man (here limited to *Homo sapiens*) did not reproduce as rapidly in the past. However, the discrepancy is so great that it seems proper to ask if man has been here for ½ Ma or more. Why has the earth become heavily populated only very recently? Figure 3, based on Coale (1974), illustrates the contrast between present growth rates and proposed earlier rates based on assumed long ages for man. (Coale uses a broader definition for man; hence his time span is greater than ½ Ma.) Coupled with the population growth considerations is the brief period of a few thousand years for the archaeological and historical data left by man. If man has been on earth for ½ Ma, should not archaeological and historical records extend further back in time? Should we not find firm evidence of human activity such as cities and roads hundreds of thousands of years old? Good evidence of past human activity is abundant and very recent. All three of these factors, the historical, the archaeological, and the biological rate of reproduction — suggest that man has been here for only a small fraction of the time proposed by standard geochronology.

The usual explanations given for the sudden change in rate of growth are that the development of agriculture a few thousand years ago permitted man to reproduce faster (Coale 1974), or that man may be more healthy now. Before this, man is assumed to have been a hunter and gatherer and/or more critically affected by disease. However, one can ask why man

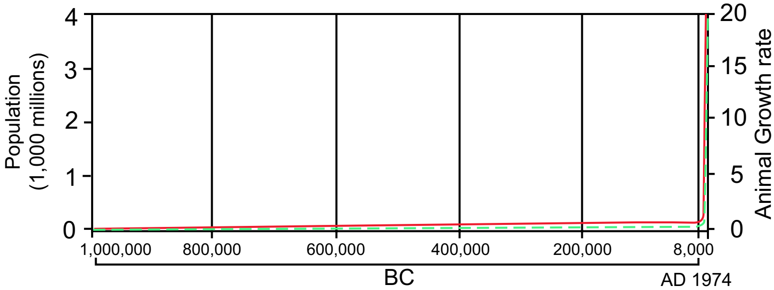

FIGURE 3. Overview of the size of the human population and its rate of growth based on assumptions that man has been on this planet for a million years. The solid line represents population; the dashed line represents rate of growth. The curves show a distinct change during the last few thousand years. Curves based on Coale 1974.

with all his inventive faculties as seen in the myriads of inventions about us should wait about ½ Ma to develop agriculture or health principles. The data seem to suggest that man has not been here for the time proposed by standard geochronology.

It can also be argued within an evolutionary paradigm that man could have become more advanced by some rapid evolutionary changes. However, the very recent appearance of major advances in man in contrast to the earlier slow evolutionary developments demands explanation.

While the question of man's past is a complex one, and significant caution seems warranted, his rather sudden authentication seems to provide some basis for questioning the putative antiquity which geochronology implies for him.

7. TIME REQUIRED FOR BIOLOGICAL EVOLUTION

Charles Darwin (1809-1882) refined and popularized the concept of organic evolution in his work *The Origin of Species* (1859). He knew that his proposal of small random changes guided by natural selection would require enormous amounts of time for the production of successful complex organisms. He suggested that 300 Ma had elapsed since the last part of the Mesozoic Era (Eicher 1976, p 10). Interestingly this is more than 4× longer than the 65-70 Ma proposed for this period by standard geochronology. While Darwin's view can now be considered only of historical interest, it is noteworthy that even then he was keenly aware of the tremendous amount of time necessary for the improbable events postulated by his theory.

This problem has taken on more significance in the context of modern molecular biology. For instance Eden (1967) in *Mathematical Challenges* *to the Neo-Darwinian Interpretation of Evolution* infers that an assumed age of 5000 Ma for the earth is far too short for the improbable events proposed by current evolutionary concepts. Eden uses the well-studied bacterium *Escherichia coli* as an example. In the genetic information found on the chromosomes of this and other organisms, a double order is found.

The chemical pattern for the composition of the genes themselves is one order of information, but in addition the genes are found on the chromosomes at specific localities which are related to the order of use by the organism for sequential biochemical changes. Aside from the problem of evolving the genes, one wonders how the genes became located in their proper order. Eden addresses the simple question of getting only 2 genes in order. It is postulated that these genes evolved earlier at random localities on the chromosomes. Eden estimates that it would take 5000 Ma for the changes necessary to bring 2 genes in their proper order of use. This calculation is based on observed rates of reproduction and the generous assumption that this bacterium would have been spread over the earth in a layer 2 cm thick for that extended period of time. The 5000 Ma give no time for the genes to evolve — a much more complex process —, nor does it give time for the evolution of other organisms, some of which are several hundred times more complex. Suffice it to say that many orders of magnitude of time more than the 4600 Ma postulated for the earth are required for the improbable events of the scenario of organic evolution.

Evolutionary biologists have studied a number of factors that might increase the rate of evolutionary change. Considered especially significant are changes in regulatory or control genes (Hedrick & McDonald 1980, MacIntyre 1982) which may be more influential than ordinary genes. However, the evolutionary significance of regulatory genes would have little to do with the time problem posed above about the order in gene location.

In the case of the evolutionary development of complex biological systems by naturalistic means, we find a factor that requires much more time than that provided by the standard geochronological time scale. The significance of this is complex. In a purely naturalistic context it raises questions about the validity of geochronology which thus appears too short. In a broader context that includes the possibility of creation, the time incongruity would be resolved.

SOME INFERENCES FROM THE DATA

The time conflict between some observed phenomena and standard geochronology are summarized in Table 2. While some of these factors are subject to further adjustments, one gets the impression that within the

TABLE 2

Factors in Conflict with Standard Geochronology

Factor	Suggested Degree of Conflict
1. Present rate of erosion of continents	Continents would be eroded 170-340× over in 3500 Ma.
2. Sediments carried into the ocean	Present rate would produce sediments now found in oceans in 50 Ma and would fill the oceans 19× over in 3500 Ma
3. Rate of sediment accumulation on continents	In 3500 Ma, there should be 14-23× as much sediment as found, excluding some limited recycling.
4. Rates of uplift of mountains	Mountains are rising at a rate of 100 cm/1000 yrs, which would result in mountains 100 km high in 100 Ma.
5. Rate of production of volcanic ejecta	In 3500 Ma 20-80× as much volcanic ejecta as we now find would have been produced.
6. Growth of human population	Present population size could be reached in 3200 years, while man is assumed to have been here for over 100 times longer.
7. Time for evolutionary development	Many orders of magnitude more than 5000 Ma are needed for the improbable events postulated.

context of standard geochronology a number of factors are currently changing at inordinately rapid rates.

The scientific literature suggests some explanations as given above for each case. However, how can one plead a variety of special cases for time-dependent factors and still maintain confidence in current geochronological interpretation? It is logically unsettling to sometimes claim consistency between the present and the past, and then plead for special cases when the data do not fit accepted views. There seems to be some basis for wondering if the paradigm of standard geochronology has been given unwarranted acceptance. While man's meager knowledge makes inconsistencies unavoidable, when we face a number of them, it may be time for some reevaluation.

Simple reflection on the time factors described above would likewise raise questions about inconsistencies between the data presented and the short time period for life on earth as proposed by the biblical model of creation. Most of the data presented above, except Factor 6, do not point to a few thousand years. For instance, if mountains are rising at the rate of 1 km/Ma, why are some mountains so high if they are so young? However, the biblical creation model (Neufeld 1974) includes both a creation by God and a worldwide flood that was a major catastrophe which dramatically changed the surface of the earth. Such unique events are difficult or impossible to analyze quantitatively, but they carry the potential to solve the discrepancies between the 7 factors listed in Table 1 and a short period of a few thousand years proposed by creation. The inordinately rapid rates in Factors 1-5 may reflect the effects of a single recent catastrophe such as the flood described in Genesis. Such a worldwide catastrophe would dramatically increase rates of erosion and sediment deposition, and such changes could be associated with mountain formation and even volcanism. Our present rates of change may reflect uncompleted adjustments to such an event. Supporting the plausibility of such an event is the fact that rapidly moving water increases its sediment transporting capacity (Figure 4) as the 3rd or 4th power of its velocity (Holmes 1965, p 512). In other words, if one increases the speed of flow 10×, moving water can carry 1000-10,000× as much sediment. Such figures make the laying down of large sedimentary deposits, during a single worldwide flood event, appear highly feasible. A recent creation would also solve the

FIGURE 4. Kanab Creek in southern Utah. A flash flood in 1886 cut a channel 15 m deep and 80 m wide in less than 8 hours (Gilluly 1968, p 218).

problems of both the rapid human population growth rate and the lack of time for evolution of major life forms (Factors 6 and 7). One might argue that by invoking creation and a flood, one is likewise pleading a special case. However, creation and the flood are not such special cases for the biblical creation model; they are implicit to the model.

Even though the supernatural involvements which are implied in the postulated unique events of creation and the flood cannot be scientifically tested, we can evaluate evidence related to these such as a long or short time span for earth history, evidence of catastrophism, and plausibility of evolutionary changes. In our search for truth, it is better to acknowledge the possibility of unique events such as creation and the flood rather than to assume they did not occur.

CONCLUSION

There are geological and biological factors which are currently observed to change at rates that are in disagreement with the standard geochronological interpretation of thousands of millions of years for the development of the crust and of life on earth. A number of alternative explanations have been proposed to bring about reconciliation, but these involve postulating an unsatisfying variety of special cases.

Evaluating factors dealing with the past warrants a great deal of caution. Extrapolation from the present involves some risk, and new observations and interpretations can readily alter conclusions for a past that is difficult to analyze. These problems apply to all dating scenarios. On the other hand, the recognized discrepancies with standard geochronology described herein appear significant and are based on several different tests. Because of this, some alternative views to standard geochronology appear credible.

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