THE EVOLUTION OF GEOLOGICAL ORIGINS THEORIES: PART I—THE HAYMOND INTERBEDS, MARATHON BASIN, TEXAS

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Abstract

In this paper we demonstrate that rock sections, settling tank experiments, fossil reevaluations, and paradigm changes have been the basis for producing several different and conflicting theories concerning the origin of interbedded sandstone and shale strata known as the Haymond flysch. We show that when new models arise, old geological explanations may still remain viable. Debate and uncertainty ultimately prevail and this is perhaps the way it ought to be since no one can observe ancient origins.

Introduction

The Nature of Theories for Rock Genesis

In historical geology it is not possible to observe the synthesis of ancient strata. Likewise it is impossible to perform experiments directly on how any given rock formation was deposited. Its origin was a unique occurrence and perhaps differed from comparable events that we might presently study.

In order to deduce the time and the means by which various rock layers formed, historical geologists measure the extent and the rates of contemporary phenomena such as sedimentation. Then they attempt to decide which processes, working when and at what rates were involved in the production of existing beds. Quite often historical explanations are based on field and laboratory analyses of fossil and rock samples. When new analytical techniques are devised, more sophisticated origins scenarios are deduced, often differing substantially from the earlier views.

From the standpoint of philosophy, historical geologists also rely heavily on ruling hypotheses called paradigms, which are exemplified by the geosyncline theory, the plate tectonics paradigm, and others. When new paradigms are envisioned, pre-existing origins models are revised or apparently discarded in favor of new ones having greater fit with new paradigms and new data analyses. After various scenarios have been devised, however, certain workers may notice weaknesses in the latest models and may return to one of the earlier views that seemingly had been abandoned. At any particular time, several explanations may retain a limited and lingering popularity with a segment of scholars.

Studying proposals for the synthesis of the Haymond formation can serve as an example of how explanations change in response to all of the foregoing factors. In the case of the Haymond, no particular origins model has emerged as permanently triumphant. Here we discuss the Haymond flysch and in a future publication we intend to explore the various theories for the genesis of the phenomenal Haymond boulder beds.

The Marathon Basin Described

In Brewster County, West Texas, near the city of Marathon, lies a famous series of geological strata about 5,000 meters (m) thick called the Marathon Basin. These many layers are exposed in a roughly rectangular basin (McBride, 1970, p. 67). The rocks of the basin are deformed, being strongly folded and trending NE to SW

All of the strata in the Marathon Basin are assigned to the Paleozoic era of theoretical geologic time. They are capped by an alluvium which has been judged to be from the supposed Quaternary period of the Cenozoic era. Paleozoic strata to the north of this opening are not visible because they are covered by layers attributed to the Permian period. Paleozoic rocks lying to the east, south, and west are obscured by overlying Cretaceous beds. P. B. King (1937, p. 1) noted that the Marathon Basin is thus a window or opening into the Paleozoic amidst areas where the Paleozoic is otherwise obscured from view:

> . . . the region is a broad dome of Cretaceous rocks, from whose central part the Cretaceous cover has been stripped away, leaving an area of low country in the center, the Marathon Basin.

This basin is part of a much larger unit called the Ouachita Geosyncline which extends westward from Mississippi across central Arkansas, southeastern Oklahoma, and into Texas: The Marathon uplift is a topographic low situated on an uplifted part of the Ouachita Geosyncline. (McBride, 1970, p. 67)

Moving consecutively from bottom to top, one encounters the following rock members of the Marathon Basin: Dagger Flat, Marathon, Alsate, Fort Pea, Woods Hollow, Maravillas, Caballos, Tesnus, Dimple, Haymond, and Gaptank. The Tesnus, Dimple, and Haymond formations are designated as Mississippian while part of the Haymond and the overlying Gaptank have been relegated to the Pennsylvanian period (McBride, 1969, pp. 1-3). Although models for explaining the origin of the Tesnus and other Marathon Basin strata hold interest, we center here on only the Haymond formation, particularly the Haymond flysch.

The Haymond Interbeds Described

On various trips to the Marathon Basin between 1985 and 1992, the authors have examined an exposure of the Haymond formation particularly at a roadcut cliff adjacent to Highway 90, about 24 km east of Marathon, Texas. The cliff exposure reveals nearly vertical strata (Figures 1 and 2). We also examined other road cuts and outcrops. Excerpts from a nearby Texas Department of Highways sign are as follows:

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Figure 1. Haymond formation layers. In this view one is looking northward at a road cut along Highway 90, about 15 miles east of Marathon Texas. Note soil creep caused by gravity. Photograph by E. L. Williams.

Figure 2. Another view of the Haymond formation. Photograph by E. L. Williams.

> In highway cuts toward the east are excellent exposures of almost vertical rock layers, part of the Ouachita Fold Belt—northeasterly trending, folded and faulted mountainous range which was uplifted about 275 to 290 million years ago. The deformation is comparable in age to the uplift that formed the Appalachian Range of the eastern United States
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> In the hillside toward the northeast, the highly deformed strata are overlaid by almost horizontal layers of younger rock—formed about 135 million years ago. Erosion wore down the old mountains, and when the area was again covered by the sea, the horizontal layers were deposited on the sea floor. Later uplifting earth movement comparable in age to the forming of the Rocky Mountain Range gently elevated this area, exposing it to erosional forces which have shaped the topography seen today.

The lower and middle members of the Haymond consist of repeating interbeds of sandstone, siltstone, and shale (Flores, 1974, p. 709). It was estimated by McBride (1969, p. 15; 1966, p. 1) that there are more than 15,000 such separate sandstone beds in this alternating Haymond series. In its entirety, the Haymond has a composite depth of about 1,300 m (Ross, 1981, p. 139). McBride described the interbed layers as involving "... fine and very fine-grained sandstone and dark gray shale less than one foot thick" (1966, p. 88).

A repeating series of sandstone and shale strata like these is called a **flysch** (Dietz 1970, p. 124) and the sequence visible in Figures 1 and 2 is known as the **Haymond flysch.** The Haymond flysch and other sections of the Haymond formation crop out along the southeast, east, and northeast areas inside the Marathon Basin.

McBride (1970, pp. 80-81) gave a brief review of the use of the word flysch for various Texas strata. He noted that Waterschoot van der Gracht (1931, Table 3) was the first to call some Marathon Basin beds flysch by applying the term to the Tesnus and lower Haymond. King (1931) also started to use the word flysch for Haymond beds and the Tesnus. In 1964 Thompson and McBride classified portions of the Dimple formation as flysch.

The Tesnus and Dimple Formations which lie stratigraphically below the Haymond are also largely flysch interbeds. Whatever can be said about the parade of changing explanations for the origin of the Haymond may possibly apply to the Tesnus and Dimple as well. In the upper Haymond are several amazing boulder beds also known as **wildflysch.** McBride (1966, p.59) was the first to call these boulder beds wildflysch. We shall consider data and viewpoints concerning the origin of the boulder beds in a subsequent report.

The Geosyncline Theory Reviewed as Background

The geosyncline paradigm was originated by Hall in 1859 and popularized by Dana in 1873. It involves the belief that great sinking basins fill gradually with sediment under conditions of shallow water (Kummel, 1961, p. 65). The sedimentation was believed to be followed inexorably by folding, faulting, and uplifting so that mountains arose in areas where sedimentary basin originally prevailed.

"In spite of the great thickness of rocks in geosynclines, there was the belief that *at no time was the water very deep*" (Foster, 1971, p. 355, emphasis ours). Geologic deposits attributed to geosynclines often show such phenomena as cross-bedding, ripple marks, mud cracks, and fossils of shallow water life forms. These characteristics were interpreted to mean that the strata in the geosyncline were deposited in shallow water. It was imagined that shallow water prevailed for eons and it was also postulated that a geosyncline subsided at the same rate that the sediments were deposited in its shallow water (Kummel, 1961, p. 65).

According to the paradigm, mountains arose later, after the thick wedges of sediment had accumulated. It was not clear in the model how the basin sediments became converted into mountain ridges, or what caused the uplift. Kummel (1961, p. 65) offered the following succinct definition by which a geosyncline is called a "surface that subsides as additional layers accumulate." We shall see how this ruling hypothesis influenced early attempts to explain the Haymond interbeds. Then we shall note how other historical geological theories about the Haymond flysch were devised from 1940 to the present.

The Haymond Formation, Shallow Water Origins Theories, And The Original Geosyncline Paradigm—The 1930s

The early opinions of P. B. King (1937, pp. 88, 91) concerning how the Haymond strata might have formed were undoubtedly influenced by the prevailing geosyncline theory and its shallow water corollary. King believed that: "the Pennsylvanian rocks of the Marathon were laid down in a geosyncline" (p. 87), as evidenced by their great thickness and other geological features. Concerning the Haymond strata King also asserted that the "water in which its sandstones and shales were laid down was brackish or *fresh*, rather than marine" (p. 89, emphasis ours). By a study of the enclosed plant remains, which he judged to be land plants and to be water-worn, King proposed that they had been "washed for considerable distances from their place of growth" (p. 87). He reasoned that the plant remains (and by extension, the entire Haymond deposit) "might therefore have been laid down in a *shallow sea*" (p. 87, emphasis ours).

Six years earlier, Van Waterschoot Van Der Gracht (1931, p. 1040) had briefly reported the views of Powers concerning the shallow origin of the Haymond as follows: "Powers believes that the entire deposit is a *deltaic* or beach formation" (emphasis ours). Two years prior to that, P. B. King and R. E. King (1929, p. 911) had already gone on record attributing the Haymond formation to a geosyncline. Shallow water basin or deltaic schemes of development for Haymond strata were popular at first and were based on the prevailing paradigm which also stressed deposition in freshwater. But even then there was a certain amount of unrest with this generalized idea and that dismay was registered by P. B. King (1932, p. 148):

> The peculiar character of the mudstone matrix, and of the associated arkoses and regularly bedded sandstones and shales is suggestive of unusual conditions of sedimentation, and perhaps an unusual climate (Emphasis ours).

Enter an Understanding of Turbidity Currents, Graded Bedding, and Deep Water Marine Sedimentation—The 1940's and 1950's

In the late 1930s Kuenen had already begun to study submarine canyons in the ocean. He espoused a different view of sedimentation involving deep water and he initiated a series of classic laboratory experiments to test the mechanism. Likewise Migliorini independently found field evidence to support sedimentation in deep water. References to Migliorini's early papers and an excellent history of the development of this new paradigm is in Kuenen and Migliorini (1950).

"Current bedding" is known to occur when sediments are deposited in shallow water. It entails cross-bedding and ripple marks, as we previously noted. By way of contrast, "graded bedding" generally manifests few or none of these current marks but instead shows a gradual transition in grain size from coarse below to fine above in each one of the repeating members. Often such graded beds occur in a series which may be quite thick. Each member of the series may also have a vast lateral extent.

Graded bedding is characteristic of sedimentation in deep water and was shown by Kuenen to originate experimentally when water currents containing particles of a wide size range were periodically injected into deep standing water. Similar bursts of sediment laden water can come in nature from dust storms, storm waves, volcanic explosions, spring runoff, and flood water entering sea water. Strata with repeating interbeds such as sandstone and shale are thought to have been formed by turbidity currents entering deep standing bodies of water and hence the rocks themselves are known as **turbidites.**

Kuenen and Menard (1952) published results of their outstanding experiments in which water charged with sediments was repeatedly released through a channel into water which stood within a settling tank. By this means they were able to produce deposits in the lab which closely resembled turbidities in nature. Kuenen and Migliorini (1950, p. 9) concluded that naturally occurring turbidities had been produced this way.

Bouma (1962) reported on turbidities found in certain beds in the Alps and devised a series of lithologic criteria for identifying and classifying these strata microscopically. Bouma's criteria have been accepted and widely used by geologists. Kuenen (1967) continued his experimental studies and concluded that only turbidity currents in deep water (not normal currents in shallow water) can account for flysch type sandstone beds.

Turbidity Currents Applied to The Origin of the Haymond Formation—The 1960s

McBride began using this information about graded bedding and turbidity currents to propose a new theory for the origin of the Haymond flysch of the Marathon Basin. Casting aside the earlier shallow water ideology, McBride saw Haymond beds as turbidities that must have been deposited in deep water (1969, pp. 16, 86-90). He noted (1966, p. 1) that in the 15,000 separate Haymond layers, "no fossils indicative of shallow water" could be found. Incidentally, McBride (1966, p. 8) also stated concerning the fossils of the entire Haymond series that (with only two exceptions) they were of no stratigraphic value. After careful lithologic study, the many sandstone members of the Haymond ranging in thickness from about 25 centimeters down to a few millimeters, were attributed to "deposition from waning currents of high initial velocity" (McBride, 1966, p. 1).

Dean and Anderson (1967) showed that these turbidity currents had evidently been quite widespread. Using the criterion of thickness, they successfully correlated siltstone and claystone couplets between two Haymond flysch outcrops that were separated from each other by 10.5 km.

Johnson (1962) had discovered grooves, flute casts, and bounce casts (all characteristic of true turbidites) on the lower surfaces of alternating couplets in the Tesnus formation and he therefore attributed the genesis of the Tesnus strata to turbidity currents as well.

McBride (1966, p. 1) theorized that the Haymond beds were produced in a **marine** basin "that was from **several hundred** to **several thousand** feet deep,"—emphasis ours. The Tesnus and Dimple formations lying beneath the Haymond were also labeled as deep water flysch deposits. In his brief but instructive history of this topic, Flores (1972, p. 3415) noted that McBride had based his conclusions on "internal structure, bedding surface structures, and grain size of sandstone beds."

McBride (1966, p. 18) believed that Haymond rock sections manifested the expected graded bedding under the microscope. McBride confessed, however, that true graded bedding (in which grain size itself changes from large below to smaller above) was not as common in the Haymond flysch as was a peculiar form of bedding in which the quartz grain size remained relatively constant (from the bottom to the top of a given bed) but the clay content increased as one approached the top section of the sandstone bed.

Still, McBride clung to the mechanism of turbidity currents and rested his case as follows:

> (1) they are interbedded with shale that is best interpreted as a deep-water deposit, and (2) internal structures suggest that they were deposited by waning currents that initially had high velocity . . . the sandstones have sole marks, graded bedding, and convolute bedding that are typical features of alleged turbidites. (1969, p. 89)

This new origins view was a distinct departure from the shallow, freshwater, and deltaic explanations popular in the 1930s. The stimuli that fostered the change apparently were the data from the experimental settling tank and Bouma's field and microscope work on graded bedding. Consequently the geosyncline paradigm was coupled with deep water (rather than shallow water) sedimentation and a marine, rather than a freshwater, environment. By 1958 even R. B. King had modified his stance and had converted to a deep water Haymond origins scenario (1958, p. 1734). King expressed the predictive belief (1958, p. 1732) that the mechanism found for the Marathon Basin strata would ultimately fit with the studies of Kuenen and his students (meaning Bouma and others).

Further Information Concerning Turbidity Currents and Sedimentation

There is much evidence that turbidity currents occur in lakes and oceans whenever dense, turbulent, and sediment-containing water flows under the standing water which is less dense (Hamblin, 1975, p. 92; Shelton, 1966, p. 35). A cross section of Lake Mead in Figure 3 shows the effects of such currents. This is a cutaway view along the Colorado River in the western Grand Canyon and Lake Mead area. It shows deposition which occurred during the first 11 years after the lake was formed. The arrow below indicates the mouth of the canyon at Grand Wash Cliffs; the western Grand Canyon is to the right of the arrow whereas Lake Mead is to the left. The ordinate represents the relative abundance of sediments. As it loses speed and energy, the turbidity current deposits and sorts the heaviest particles first, and the successively lighter ones later. After the current has dropped its heavier particles, (presumably, forming a sandstone layer called a *turbidite)* a layer of much lighter particles (silt and mud) is deposited, forming shale, as McBride thinks has happened in the Haymond interbeds. Such a shale layer above a sandstone member is called a *pelagite.* The whole process is repeated with the next pulse of sediment-laden water flowing into the standing water and producing the next bed of turbidite sandstone followed by more of the shale (another pelagite).

Turbidity currents have been studied in Lake Mead where they have been observed to travel distances of up to 125 km (Scheidegger, 1961, pp. 23-24). In the ocean, turbidity currents caused by earthquakes have traveled with speeds measured as great as 52 miles per hour and with enough force to break telegraph cables on the ocean floor 300 miles from the epicenter (Hamblin, 1975, p. 319; Roth, 1975). The calculated volume of sediment in just one such current generated by the earthquake off the Grand Banks of Newfoundland in 1929 was 100 km^3, carpeting 20,000 square miles of sea floor with sediments up to one meter in depth (Sullivan, 1974, pp. 44-48).

Concerning this same earthquake, Hodgson (1964, pp. 23-24) noted that the resulting turbidity current had:

> . . . tremendous erosional powers. The fact that an earthquake triggered this particular current is not to imply that they can be started only in this way. Any accident which starts material moving down the continental slope can cause a current, although perhaps only an earthquake can cause such a big one.

Strahler (1977, p. 148) observed that:

> On continental shelves and deltas of large rivers, mud is continually accumulating and may form precariously situated deposits that are easily disturbed and sent sliding by storm waves or earthquake shocks.

Longwell and Flint (1964, p. 298) reported that turbidity currents occur frequently. Concerning the

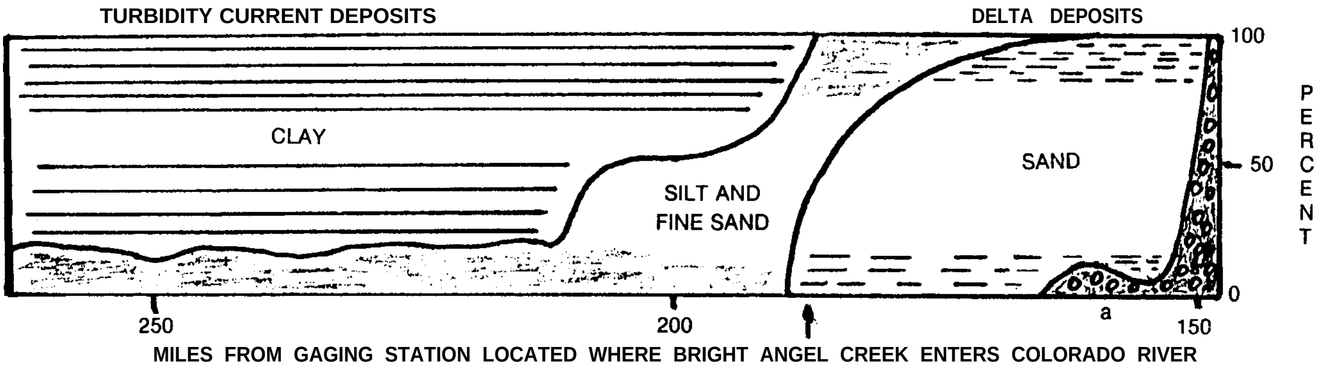

Figure 3. Idealized diagram of turbidity and delta deposits, Lake Mead. a = course sand and gravel. Figure by E. L. Williams after Shelton (1966, p. 35).

same 1929 current mentioned earlier, they indicated that: "similar events have occurred at least twice at each of 40 localities around the world within the past 74 years."

Were Turbidity Currents Associated with The Flood?

We believe that the Haymond deposits may have been produced by a series of turbidity currents generated in a relatively short time span by volcanic, meteoric, or tectonic processes. A rapid formation of Haymond interbeds is also suggested by the general conformity of these many layers to each other. This rapid and catastrophic role of turbidity currents in the origin of strata was stressed by Roth (1975) and more recently by Howard (1992).

One wonders what conditions might have prevailed to set the stage for turbidity currents which may have produced the Haymond formation. Moore (1989) speculated that during the Paleozoic Era an inland sea called the Ouachita trough covered this area of Texas and extended northeastward into Arkansas and Oklahoma. This deep-sea trough is thought to have received vast quantities of sediment from the north. Turbidity currents pouring into this large body of water might have deposited the sedimentary beds that eventually became the Haymond Formation. Catastrophists could argue that the Ouachita Trough developed near the end of the Flood. If so, it may have served as a site through which flood waters moved from the north to cause turbidity currents that deposited the sediments of the Haymond flysch.

Whitcomb and Morris (1960, p. 269) spoke of the possibility that turbidity currents operated during and after the Flood:

> The newly-deposited sediments were still relatively soft and unconsolidated, and the imposition of new gradients and currents over them when the lands began to rise would have immediately induced scouring action on a large scale. The mixture of water and mud thus formed would, in flowing downslope, itself cause tremendous submarine erosion and ultimate redeposition. The great sedimentary competency of these turbidity currents . . . has only been appreciated in recent years but has been adequately demonstrated both by field data and laboratory studies.

They also speculated that rapid action of turbidity currents may have caused the banding or laminations evident in certain other deposits such as the Green River oil shales—(Whitcomb and Morris, 1960, pp. 427-428).

Surprise—A Return to A Shallow Water Haymond Scenario in The 1970s!

During the six years from 1969 to 1975 Flores turned the tables by reinterpreting most of the data to support what he called a "short-headed stream delta model" for the Haymond. After a brief preview (1969), in 1970 Flores published a larger work in which he asserted that:

> Present studies . . . of this formation suggest that the Haymond need not have been of deep water origin but that a deltaic origin is equally likely. (1970, p. 621).

Flores argued (1970, p. 626) that the flysch could have formed at a delta front which continually ". . . received pulse-like influxes of sediments during periods of heavy rainfall in the source area." He believed that the turbidite interbeds were of slightly deeper (delta front) origin and he attributed the upper, coarse grained, Haymond sandstones to the delta plain (1975, p. 2288). He supported his reinterpretation by gathering monumental amounts of field data and performing numerous laboratory rock analyses (Flores, 1972, 1974).

He envisioned a shallow-water deposition in a delta, as Powers had done and argued that:

> the origin of the turbidite portion of the sequence is not necessarily deep water, and the presence of carbonaceous shale, coal, and "seat rock" type sandstone favor a very shallow and perhaps subaerial environment. (Flores, 1970, p. 622)

Upon analysis of rock sections, he consistently noted such features as cross-bedding, an upward increase of quartz grain size, and other phenomena which he believed to be in direct conflict with the classical Bouma criteria for true deep-water turbidites (Flores, 1974, p. 709).

In his concluding and summary report of 1975, Flores compared modern day delta deposits to his delta-based Haymond scenario. Modern day deltas often consist of fine deposits below, made at the delta front. The deltas have coarser sediments above because delta plain sediments eventually bury the existing delta front strata. This pattern, Flores argued, also applies in general to Haymond strata. Flores observed, however, that Haymond rocks differ in some ways from ordinary delta deposits. He attributed all of the Haymond flysch sandstones to the delta front and the coarse sediment plus boulder beds of the upper Haymond to the delta plain sediments. Flores admitted that with flysch below and boulder beds above, this supposed Haymond delta would have been different than typical modern deltas such as those of the Fraser, Niger, or Orinoco Rivers. These differences, Flores concluded, arose because the source area for the theoretical Haymond delta was "much closer to the site of deposition than in modern deltas" (1975, p. 2297). The extreme proximity of source area to delta deposition site, he believed, explains the unusual resemblance of the lower Haymond strata to deep water turbidites (which he labeled merely "flysch-like"). He supported these conclusions by field analyses of the delta produced by a short-headed stream which empties into Lake Erie in western New York (Flores, 1970).

While some other workers had imagined that the source area for Haymond sedimentary material was from the north, Flores argued that it came from an adjacent river to the southeast. The issue of sediment source and dating of rocks in the boulder beds will be discussed in Part II.

Life after The Delta Debut

During this flurry of revisionist thought concerning the Haymond genesis, McBride (1970, 1973) appears to have continued stressing the Haymond features which he believed to support the deep water turbidity view. Where Flores appealed to a present day delta in a New York river, McBride described the Var, a river in France which enters the Atlantic and has a deep submarine channel through which continental debris can flow into deep ocean water to create turbidity currents (McBride, 1970).

McBride (1970, p. 80) did briefly mention Flores' 1969 presentations and described Flores' proposed deltaic environment with water that was shallow enough to permit plant growth. Although Flores' work is discussed on p. 80, a reference to Flores' 1969 abstract was missing in the reference list, p. 82. This was apparently an inadvertent publishing omission.

The turbidity current concept was also still very much alive in the thinking of Ross (1981) who treated the Haymond formation as a turbidity deposit. Curiously, Ross made no mention of any of the papers by Flores regarding the deltaic view; one wonders if Ross ignored them or if he was completely unaware of Flores' work. In 1975 King again discussed the origin of the Haymond from a deep water standpoint but he likewise avoided reference to any of Flores' papers.

In a brief abstract appearing more recently (1982, p. 559) McBride asserted once again that the entire series of Marathon Basin strata (except the Gaptank) "is best interpreted as slope and basinal deposits." Thus despite Flores' persuasive rationale for a delta front and delta plain mechanism, McBride, Ross, and King appear to have remained firmly convinced that the Haymond interbeds were of deep water turbidity current origin, paying little or no attention to Flores, except to mention his abstract (1969) once—McBride (1970, p. 80).

In 1992, Howe wrote to Flores asking what was presently happening in the Haymond debate. In a cordial reply, Flores (1992) indicated that since 1975 his own research emphasis had changed and that he had temporarily ceased from further investigations of the Haymond. Flores supposed that the Haymond origins debate still continued. He indicated having heard from former coworkers that his original delta view for the Haymond had been turned into a similar alluvial fan delta concept.

Future studies might center on apparent conflicts lingering in the evaluation of scientific data. Does microscopic analysis generally reveal the Bouma signs for turbidites (as McBride believed) or does it show a strange type of bedding best explained by the delta deposition of Flores? Do the plant fossils betray a shallow water environment (as Flores maintained and as was claimed in the 1930s) or are these fossils of little stratigraphic significance or even nondescript as McBride implied? An open field of continuing scientific and theoretical study beckons those who possess the skills, energy, and insight required.

Summary and Conclusions

Early concepts of Haymond interbed formation were based on shallow water and freshwater deposition, in close keeping with the original geosyncline paradigm. Deep water turbidity currents were then discovered and their profound effects were noted in the 1940s and 1950s. Shallow water ideas gave way in the 1960s to the concept that Haymond strata were actually a series of deep water turbidites. Such conclusions were based on rock analyses and application of the diagnostic criteria that had been advanced by Bouma or the identification of turbidites.

Extensive scientific analysis of the same beds, however, led Flores in the 1970s to the opposite conclusion that Haymond strata do not actually satisfy established deep water turbidite criteria. He maintained that they were probably produced in shallow water by the delta of a short-headed stream. The origin of the Haymond interbeds still remains an open question.

Catastrophists are fascinated by the rapid sedimentation rates made possible by turbidity currents. Yet we realize that if a deltaic model for the Haymond ultimately gains greater scientific credence, rapid delta formation could have occurred during the intense draining of inland seas toward the end of the Flood. Even at present it is recognized that delta formation on major rivers can occur with astounding speed. Consult Seeman (1942, p. 196), Miller (1948, p. 218), and Thronbury (1969, p. 169) who recognized rapidity in delta formation but still imagined that in many cases the process took millions of years. Some young earth catastrophists have also written about the speed of delta deposition (Allen, 1972; Mehlert, 1988).

Hopefully in the future geologists will devise new scientifically-based technologies to help distinguish which of the Haymond models is most credible—shallow water geosynclines, deep water turbidity currents, short-headed stream deltas, or possibly other models that have been or will be offered. Such an array of viable origins theories illustrates the tentative and speculative character of historical geology in general. An admonition to creation scientists might go as follows: "If a certain geological model seems not to fit with catastrophist biblical concepts, wait a few years; the theory will most likely change."

While the ephemeral nature of geological origins schemes is familiar to specialists in that field, the reading public needs to be reminded periodically that any new theory (or any old one, for that matter) which purports to account for rock genesis is always subject to revision or abandonment. Furthermore, non-geologists should know that if geological theories (which are based on direct scientific observations and experiments) are at best uncertain, then the geologic "dates" applied to the strata are even more speculative.

People will probably never deduce the Creator's past geological activity with finality and assurance. In all of the sciences, but especially in historical geology, workers ought to heed the words of Isaiah 55:8

> For my thoughts are not your thoughts, neither are your ways my ways, saith the Lord. For as the heaven is higher than the earth, so are my ways higher than your ways, and my thoughts than your thoughts.

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