Catastrophism in Geology: Determination of the Generation Time of Coastal Submarine Placers Based on Mathematical Modelling

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ABSTRACT

An attempt was made to determine the age of formation of coastal submarine placers using a diffusional-convectional generation model. Preliminary results provided an estimated age for the sedimentary strata (traditionally estimated by evolutionary geologists as generated over 40 million years) of only 2,000-5,500 years, which bears testimony to their generation in post-Flood time. This may thus provide a new method of determining the time required for the generation of geological strata. Furthermore, this model has been tested on field data in the north-east of Russia and has considerable economic benefits.

INTRODUCTION

Determination of the generation time of geological objects is one of the most difficult problems in modern geology. Evolutionary geologists determine age with radiometric and palaeontologic analyses. Both of these methods are based on questionable assumptions.[1-3]

During the period 1983-1990 the authors investigated the geochemistry and lithology of alluvial and submarine placers on the Middle Chucotka coast of north-eastern Siberia. It was only a few years ago that we (the authors) were supporters of evolutionary geology, like most geologists in Russia. We had been modelling sedimentation processes, but our previous investigations had not involved the problem of the rates of geological processes because they were not important for the mining industry where we worked at that time. So it was quite unexpected, even for us, when our mathematical modelling of placer generation with the parameter t (time of generation) gave results that are much more in correspondence with catastrophic geology than with evolutionary/uniformitarian geology. It should be pointed out that the researched sediments are traditionally estimated by evolutionary geologists to have been generated over 40 million years, yet we now believe they were formed during Noah's Flood and since.

In this paper we consider a mathematical model for the prediction of tin content in the bottom sediments on the continental shelf and thus the determination of the placer generation rate. We tested our model against actual field data.

THE MATHEMATICAL MODEL

For our purpose we used the diffusional-convectional model of two-dimensional dispersion of a tracer in a one-dimensional unlimited-length stream[4] and transformed it conformably for placer formation. The subsequent equation describes tin content in the bottom sediments of the continental shelf downflow due to lateral coastal drift from the source of the tin-bearing material:-

$$C(x,y) = \sum_{i=1}^{n} f_i(y) \times \left(B_i\left(x-\bar{x}\right)^{-A_i}\right)^E$$
$$\text{where } E = \exp\left[-\beta_i(y-g_i(x))\right]^2 \times \left(x-\bar{x}\right)^{-2A} \qquad (1)$$

where C = content of tin in the bottom sediments at the point with co-ordinates *(x, y)*.
x = distance from the beginning of the lateral coastal drift, with the x-axis position in the drift direction and parallel to the shoreline.
y = distance from the shoreline perpendicular to it in the oceanward direction.
$\bar{x}$ = co-ordinate of the centre of arrival into the lateral coastal drift tin-bearing material zone. We assume the source of the tin-bearing material is like a point source because its width is much less than the length of the placer.
f_i = coefficient defining the quotas of coarse and fine sediment fractions.
g_i = coefficient defining the trajectory of migration of the coarse and fine sediment fractions.
B_i, A_i, β_i = coefficients of the equation defined by the field data.

The method of application of this equation and the determination of the equation's coefficients have been well established by the authors. The equation has also been applied in geological prospecting of coastal submarine placers of tin, which has had considerable economic benefits.

Calculation of the correlation coefficients and testing the adequacy of the model were conducted in several tin-bearing districts of the north-eastern coast of the Russian Arctic, but for only one of them has enough data been obtained to calculate the placer's age. It is located a short distance from Val'cumey Point in Chaun Bay, East-Siberian Sea.

C is calculated as the sum of the different fractions of cassiterite (the tin mineral in the ore). In the case of the Val'cumey ore field the quantity of main fractions is two — coarse, more than 0.33 mm, and fine (small), less than 0.33 mm — so we used subscripts c and s to denote coarse and fine (small) fractions accordingly. Thus we put into the computation two types of coefficients and calculated C as the sum of the two fractions ($n = 2$).

The coefficients f_i, g_i are complex. g_c and g_s define the trajectory of the migration of the coarse and fine fractions in the lateral coastal drift accordingly, and are calculated as:

$$g_c(x) = \alpha_c\left(x-\bar{x}\right) \qquad \textbf{(2)}$$

$$g_s(x) = \alpha_s\left(x-\bar{x}\right) \qquad \textbf{(3)}$$

where a. is defined by the field data.

f_c and f_s define the quotas of the coarse and fine (small) fractions in the sediments accordingly, and are calculated as:

$$f_c(\bar{y}) = \exp\left(-\lambda Y^2\right) \qquad \textbf{(4)}$$

$$f_s(y) = 1 - \exp\left(-\lambda Y^2\right) \qquad \textbf{(5)}$$

where X depends on the sedimentological characteristics of the zone and is defined by the field data.

The authors developed their own software for computing the optimum value of the coefficients for the best correlation of the modelling and field data. In this best case the correlation coefficient of the field and modelling data is 0.87 (the critical value for the 1 per cent level of significance is 0.25), which indicates there is a significant correlation between the model and the actual processes.

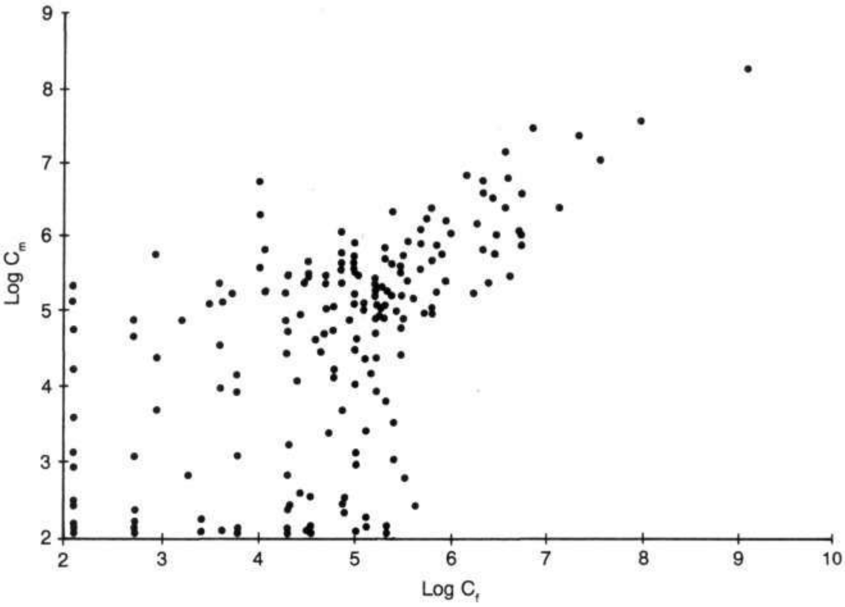

Figure 1. *Correlation of field (C_f) and modelling (C_m) contents of tin in the bottom sediments on the continental shelf near Val'cumey Point.*

In Figure 1 (a plot of the logarithm of the field content of tin on the x-axis versus the logarithm of the modelled content of tin on the y-axis) it can be seen that in the range of high tin contents (that are important for the mining industry especially), the correlation is even better. Some dispersion of the correlation in the range of low tin contents is accounted for by being near the local background of tin concentrations, where the distribution of tin is random. This can be seen on Figure 2, which shows the tin contents of the bottom sediments of the Val'cumey placer within the limits of importance to mining ($\log C_f > 5$). Within these limits there are considerable values of difference between the field and modelling data $(\log C_f - \log C_m)^2 > 1.0$ observed over only 14 per cent of the placer's area, which means that 86 per cent of the deposit is closely predicted by the model.

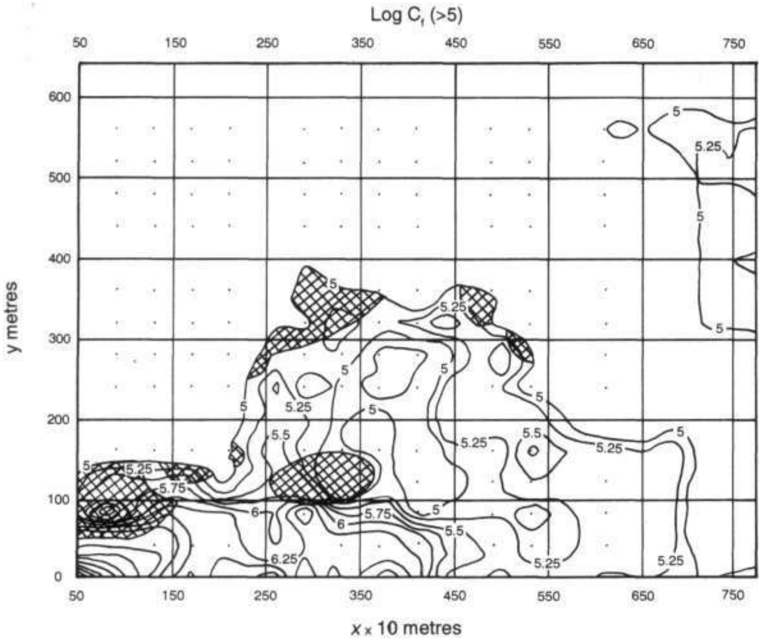

Figure 2. *The tin contents of the bottom sediments of the Val'cumey placer within the limits of importance to mining (log C_t>5). Cross-hatched areas are zones where (log C_t-log C_m)^2> 1.*

For visual illustration the results have also been treated by the inverse distance squared method and made into a computer three-dimensional diagram. This method allows the local variations of tin contents to be eliminated and most sharp peaks to be smoothed out. Figure 3 shows the real tin contents with only a small distance of averaging. Figure 4 shows the same tin contents but with a greater distance of averaging; while Figure 5 shows the modelling data. It should be immediately apparent from comparing Figure 5 with Figures 3 and 4 that Figures 4 and 5 are very similar and so are comparable. However, Figures 3 and 5 are not so similar, so therefore it is important to choose a suitable averaging distance.

Thus we believe that the obtained model is describing the real process of placer formation, and we can therefore use this method both for prediction of tin contents in the bottom sediments on the continental shelf for the needs of the mining industry, and for estimation of a placer's age.

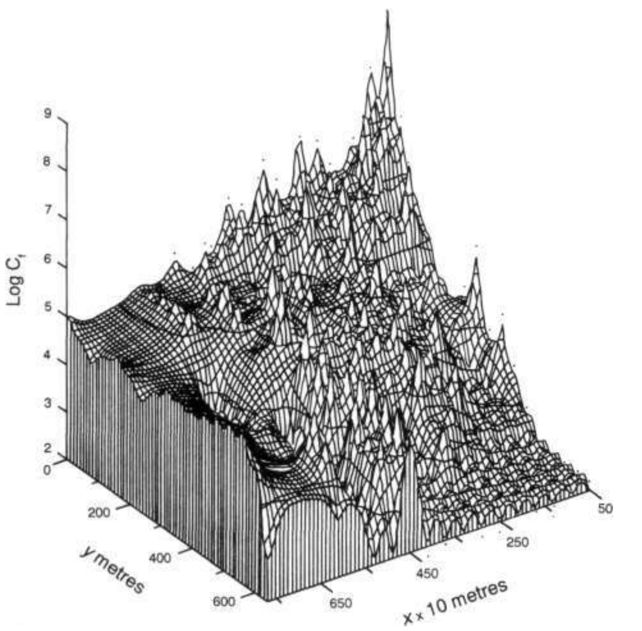

Figure 3. *Three-dimensional diagram of the tin contents in the bottom sediments (field data) approximated using the inverse distance squared method with a small distance of averaging.*

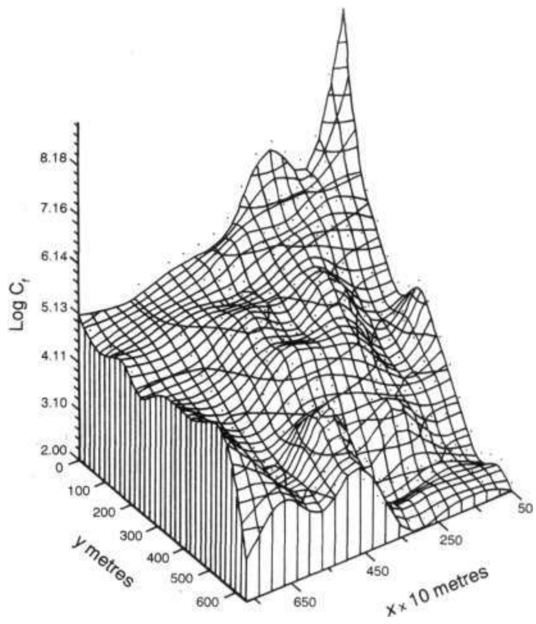

Figure 4. *Three-dimensional diagram of the tin contents in the bottom sediments (field data) approximated using the inverse distance squared method with a big distance of averaging.*

GEOMORPHOLOGY AND SEDIMENTOLOGY IN THE RESEARCHED DISTRICT

The Val'cumey coastal submarine tin placer, in Chaun Bay on the north-eastern Siberian coast, is associated with an actively denuding relief in the southern part of the area. Abrading cliffs have provided friable slope sediments which are tin-bearing when they arrive in the active zone of the beach. The direction of lateral coastal transport is to the north from the end of the point. The coastal submarine placer therefore stretches northwards from the source in accordance with the concept/process of lateral coastal drift (see Figure 6).

Almost all strata of the coastal submarine deposits with a thickness of 30-50 m are tin-bearing, but high concentrations of cassiterite ($Sn0_2$) have been deposited as lenses by currents parallel to the modern shoreline.

The tin contents are constant enough in the vertical direction: the coefficient of variation is about 1.5. Cassiterite concentrations are located in the beach and

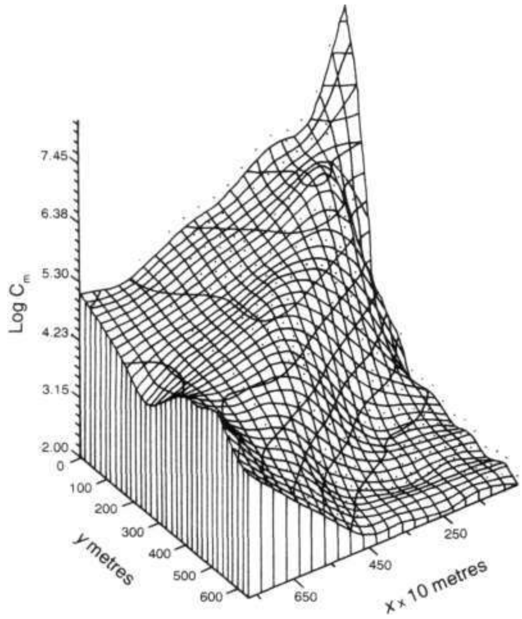

Figure 5. *Three-dimensional diagram of the tin contents calculated with the obtained model.*

submarine slope pebble, sand and silt deposits. The average diameter of cassiterite grains is 0.31 mm. However, the diameters of the grains differ in the different types of deposits: pebble deposits contain more large diameter grains (average 0.54 mm), whereas the sand averages 0.18 mm diameter cassiterite grains and the silt averages 0.13 mm. The highest concentrations of cassiterite are associated with the sand and pebble deposits.

Modern sediment movements within the lateral coastal drift near Val'cumey Point are described as loads not saturated with sediments that are actively abrading (the abrading zone). Far to the north along the coast the sediment movements are more stable (the transition zone), and in the northern part of the placer the sediment loads are being deposited in layers that show accumulation features (the accumulation zone). The highest concentrations of cassiterite and the greater part of the occurrence volume are associated with the abrading zone.

We were not, of course, able to research the sediment-movement conditions in the past as directly as we can study them today, but drilling data in the area have shown that conditions resembling today's have been occurring in the past.

DETERMINATION OF THE PLACER'S AGE

Initially we determined the velocity of the sediment load's drift across the section of the active zone near the lower border of the drift at the area of arriving tin-bearing material. This calculation had been made for one of the largest coastal submarine tin placers in north-eastern Russia near Val'cumey Point (Chaun Bay, East-Siberian Sea).

The volume of fragmented material arriving into the lateral coastal drift per year had been calculated in two ways:-

(a) From field investigations the volume of abrading diluvial sediments had been estimated at 3,000 m^3. All this material has been abraded into the lateral coastal drift during storm periods. The rate of abrading for solid rocks is much less than one for fragmental diluvial sediments, so the minimum volume is 3,000 m^3.

(b) The same volume can be calculated in an indirect way. The square of land being denuded to supply material to the researched district has a volume of 3,000,000 m^3. The average rate of denudation has been estimated at 1 mm per year, so the volume of material arriving into the lateral coastal drift is about 3,000 m^3 per year.

The width of the zone of active movement of loads near the researched section is about 100 m, and the thickness of the active layer (z) is estimated with field data as not more than 1 m. Thus the velocity of the drift (v) is:

$$\frac{3{,}000\,\mathrm{m}^3}{1\,\mathrm{m} \times 100\,\mathrm{m}} = 30\,\mathrm{m} / \mathrm{year}$$

Now we can calculate the time for the placer's generation:

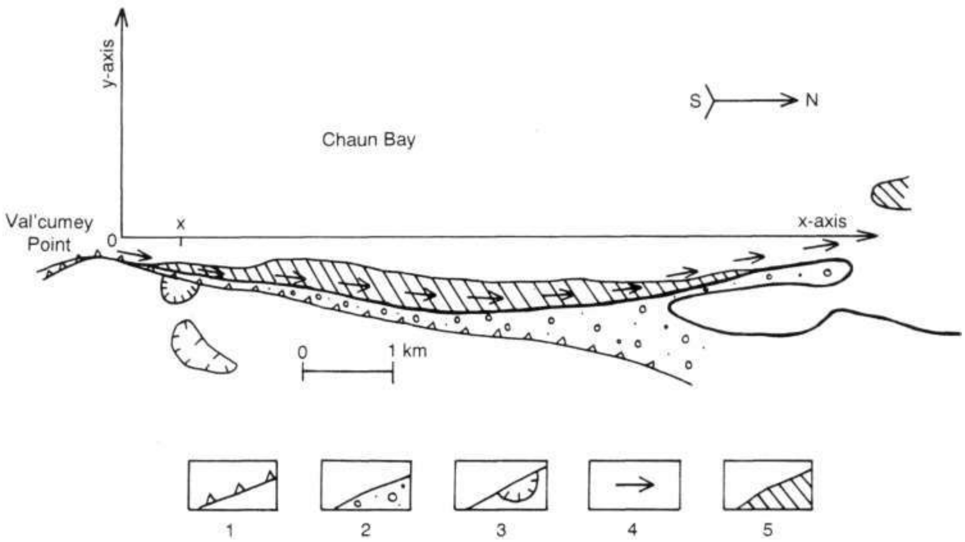

Figure 6. *Map of the Val'cumey tin placer and plan of the construction of the model. Legend:*
(1) Cliff
(2) Subaerial beach sediments
(3) Cassiterite-bearing ore zones
(4) Direction of lateral coastal drift
(5) Mining importance limits.

$$t = \frac{P}{z \times v \times \int_0^\infty C(x,y)dy} \qquad (6)$$

where P is the quantity of tin in the placer in conventional units (c.u.) downflow due to the lateral coastal drift from the researched section near the source of the tin-bearing material. (We cannot change the 'conventional units' to the real content of tin because the tin grades and volumes are kept as a state secret in our country and so we are obliged not to divulge them.)

$$\int_0^\infty C(x,y)dy$$

is the line production of the placer in the researched section, the 'line production' being the quantity of tin in the section of 1 m thickness across the direction of the lateral coastal drift.

We can then compute the line production in two ways — with field data and with modelling data.
The generation time obtained with the field data (t_f) is:

$$t_f = \frac{25{,}500{,}000{,}00\,\text{c.u.}}{1\,\text{m} \times 30\,\text{m / year} \times 447{,}690\,\text{c.u./m}^2} = 1{,}897 \text{ years}$$

The generation time obtained with the modelling data (t_m) is:

$$t_m = \frac{25{,}500{,}000{,}000\,\text{c.u.}}{1\,\text{m} \times 30\,\text{m / year} \times 155{,}292\,\text{c.u./m}^2} = 5{,}474 \text{ years}$$

Thus it is contended with a great degree of certainty that the time for the Val'cumey placer's generation (and also all the corresponding thickness of sediments in the Arctic region from the Late Oligocene to the Holocene) has been estimated at from 2,000 to 5,500 years, that is, 6,000-20,000 times less than the age span derived from the uniformitarian geological time-scale, which is usually determined as 40 million years. According to the creationist classification of sedimentary strata[5] we can determine the time of formation as post-Flood and recent. Some difference in this calculated date from the date for the Flood based on a literal addition of chronologies in Genesis is within the limits of these calculations.

One needs to check that the determination of the age with the modelling data has a greater degree of reliability, because it allows the elimination of errors such as:

(1) the discreteness of the sampling of the bottom sediments with different intervals;
(2) the large error of determination of the tin content due to both the small volume of samples and the non-uniformity of the distribution of the tin in the bottom sediments; and
(3) the natural and analytical dispersion of the tin contents that gives a large error in the line production calculation.

Thus the determination of a placer's generation time with the model has been tested with a natural system, which allows for the elimination of errors in the determination by using the pure field data.

DISCUSSION

One of the possible sources of errors in the age determination with equation (6) is connected with any error in the definition of the velocity of cassiterite movement in the lateral coastal drift. Some authors, based on field and experimental data,[6-8] have concluded that the transport of heavy minerals corresponds to the velocity of drift and the concentration of the ore-bearing material is the result of the dispersal of thin fractions of non-ore-bearing sediments. However, this is only a single point of view about the problem, which we suppose will be the subject of discussion and criticism by evolutionary geologists once it is published.

The best way to produce more confidence in our results and to scientifically substantiate them is to confirm them with experimental data. Suitable experiments to do this may soon be undertaken in the Hydraulics Laboratory of the Engineering Research Centre at the Colorado State University, USA.

However, in our work thus far the real tin contents have had to be changed to 'conventional units' because all data on occurrence volumes and tin contents (in this case study) have been kept as a state secret in Russia and we are still obliged not to divulge precise details. Even the field data from the Val'cumey placer are embargoed for security reasons. Unfortunately, this does not allow our results to be tested independently by other researchers.

Perhaps the best way to test our results is to calculate fresh results using natural data from other coastal submarine tin placers. There are suitable ones in Indonesia, the Philippines, Australia (Tasmania), Alaska and some other regions.[9-11] We would thus welcome appropriate proposals from any interested party.

CONCLUSIONS

We have presented a mathematical model for the generation of coastal submarine placers that successfully predicts the distribution of the heavy minerals in such placer deposits. This model has been tested with field data in the north-east of Russia (Chaun Bay near Val'cumey Point, East-Siberian Sea). The testing showed that the proposed model clearly reflected the structure of the geological object being modelled.

This model allows for the estimation of the placer deposit's generation age. Our calculations show that all the tin-bearing strata (with a thickness of about 50 m, from the Late Oligocene to the Holocene) have formed within

2,000-5,500 years, which bears testimony to the placer's generation in post-Flood time. This may provide a new method of determining the generation time for such geological objects and other strata.

This model has enormous practical significance. Creationism is often considered by its opponents to have little connection with practice. A mathematical model of the placer generation process motivated by a creationist perspective nevertheless offers notable economic benefits. We believe there are other similar examples in the field of economic geology that if developed would further the credibility of the creationist framework of Earth history.

Our model still needs to be further tested and refined in both the laboratory and the field. Unfortunately, we are unable to extend our investigations by ourselves due to our circumstances, so we would be happy to discuss any appropriate proposals for collaborative help.

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