CATASTROPHISM AND MODERN GEOLOGY: MODELING THE PLACER GENERATION PROCESS

ALEXANDER V. LALOMOV* AND SERGUEI E. TABOLITCH**

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Abstract

We present a mathematical model for coastal submarine placer (CSP) generation under lateral coastal drift conditions. We test the model against field data and propose a method of predicting CSP parameters which has possible economic application for locating placer deposits. The model provides a method to estimate the time and rate of CSP formation. The model yields an age for a tin-bearing sediment in northeastern Siberia to be less than 40,000 years. This estimate is approximately 1000 times less than age given by the standard evolutionary geology time scale. A logical extension of this work is to two and three dimensions. This would make possible more detailed comparison of the models with field data and produce improved methods for estimating placer parameters.

Introduction

Elucidating the role of catastrophism from available field data is a massive task indeed. Our approach has been to focus on a specific process and to combine modeling with testing of the model against actual field data. We selected one of the least investigated topics of geological process theory—the process of placer formation.

A correct understanding of the generation mechanism, as well as the age and duration of both alluvial and submarine placers we believe is closely connected with catastrophic geologic activity. Modeling placer formation is therefore important both in prospecting and for a correct understanding of geological history.

During the period 1983-1990, the authors researched the geochemistry and lithology of alluvial and submarine placers in Middle Chucotka, northeastern Siberia. Local geologists generally believed the placers of Chucotka had formed through multistage processes of long duration. However, we contend on the basis of our research, that coastal submarine placers (CSP) need much less duration for their formation. This mechanism of short duration provides a successful description for at least CSP's.

In this paper we consider a mathematical model for transport by lateral coastal drift (LCD), that describes the generation process for coastal submarine placers (CSP). We test our model against actual field data.

Our model for load migration describes: 1) arrival of fragmented material into the active drift zone of beach and submarine slope and 2) transport by lateral drift with irreversible dispersal from the shore to the submarine environment.

Mathematical Model

We choose, for inclusion in the initial differential equations, an elementary cell having a vertical height H (direction corresponding to the thickness of the active layer of sediments), length Δ X (with the x-axis positive in the drift direction and parallel to the shore line), and active accommodation zone width Y (Figure 4). Material from land enters through the side Δ XH with velocity U. The amount of load (Per unit volume) carried into the cell by lateral drift from the direction of drift is VHY, where V is the drift velocity. The amount of load transported out of the cell through the downdrift side is VHY + (δ(VHY) /δ x)Δ X. An amount WH Δ x of load leaves the cell through the oceanward side of the cell parallel to the shore (W is the velocity of this material exiting this side of the cell). The velocity is different for light (W) and heavy (W_p) fractions of the sediments. Here we use a subscript p to denote the ore material.

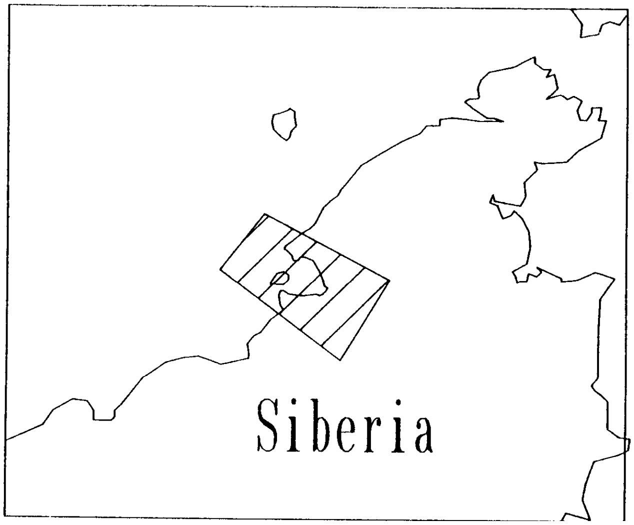

Figure 1. Research district.

For simplicity, we replace the actual lateral drift rate, which is pulsating in time, with a steady one that has constant parameters for the material migration through the cell. Let us assume that all parameters are constant along the coastal zone under study except the content C of heavy (ore) minerals and the width Y of the active accumulation zone. Then we equate to zero the difference of material carried into and out of the cell and divide the whole expression by the constant quantities Δ X and H to obtain the following expression for all migrating material:

$$\frac{\delta Y}{\delta x}V+W-U=0 \tag{1}$$

For the ore minerals in the flux of ore-bearing material (x_0x_1) we have:

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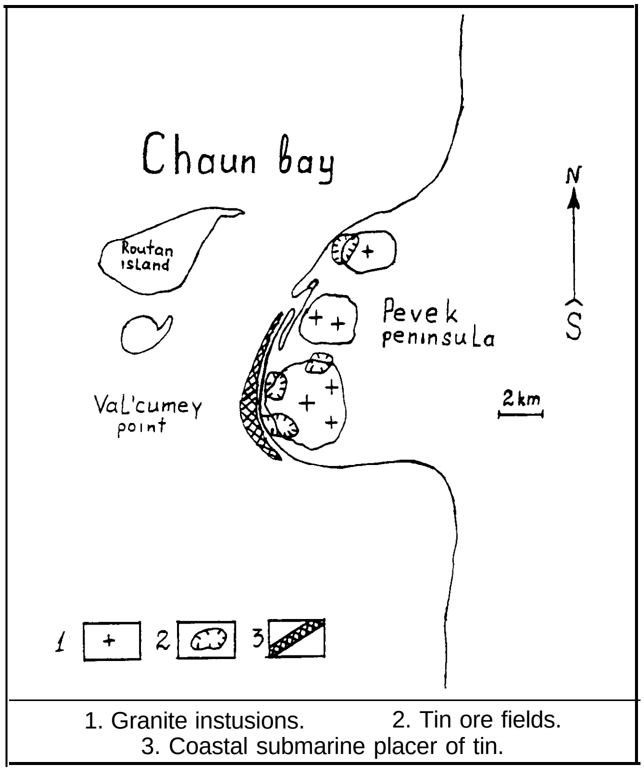
*Alexander V. Lalomov, Ph.D., 24/32 ap. 3, ul. Zemlianoy Val, Moscow, Russia, 103064.

**Serguei E. Tabolitch, 1 - 55, Balaklavski pr., Moscow, Russia, 113639.



1. Granite instusions. 2. Tin ore fields.
3. Coastal submarine placer of tin.

Figure 2. Map of Pevek peninsula.

$$\frac{\delta(CY)}{\delta x}V + CW_p - C_pU = 0 \qquad (2)$$

C_p represents the average content of ore minerals in the incoming ore-bearing material.

In the direction of the drift where ore-bearing material is absent ($x > x_l$) we have:

$$\frac{\delta(CY)}{\delta x}V + CW_p = 0 \qquad (3)$$

Then we solve equation (1) for Y and obtain:

$$Y = Y_0 + BX \qquad (4)$$

where $B = (U - W)/V$. Let $Y_0 = 0$, substitute (4) into (2), (3) and solving for C (see the Appendix for details) we obtain:
for the segment x_0x_1:

$$C = KC_p\left(1-\left(\frac{x_0}{x}\right)^A\right) \qquad (5)$$

where:

$$K = U/(U-W+W_p) \qquad (6)$$

$$A = (U-W+W_p)/(U-W) \qquad (7)$$

for the segment $x > x_1$

$$C = KC_p(x_l^A - x_0^A)/x^A \qquad (8)$$

It is important to note that this model may be used for the description of lateral migration of any material; for example, marker pebbles. In this case one must in all formulas change C to C_m, C_p to 1 (100% ore), W_p to W_m, A to A_m, K to K_m. We designate the flux of incoming marker rock pebbles as x_2x_3. Here we use the subscript m to denote marker pebbles.

A test of the adequacy of the model was conducted in several tin bearing districts of the northeastern Siberian coast. One of them is located a short distance from Val'cumey point in Chaun Bay and is associated with actively denudated relief in the southern part. Abrading cliff and friable slope sediments arriving in the active zone of the beach are tin bearing. Lateral coastal transport is directed from the top of the point to the north. In the northern part of the district lateral coastal drift occurs and a placer ore zone is formed. CSP of tin is directed from the source north in accordance with the concept of lateral coastal drift (LCD).

Almost all the layers of the coastal submarine deposits are tin-bearing, but the highest concentrations of cassiterite are deposited as lenses and currents parallel to the modern shoreline.

Cassiterite (SnO_4) concentrations are located in the pebble, sand, and silt deposits of the beach and submarine slopes. The average dimension of cassiterite grains is 0.31 mm. The grain dimensions are different for the different types of deposits: pebble deposits contain more large dimension ones (average 0.54 mm), sand—0.18 mm silt—0.13 mm. The highest concentrations of cassiterite are associated with sand and pebble deposits.

Modern lithodynamical characteristics of LCD near the Val'cumey point are described as non-satiated loads (abrading zone). Far to the north coast are more stable (transit zone) and in the north part of the placer we see the deposition of loads on the accumulation forms (accumulation zone). The highest concentrations of cassiterite and the greater part of occurrence volume are associated with the abrading zone.

We could not research the lithodynamical conditions of the past as well as the modern conditions, but drilling data have shown that similar conditions occurred in this region.

The cassiterite concentrations in the active layers of sediments in the abrading and transit zones are dynamical, that is concentrations are conditioned by arriving and departing material. Tin content in every point of the active layer is constant (with some fluctuations) until the velocities of arriving and departing material are stable.

Figure 5 shows results of measurement of the content of tin and marker pebbles and model calculations for each. The values for the model coefficients are obtained for the descending branch of the curves in the following way:

The constants:

$$D = KC_p(x_1^A - x_0^A) \qquad (9)$$

and A for tin,

$$D_m = K_m(x_3^{A_m} - x_2^{A_m}) \qquad (10)$$

and A_m for marker pebbles were calculated in the intervals $x > x_1$ and $x > x_3$ respectively, in the conventional manner by a trial and error method as coefficients of regression equations:

$$C(X_1) = \frac{D}{x_i^A} \qquad (11)$$

$$C_m(X_1) = \frac{D_m}{x_i^{A_m}} \qquad (12)$$

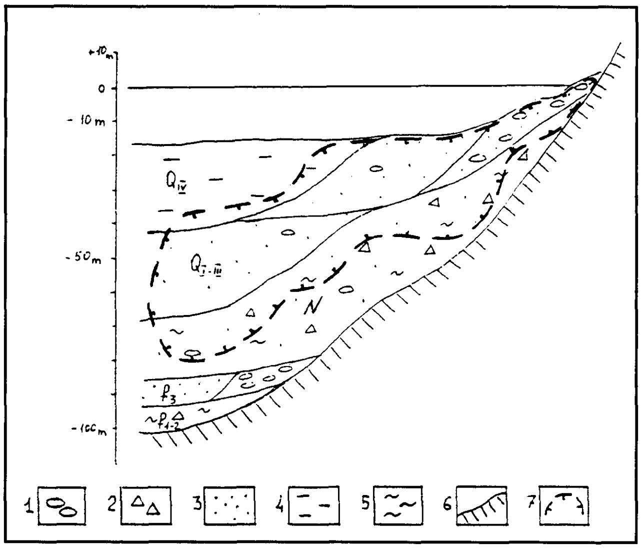


Figure 3. Diagrammatic representation of a section through the coastal submarine deposits near the Val'cumey point. Legend: 1. Pebbles. 2. Detritus. 3. Sands. 4. Silt. 5. Clay. 6. Shale. 7. Placer deposits. P_{1-2} - paleocene-eocene; P3 - oliogocene; N - miocene-Pliocene; Q_{I-III} - pliestocene; Q_{IV} - golocene.

These coefficients and known quantities x_0, x_1, x_2, x_3, C_p are used for the calculation of the K and K_m values.

For Val'cumey district, these coefficients are A = 1.65, A_m = 1.50, D = 3.4 x 10^8, D_m = 1.8 x 10^6, with x_0 = 200 m, x_1 = 1200 m, x_2 = 1160 m, x_3 = 1200 m, C_p = 370 g/m^3. Calculated quantities are K_m = 8.8 and K = 8.0.

The near equality of the coefficient values K_m, K and A_m, A for tin and pebbles suggests a method for predicting tin content in coastal submarine sediments under lateral drift conditions. The less than 10% difference in coefficients allows one to apply routine geological prospecting methods. The coefficients K_m and A_m, are calculated with this method and then used for tin. If we know the values (x_0, x_1, C_p) of the tin bearing source, then we can calculate the tin content in the coastal submarine sediments. C_p is obtained from geochemical sampling of friable slope sediments arriving at the active zone of the beach or from data from drilling into submarine sediments in the vicinity of point x_1. The results of the modeling are seen in Figure 6.

One of the curves is constructed using drilling data from submarine sediments in the vicinity of point x_1 = 1200 m from the beginning of lateral coastal drift. The other curve is obtained using data from geochemical sampling of friable slope sediments from the shoreline. Geochemical sampling gave the estimate C_p = 250 g/m^3. To calculate C we used coefficients K_m and A_m obtained from data giving the content of granite marker pebbles. Sufficient conformity of the calculated and actual data argues that this model is useful for predicting parameter values for CSP as the initial stage of geological prospecting. The correlation coefficient for calculated and field data is 0.82 (the critical value for the 1% level of significance is 0.62) which indicates a genuine correlation between the model and the actual processes.

From this model, we can obtain the time interval T for placer deposit generation within an active layer for deposits of thicknesses up to 2 meters:

$$T = L/V$$

where L is the length of the placer deposits and V is the velocity of lateral drift.

The T for Val'cumey placer deposits L is about 8000 m, V calculated in two different ways (with drift velocity for sands and pebbles) is 100 m per 24 hours, thus T for Val'cumey placer deposits is 80 days.

The dynamical nature of heavy mineral anomalies has been corroborated many times on the different natural objects (Mero, 1969; Gardner, 1955). As usual,

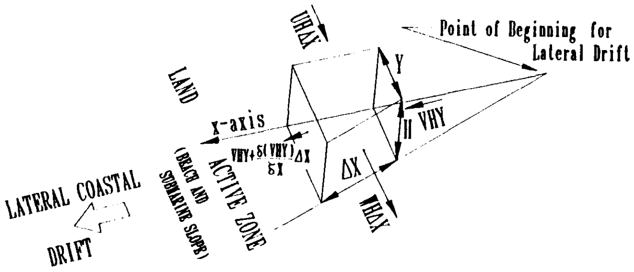


Figure 4. The elementary cell for the mathematical model.

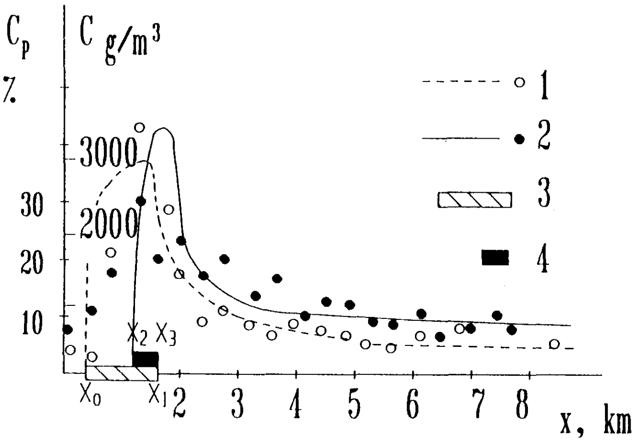


Figure 5. Contents of tin and granite marker pebbles. Natural contents: 1 - tin; 2 - granite pebbles and approximated curves. Districts where new material joins the lateral coastal drift: 3 - tin, 4 - granite detritus.

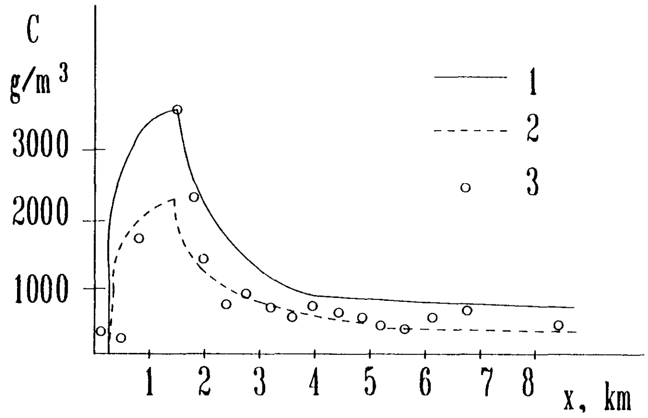


Figure 6. Calculated curves for tin based on the model equations. Constructed: 1 - with data from drilling in submarine sediments near the point Xl = 1200 meters from the beginning of lateral coastal drift, 2 - with data from geochemical sampling of friable slope sediments near the shoreline, 3 - natural contents of tin.

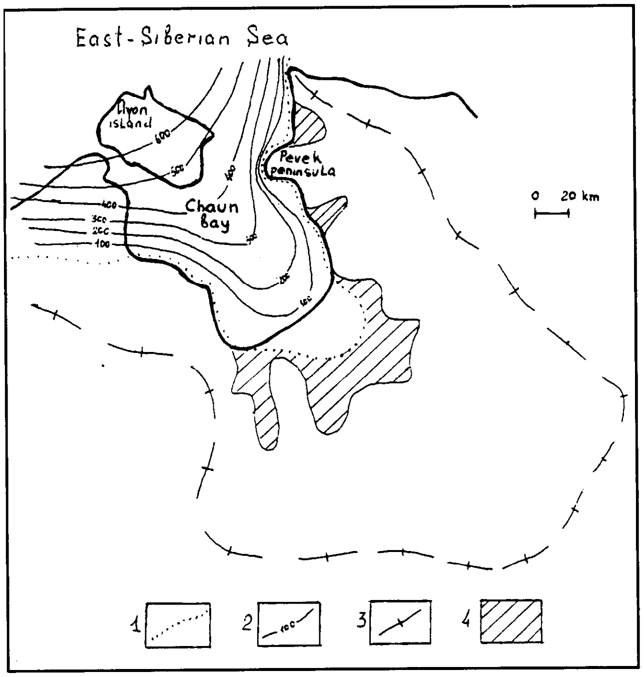


Figure 7. Lithodynamic condition of Chaun depression and mountain setting. Legend: 1 - border of Chaun depression (sedimentation zone); isolines of sediment thickness (in m) based on geophysical and drilling data; 3 - border of denudation zone relating to the Chaun depression; 4 -transit zone without considerable denudation or sedimentation.

the velocity of sedimentation was understated and the time interval for placer deposit generation was overestimated.

Recent research on sedimentation shows that generation of massive thicknesses of stratified sediments can occur in a short time interval (Julien, Lan, and Berthault, 1993). Under the conditions of rapid subsidence of a sedimentation basin, fast burial of the generated placer deposits can occur. Thus one can observe accumulation of massive ore-bearing sedimentary thicknesses that exceed by many times the thickness of individual placers layers. We see such a situation in the tin CSP's within a short distance from Val'cumey point. Tin content in the sediment column (thickness more than 30 m) is consistent enough (the coefficient of variation is 1.51). The tin content in the active layer correlates well with the average tin content in the entire thickness of the placer deposits (the correlation coefficient is 0.74 and the critical value for the 1% level of significance is 0.54). Such stability of tin content in the column is evidence of constant litho-dynamical conditions throughout the period of placer deposit generation and accordingly proves the recent age of its generation. This is because the litho-dynamical factor is the most unsteady of all the geological factors. Variation of the tin content in the sedimentary column and the localization of the increased tin content to layers of coarse sediments is explained as a result of stream pulsation (Julien et al., 1993).

Past estimates of the duration of placer deposit generation were based on paleontological data and the overall geological history of the East Arctic region. The authors attempted to estimate the duration of placer deposit generation on the basis of the balance of the volume of material from land denudation arriving offshore and the volume of accumulated material in the Chaun depression (Figure 7). The approximate calculation of placer deposit generation duration based on the estimated northeastward velocity of denudation of 1 mm per year gives a greatest possible duration of 40,000 years, which is approximately 1000 times less than the age estimated from paleontology. If we take into account that the velocity of denudation may have been much greater in the past, especially in the post-Flood time (Nevins, 1974), then this age is an upper limit and the real age may be much less. More exact estimates of the age of the sediments and also the velocity of placer generation perhaps can be calculated through future research.

The scientific literature contains several efforts to model the placer generation process. However, most of these are based on heavy use of geological prospecting data and most have difficulty in calculating practical parameters. An important distinctive feature of our method is that it can be applied with much less reliance on drilling. It therefore should be of significant practical interest for the mining industry since it makes the process of prospecting for placer deposits considerably less expensive.

Conclusion

We have presented a mathematical model for generation of coastal submarine placers that successfully predicts the distribution of heavy minerals in placer deposits. The model implies that, under favorable tectonic conditions, massive thicknesses of placer deposits can occur in a brief time interval.

For example, the time span for generating individual placer layers in the much researched Val'cumey placer deposits is estimated as 80 days. The available data show that the age of the entire thickness of these placer sediments is not more than 40,000 years. This upper limit is approximately 1000 times less than the age derived from the standard geological time scale. The actual age may be much less. It means that the true rate of placer generation is dramatically larger than evolutionary geologists usually assume.

This model has enormous practical importance. Creationism is often considered to have little connection with practice. Mathematical model of the placer generation process motivated by a creationist perspective nevertheless offers notable economic benefits. We believe there exist other similar examples in the field of economic geology that if developed, would further the credibility of this understanding of history.

Our model still needs further testing and refinement in both the laboratory and the field. We hope to extend the method to two and three dimensions, to test it in more detail against field data, and to develop improved strategies for estimating placer age and formation rates.

Acknowledgments

We thank the participants in the second Moscow International Symposium on Creation Science, May 27, 1994: Dr. Duane Gish, Dr. Terry Spohn, Dr. Charles Thaxton, and Prof. John Whitmore for their participation in the discussions and favorable regard for our investigation. We want to thank Dr. Eugene F. Chaffin and a reviewer for editing an earlier version of our manuscript, useful notes to its content and improvement in the English.

Appendix: The Derivation of Equation (5).

Substitute the values of B and Y_0 into (4) to get the expression for Y, then substitute for Y in (2) to obtain:

$$\left(\frac{\delta}{\delta x}\left(C\frac{U-W}{V}x\right)\right)V+CW_p-C_pU = 0 \qquad (13)$$

Treat U, V, and W as constants. Then C is a function of x, thus the derivative of C times x is C times the derivative of x plus the derivative of C times x. The values of K and A are defined in (6) and (7). Simplifying the equation using these definitions yields:

$$\frac{x}{A}\frac{\delta C}{\delta x} = -(C-KC_p) \qquad (14)$$

Rearranging and integrating we get:

$$\int\frac{\delta(C-KC_p)}{C-KC_p} = -A\int\frac{\delta x}{x} \qquad (15)$$

We put the limits of integration as C = 0 to C = C for the left hand integral and x_0 to x for the right hand integral. After simplification, the integration yields (5).

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LETTER TO THE EDITOR

The Red Fox in Montana and Alberta and The Uniformitarian Geologic Column

I read with interest the article on *Vulpes fulva* (or *Vulpes vulpes)* in the December, 1995, issue of the *Quarterly*. The authors state that “It is currently absent in the grasslands east of the front range of the Rocky Mountains. . . .” Since reading the article, I have inquired of several acquaintances in Montana and Alberta about sightings of the red fox. All have indicated that it has been common during recent decades east of the Front Range in Montana and north into Alberta. From this cursory survey, it is evident that it inhabits the grasslands east of the Front Range at least as far as Great Falls (ca. 90 km). Was the red fox previously absent from this region? One day a couple of years ago, I observed a red fox hunting rodents outside my office window, well within the city limits. Has *Vulpes fulva* adapted to urbanization of its range, or might it have expanded into this area during the past century?

On an unrelated matter . . .

Kudos for John Reed’s article, “Critique of the Naturalist-Uniformitarian System,” in the June, 1996, issue of the *Quarterly*. He put the issue succinctly when he said, “The most severe deficiency in the geologic column is its inextricable linkage to the naturalist-uniformitarian system, and its resulting inability to define and defend its axioms on a metaphysical level (p. 6).” Failure to recognize this fact has hamstrung creationist geologic research to this day. Few have recognized that historical geology is not essentially science, and that condensing the establishment’s scenario into a biblical time-frame does justice to neither science nor Scripture. Reed recognizes this, stating the geologic column “. . . is not merely an empirical model, but instead a comprehensive definition of earth history fundamental to a larger, naturalistic-uniformitarian framework (p. 8).” Acknowledgement that the ultimate debate is over a philosophy of history, not a somehow neutral interpretation of self-evident facts, is long overdue. The expose of the logical inconsistencies of the naturalist-uniformitarian system was well reasoned.

Francis Schaeffer and others have addressed these principles well in past years. But to my knowledge, Reed’s article is the first that applies these principles so directly and effectively to the issue of the geologic column. As I heard Gregory Hull put it, “Most Ph.D.'s are just over-trained technicians.” I agree with him. The American academic establishment is largely obsolete, and Ph.D. degrees are anachronisms, with no real ties to philosophy at all. Many fail, therefore, to recognize that science and history play by different rules. It is refreshing to see capable scientists like John Reed living up to the original standards of science (that branch of philosophy that limits itself to the empirical). It is essential that whenever we face a pivotal issue, such as the veracity of the geologic column, we cut through to the heart of the issue and develop a solid philosophical basis for our research. Reed’s article is a definite step in that direction.

Peter Klevberg
512 Seventh Avenue North
Great Falls, MT 59401