Age determination of coastal submarine placer, Val'cumey, northern Siberia

Alexander V. Lalomov and Serguei E. Tabolitch

The age of a coastal submarine tin placer in the Chaun Bay of the East-Siberian Sea near the Val'cumey ore field in northern Siberia has been estimated from a simple accumulation model. The placer began to form after a major mountain-building episode and continental uplift, and has continued to accumulate to the present day. The age accumulation model was applied using field data and also with data obtained from a diffusion-convection model of placer ore generation. The calculated age for the placer was 5,500 years (±20 %). This contradicts the traditional uniformitarian age estimate of 40 Ma, but is consistent with the biblical framework. The mountain building episode and placer initiation occurred during the Recessive Stage of the Flood some 4,300 years ago, and placer accumulation has continued through the post-Flood era to the present time.

There are many different scientific 'dating' methods that have been used to estimate the ages of various geological objects. However, unlike historical dating which depends on direct observation of past events, and is reliable, all 'scientific' dating methods depend on assumptions about what happened in the past. Without such assumptions no age can be calculated. No matter how reasonable these assumptions may seem, we can never be certain they are true unless we have eyewitnesses for the entire time period in question.

Although radiometric and palaeontological 'dating' methods are used to support ages of millions and billions of years, many geological processes have been found to indicate a relatively young age for the earth. These include Na^+ accumulation rates in the ocean,[1] the rate of disintegration of comets,[2] sedimentation[3] and coal generation rates.[4]

In this paper we present an age determination of a tin placer at Val'cumey Point, northern Siberia. Estimates have been determined using analysed tin concentrations in field samples from different parts of the placer, and also using calculated tin concentrations derived from a mathematical model of placer dynamics.

Geological structure and sediment transport

The Val'cumey coastal submarine tin placer is situated in the Chaun Bay of the East-Siberian Sea near the Val'cumey ore field in northern Siberia (Figure 1). The geomorphology and stratigraphy of the Val'cumey Point area have been described in detail in a previous report.[5] Tin-bearing sediments are eroded from a cliff and the friable slope above the beach (Figure 2). Longshore currents transport and disperse the eroded sediments laterally along the shore from the top of Val'cumey Point toward the north. Sediment transport is restricted to the surface layers of the near-shore zone; here termed the active zone. High concentrations of tin are deposited as lenses of cassiterite (SnO_2) parallel to the modern shoreline. The highest concentrations and greatest volumes of cassiterite are relatively close to the eroding cassiterite source. Farther to the north concentrations of the cassiterite decrease.

Almost all the coastal submarine placer is confined to the strata that extend some 70 m below the surface (Figure 3). The strata consist of buried slope deposits (clays with angular detritus and poorly rounded pebbles), beach and submarine shelf pebbles, and sand and silt deposits. According to uniformitarian geologists, the age of these strata vary from Paleocene (~60 Ma) to Holocene (<10,000 years). All the stratigraphic units have been correlated with those of other regions of the Russian Arctic.[6]

MountainHigh Maps

Figure 1. *Location of Val'cumey tin placer in northern Siberia.*

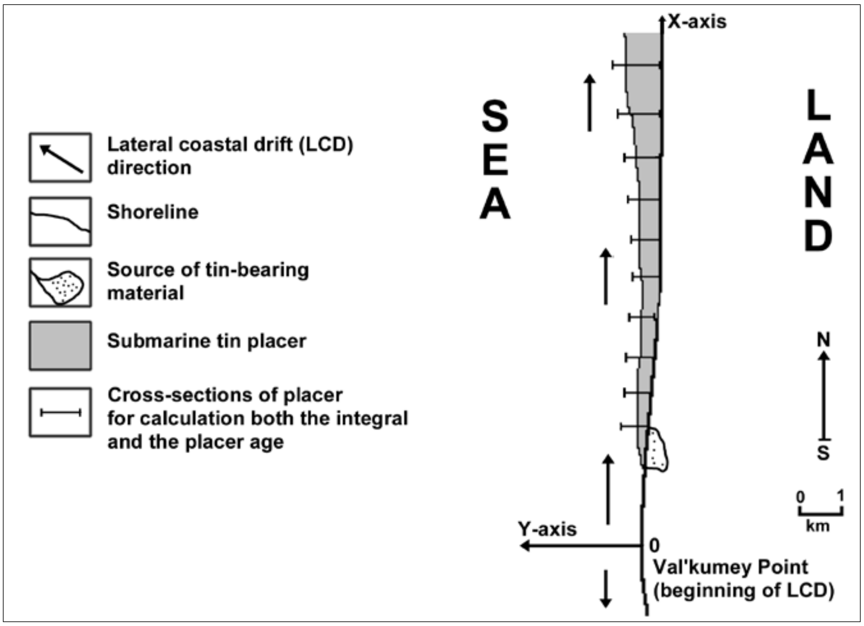

Figure 2. *Val'cumey tin placer in Chaun Bay showing direction of longshore drift, and location of sediment erosion, and sediment transport.*

The average diameter of cassiterite grains in the deposit is 0.31 mm, but this varies locally depending on the host sediment (Table 1). Pebble deposits contain the largest cassiterite grains (average 0.54 mm), and silt the smallest (0.13 mm). The average size of cassiterite grains in host sand is 0.18 mm. The highest concentrations of cassiterite are associated with sand and pebble host deposits.

Comparison of the rock lithology, sediment particle size, and cassiterite concentration in drill cores, shows that sediment transport occurred in the same direction and with similar intensity from the beginning of placer formation to the present day.

Determination of placer age

The age of the placer was estimated from a simple accumulation model by assuming that the lateral drift processes operating at present have formed the entire placer in the past (Figure 4). The longshore transport of sediment occurs in the active surface layer only, carrying tin into the placer downstream of section X. Thus, to calculate the time since tin first began crossing Section X, it is necessary only to estimate:

1) The quantity of tin entering the placer in the active zone at Section X.
2) The total quantity of tin in the placer downdrift of Section X.

Let the total quantity of tin in the placer downstream of Section X be Px (tonnes) and the rate at which tin enters the placer at Section X be Rx (t/year). Thus the generation time (that is, the time elapsed since tin first started entering the placer downdrift of Section X) is given by

$$Tx = Px / Rx \quad \text{(years)} \qquad (1)$$

The rate at which tin enters the section can be determined by estimating the longshore drift velocity and tin concentration in the active layer at Section X. Let V be the longshore drift velocity (m/year) in the active zone, and Z the thickness (m) of the active zone. Assume these are constant across the whole width, Y, of Section X. (We also assume V and Z are constant over the whole length of the placer).[7] Let the tin concentration (t/m^3) in the active layer be C(x,y), which will vary across the section and over the length of the placer. The amount of tin in a square prism 1m wide and 1 m thick that extends across the whole of Section X in the active zone is given by:

$$\int C(x,y)dy \quad (t/m^2)$$

This is referred to as the line production at Section X. The rate at which tin enters the placer at Section X (t/year) is therefore given by:

$$Rx = V\,Z \int C(x,y)dy \qquad (t/year)$$

Thus the generation time, or the time since tin first entered the placer downdrift of Section X can be calculated

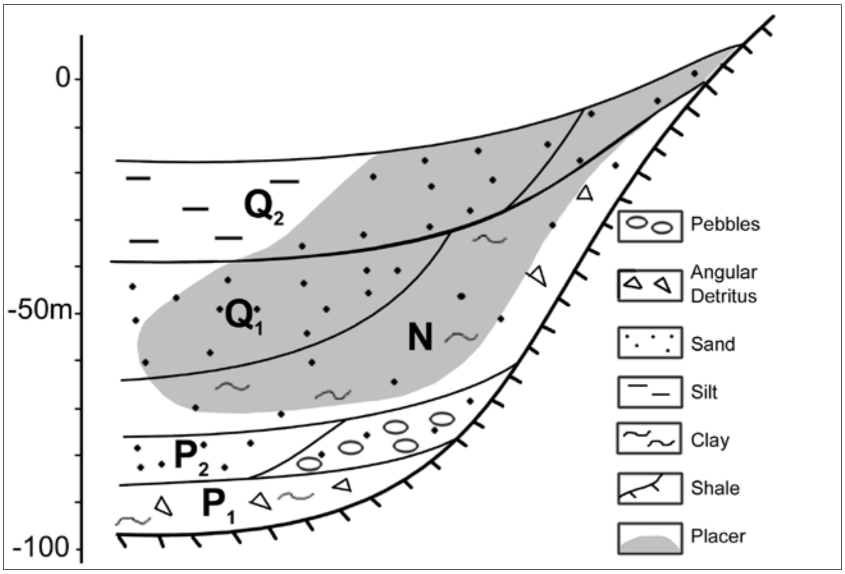

Figure 3. *Diagrammatic section through the coastal submarine deposits near Val'cumey Point. P_1 = Paleocene–Eocene; P_2 = Oligocene; N = Miocene–Pliocene; Q_1 = Pleistocene; Q_2 = Holocene.*

from equation (1)

$$Tx = Px / (V\ Z \int C(x,y)dy) \quad \text{(years)} \quad (2)$$

Longshore drift velocity

The longshore drift velocity was estimated at the active placer tongue near the source of tin-bearing material at the cliff (X = 0, Figure 2). The estimated volume of sediment eroding from the source into the drift zone is about 3,000 m^3 per year.[8]

Table 1. *Average size of host sediment and cassiterite grains in deposits, and calculated size of quartz grains hydraulically equivalent to cassiterite.*

Host Sediment Type	Average Size of Grains — mm		Calculated size of quartz grains hydraulically equivalent to cassiterite — mm
	Of Host Sediment	Of Cassiterite	
Pebbles	29.10	0.54	2.47
Sand	0.39	0.18	0.39
Silt	0.08	0.13	0.22

The width of the active placer tongue at this point is about 100 m and the thickness, Z, of this active layer is not more than 1 m. We estimated this thickness in the field from periodic drilling measurement of sand depth, experiments with marked sands, and geochemical sampling for marked elements. Thus the longshore drift velocity (V) is the arrival rate divided by the cross-sectional area:

$$3{,}000 / (1 \times 100) = 30 \text{ m/year}$$

We can use this velocity as the velocity of cassiterite movement in the lateral coastal drift because cassiterite grain-size correlates strongly with the average grain-size of the host detrital material.[9] This correlation was first formulated by Rubey.[10] He called it the 'principle of hydraulic equivalence', which means that grains with different specific gravity having identical hydraulic equivalence will experience similar movement in the same hydraulic environment. Rittenhouse[11] describes a practical method for the determination of the relative sizes of hydraulically equivalent sediment grains. Others subsequently improved this method.[12–15] Osovetsky[16] notes another 11 factors, apart from hydraulic equivalence, which influence the relationship between the sizes of heavy mineral grains and their host sediment grains. Some of these include grain shape, mode of transport, the roughness of substrate, etc. Hydraulic equivalence is only one factor.

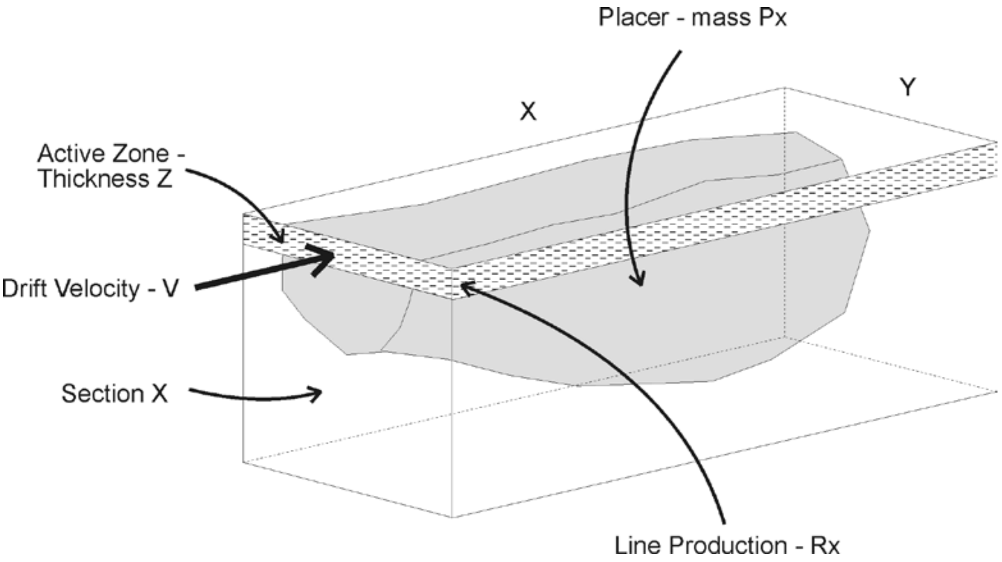

Figure 4. *Accumulation model of placer.*

We calculated the sizes of quartz grains, which have the same hydraulic equivalence as cassiterite using Osovetsky's method (Table 1). In the area of sand-sized deposits, the calculated quartz grain size that is hydraulically equivalent to the cassiterite grain size is indistinguishable from the observed non-cassiterite particle size. This indicates that the cassiterite and host sandy sediment grains are drifting at the same velocity.

Results using field data

The generation times at a number of cross sections have been calculated from equation (2) using analysed tin concentrations from field samples in the active zone, C(x,y), and the total quantity of tin in the placer downstream of each section. Table 2 sets out the calculation and Figure 5 shows the calculated age.

It can be seen (Figure 5) that there is considerable scatter in the calculated 'age' ranging from 1,700 years to 7,900 years. We consider that the scatter is due to statistical variation associated with the sharp, natural variability in the raw field data due to:

1. The inhomogeneous distribution of tin in lenses etc. within the host sediments of the placer.
2. The intermittent and discontinuous method of sampling of the bottom sediments.
3. Analytical errors in determining the tin content

Table 2. *Placer generation times (time that tin started to accumulate in the placer downstream of Section X) calculated from field data. The measured tin concentration (g/m³) in the active zone (~ 1 m thick) of the placer was analysed from field samples. The mass of the placer (up to 70 m thick) downdrift of each section was calculated from drill cores. The line production at each section was calculated by integrating the tin concentrations across the placer from 0–640 m using the Trapezoidal Rule for integration [Line production (g/m²) = $(C_1/2 + C_2 + C_3 + \ldots + C_{(n-1)} + C_n/2)$ x 40 m)] where C_n is the tin concentration at location n across the active layer. The placer age was calculated by dividing the mass of placer downdrift of the section by the product of line production, drift velocity (30 m/year), and active layer thickness (1 m).*

Distance from start of lateral drift — m	500	900	1,300	1,700	2,100	2,500	2,900	3,300	3,700	4,100	4,500	4,900	5,300	6,100	7,700
Distance from Shoreline — m	Measured Tin Concentration in Active Layer of Placer - g/m³														
0	9160	3010	729	486	860	1270	393	836	262	580	206	150	243	187	168
40	972	1570	1960	580	644	224	542	673	860	654	337	299	158	200	120
80	311	56	748	580	729	393	860	355	374	131	150	187	112	222	86
120	168	767	318	337	56	299	299	19	243	94	131	187	280	230	120
160	74	44	74	59	131	411	150	150	243	37	187	150	340	243	150
200	30	133	44	74	112	250	206	131	224	94	524	187	250	100	120
240	74	74	44	44	74	337	112	150	94	56	262	187	112	15	82
280	207	74	15	15	224	250	287	244	75	131	94	617	150	25	120
320	44	15	44	130	74	150	131	243	194	212	393	112	89	33	168
360	74	15	15	15	74	94	252	168	178	75	206	355	8	42	155
400	30	15	15	44	15	30	133	84	75	37	37	187	8	59	142
440	15	15	15	15	89	74	168	15	8	8	206	187	8	38	165
480	8	8	8	8	15	44	37	15	8	8	224	19	8	15	191
520	8	8	8	8	8	8	44	8	8	8	280	150	8	105	199
560	8	8	8	8	8	8	8	8	8	8	206	75	8	187	206
600	8	8	8	8	8	8	8	8	8	8	150	94	8	113	110
640	8	8	8	8	8	8	8	8	8	8	94	8	8	26	19
Line Production — kg/m²	264.6	172.8	147.7	86.9	107.8	128.8	137.5	107.7	109.4	74.2	141.5	122.9	66.9	69.3	89.1
Measured Downdrift Mass of placer — t	25,500	23,155	21,516	20,533	19,272	17,759	16,322	15,061	13,901	13,044	11,556	10,295	9,564	8,253	4,496
Downdrift Age — years	3,212	4,468	4,856	7,878	5,959	4,597	3,957	4,661	4,236	5,860	2,723	2,793	4,765	3,967	1,682

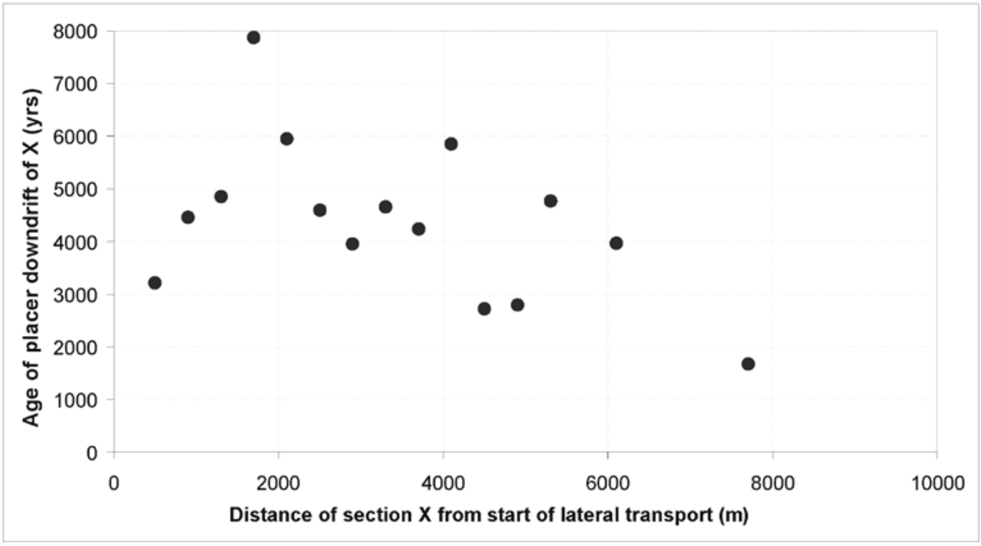

Figure 5. *Placer generation time (time that tin started to accumulate in the placer downstream of Section X) calculated from placer tin concentrations sampled in the field (circles).*

of individual samples due to small sample volumes and non-uniform cassiterite distribution in the bottom sediments.

Nevertheless, there is a general trend of decreasing age with increasing distance from the source (Figure 5).

Results using modelled placer concentrations

To overcome the problem of scattering caused by variations in the field data, we have calculated the placer age using a mathematical diffusion-convection model of placer generation.[5] This model has been calibrated against actual field data from north-east Russia.

The authors' field experience led to the application of this model and determination of its mathematical coefficients for the Val'cumey deposit. These coefficients define the trajectory of migration of the coarse and fine sediment fractions, the hydrodynamic activity and the influence of the source of cassiterite. The model may be applied in the early stage of prospecting work and refined as subsequent drilling information accumulates. It has been applied in prospecting for coastal submarine tin placers in far north-eastern Russia with considerable economic success.

The correlation coefficient between field data and modelled results shows that the results of the model clearly reflect the structure of the geological object being modelled.[7] We thus conclude that this mathematical model well represents the physical process of placer formation. We also argue that we can apply the results of this model to estimate the age of the placer.

Table 3 sets out the 'age' calculation based on modelled data using a calculation interval of 0.2 m across the longshore direction. The results are shown in Figure 6 together with the previously calculated ages based on the field data. The placer generation time based on modelled placer tin concentration correlates with the results of the field data.

Discussion

According to the theory of placer generation, placers form after a phase of intensive tectonic movement that is commonly accompanied by ore lode emplacement and mountain-building. After this, a process of denudation forms a thick sequence of overlying conformable clastic deposits which contain large amounts of heavy minerals in low concentrations. New placers are generated when the heavy minerals are concentrated by the action of water on these sediments.[17,18]

The age results (Figures 5 and 6) display a trend of decreasing generation time with increasing distance from the source. That is, the estimated age is much smaller in the tail of the placer, which is farthest from the source of tin. This is consistent with the extra time required for the tin to drift further along the shore before the placer can start to accumulate in the more distant section. This confirms that the placer is still actively forming and has not reached a long-term equilibrium. The trend of 'age' ranges from around 5,500 years at X = 0 to about 1,000 years at X = 8,000 metres. If the placer really were millions of years old, then this clear downward trend in 'age' would not be discernible.

Interestingly, we created this age model using the uniformitarian assumption, 'the present is key to the past'. But when we used present-day rates of erosion, velocity of sediment transport, and source concentration of tin, we obtained results that agree with the biblical time-scale for Earth history.

It could be objected that the calculated age is not the real age of the placer, but only the interval of time required to form at today's rate of geological processes. If this is the case, then the placer would have needed to have remained under stagnate conditions for 39,994,500 years (40 Ma less

Table 3. *Placer generation times (time that tin started to accumulate in the placer downstream of Section X) calculated from modelled estimates of tin concentrations in the active zone and the mass of placer downdrift of each section. The method of calculation is the same as for Table 2.*

Distance from start of lateral drift — m	500	900	1,300	1,700	2,100	2,500	2,900	3,300	3,700	4,100	4,500	4,900	5,300	6,100	7,700
Distance from Shoreline — m	Modelled Tin Concentration in Active Layer of Placer - g/m^3														
0	3927	1967	1277	933	729	595	500	431	377	335	301	273	250	213	164
40	1781	1594	1147	866	686	564	477	411	361	321	289	262	240	204	157
80	144	843	888	580	729	393	860	355	374	131	150	187	112	222	86
120	10	237	512	337	56	299	299	19	243	94	131	187	280	230	120
160	8	49	189	59	131	411	150	150	243	37	187	150	340	243	150
200	8	133	63	74	112	250	206	131	224	94	524	187	250	100	120
240	8	8	22	44	74	337	112	150	94	56	262	187	112	15	82
280	8	8	11	15	224	250	287	244	75	131	94	617	150	25	120
320	8	8	8	130	74	150	131	243	194	212	393	112	89	33	168
360	8	8	8	15	74	94	252	168	178	75	206	355	8	42	155
400	8	8	8	44	15	30	133	84	75	37	37	187	8	59	142
440	8	8	8	15	89	74	168	15	8	8	206	187	8	38	165
480	8	8	8	8	15	44	37	15	8	8	224	19	8	15	191
520	8	8	8	8	8	8	44	8	8	8	280	150	8	105	199
560	8	8	8	8	8	8	8	8	8	8	206	75	8	187	206
600	8	8	8	8	8	8	8	8	8	8	150	94	8	113	110
640	8	8	8	8	8	8	8	8	8	8	94	8	8	26	19
Line Production — kg/m^2	159.9	152.1	141.5	130.7	121.0	113.5	107.4	102.7	98.9	95.9	93.1	90.7	88.5	84.4	73.4
Modelled Downdrift Mass of placer — t	25,500	23,460	21,558	19,829	18,238	16,751	15,333	13,985	12,670	11,426	10,215	9,039	7,898	5,962	2,192
Downdrift Age — years	5,314	5,140	5,077	5,059	5,025	4,918	4,757	4,537	4,269	3,973	3,657	3,323	2,973	2,354	996

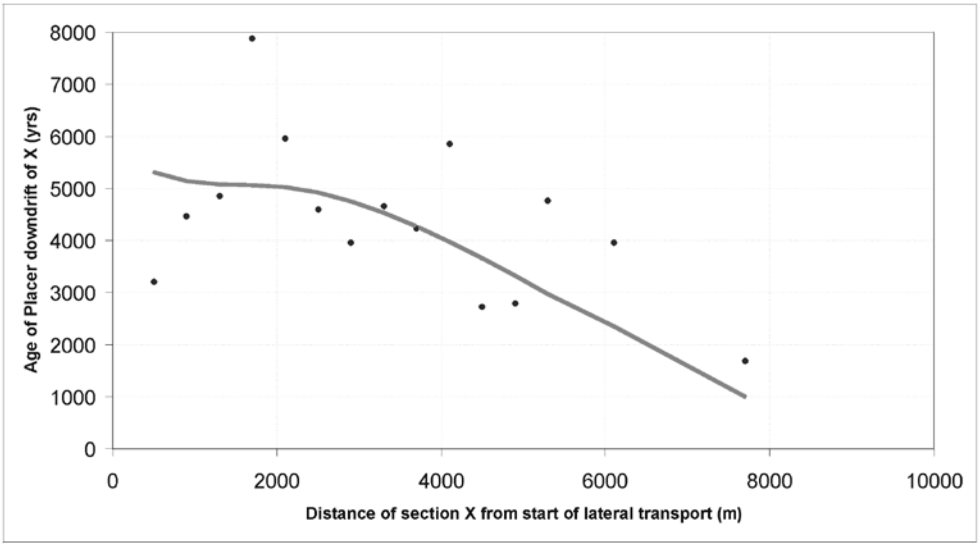

Figure 6. *Placer generation time calculated from modelled placer tin concentrations (solid line), compared with times previously calculated from measured concentrations as sampled in the field (circles).*

5,500 years) without any trace of erosion or sedimentation. If this were so, there should be evidence of a residual soil — a significant reduction in sediment particle size and an increase in the abundance of organic material. No such evidence is observed in any part of the Val'cumey placer. The sediment characteristics (boulders, gravel, sand and clay) at the base of the placer are very similar to those of the modern deposits at the surface. Thus, the calculated age closely represents the real age of the placer.

Therefore, one can contend with confidence that the time interval for the Val'cumey placer generation (and with all the corresponding sediments of the Arctic region from the Oligocene to the Holocene) was about 5,500 years. This is within range of the biblical time-frame for the global Flood which ended with tectonic movement, continental uplift, falling sea levels and receding floodwaters about 4,300 years ago — an age based on a literal addition from the chronologies in Genesis. This age is within the limits of accuracy of our calculations — an accuracy we estimate to be 10–20 % at best.[19]

We can easily explain the difference by a higher frequency and intensity of storms in the past, immediately after the Flood.[20] In this case, the longshore velocity, V, would not be constant with time, but may have been decreasing even exponentially[21] from a much higher magnitude to the present-day rate. Our earlier investigation shows that the initial post-Flood rate of denudation (a surrogate for energy of geological processes and hydrodynamic intensity) for north-eastern Russia was 10–32 times higher than now.[22] Therefore, the actual age, especially near the placer source, may be much less than the age determined in these calculations.

Thus we infer from the above age calculations and the model of placer generation, that the placer at Val'cumey Point was initiated during the Flood about 4,300 years ago near the source of tin. Powerful tectonic movements during the Flood accompanied the beginning of this process and resulted in the formation of the Chaun depression and the high mountains around it. Subsequent activation of land surface erosion as the Flood receded, transported tin-bearing material to the coastal submarine environment, and cassiterite concentration by wave action has led to the development of the deposit. These processes formed the largest part of the placer during a short time. More recent extension of the placer has occurred as the result of the transport of tin-bearing loads by means of lateral coastal drift, separation and concentration of cassiterite during this transport, and sedimentation in the accumulation zone. This process continues today.

Hence, according to the creationist classification of sedimentary strata,[23] we link placer initiation to the Recessive Stage of the Flood 4,300 years ago, with placer accumulation continuing through the post-Flood era. This period is one of two periods in Earth history favourable for placer generation.[24]

Conclusion

Age calculations of ore bodies based on a diffusion-convection model for ore generation provide a useful method for determining the age of local and regional geological structures. Applied to a tin placer in northern Siberia, the modelling data reflects well the natural process of placer formation and smoothes much of the extreme local variability of the sampled field data.

Detailed investigation has allowed us to estimate an age for sedimentary strata hosting a submarine tin placer, traditionally estimated by evolutionary geologists as 40 Ma. The results show that the placer began to form some 5,500 years ago (±20 %) after major mountain-building tectonism, and continues to form to the present day. The calculated age is consistent with a mountain building episode and placer initiation occurring during the Recessive Stage of the Flood, dated from the Bible at approximately 4,300 years ago. Placer accumulation continued through the post-Flood era. The period commencing in the Recessive stage of the Flood and extending to the post-Flood era is one of two periods in Earth history favourable for placer generation.

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7. These assumptions were tested by comparing the field data with the model results. The correlation coefficient between field and modelled data was 0.87 (the critical value for the 1 % level of significance is 0.25) indicating a good correspondence between the model and the observed field data. It was thus concluded that the assumption of constant velocity and constant thickness for the active zone is reasonable.
8. Lalomov and Tabolitch, Ref. 5, p. 376.
9. To simplify the calculation we assume the longshore velocity is constant. The shape of the beaches and the cliff suggest that the volume of transported sediments in the transit zone downdrift of $X = 0$ is approximately constant. Hence, the width increase in the downdrift section (390 m compared with 100 m) is balanced by a decrease in the active zone thickness. Therefore, the sectional area of the active zone, and the transport velocity, are approximately constant. In any case, the assumption does not greatly affect the calculated age.
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Alexander V. Lalomov is a sedimentologist who graduated from Leningrad State University in 1982, and then worked in the Russian Arctic until 1990 as a senior geologist prospecting for gold and tin placers. In 1992 he defended his Ph.D. thesis on the mathematical modelling of placer generation. Alexander is a life member of Creation Research Society and director of Geological Research Laboratory ARCTUR (Moscow, Russia).

Serguei E. Tabolitch is a geochemist who graduated from Moscow State University in 1983, and then worked in the Russian Arctic until 1990 as a senior geologist in geochemistry, prospecting for gold and tin placers. He is a member of the Moscow Creation Science Fellowship.