CRSQ
CREATION RESEARCH SOCIETY QUARTERLY

Time Required for Sedimentation Contradicts the Evolutionary Hypothesis

Guy Berthault*

Abstract

Stratigraphy, the basis of geological dating, was founded in the seventeenth century on three principles proposed by Nicolas Steno: superposition, continuity, and original horizontality. Successive observations and experiments show that his stratigraphic model was not in line with experimental data, because it overlooked the major variable factor of sedimentation: *the current and its chronological effects*. Experiments simulating the formation of sedimentary layers at variable current velocities using different-sized particles show that Steno's principles apply only to the case of deposition at zero current velocity. Since sedimentary processes affect stratigraphy and geological dating, paleohydraulic conditions must be considered in any stratigraphic analysis. The estimated time of deposition is often the crucial factor in developing a local timescale, and the paleohydraulic approach links deposition to the critical transport velocity of current as determined by particle size. From this velocity, the corresponding transport capacity in units of volume and time is calculated. The time of sedimentation is the quotient obtained from dividing the volume of sedimentary rocks by the transport capacity. A team of Russian sedimentologists have applied this method to geological formations of the Crimean Peninsula and of the Northwest Russian Plateau in the St. Petersburg region. They discovered that the time required for sedimentation was only 0.01% of the corresponding period of the geological timescale. This is at variance with the time required for species to evolve.

Introduction

This review of my research goes to the heart of the subject of evolution. My research has focused on empirical experiments showing how strata form, a topic about which little work has been done. While it is true that sediments had been examined and flume experiments performed in connection with building and other projects, none of these attempted to explain the mechanics of stratification. In fact, my early literature research found very little to guide my practical research. With regard to sedimentation, the basic principles of superposition, continuity, and initial horizontality laid down in the seventeenth century had been accepted, albeit with elaboration, virtually without question. There seemed to

---

* Guy Berthault, 28, Bd. Thiers, 78250 Meulan, France

Accepted for publication December 1, 2009

have been few subsequent attempts to examine the actual mechanics of how strata form.

Yet that question has far-reaching implications for both the geological timescale and the fossil record. Since the late eighteenth and early nineteenth centuries, stratigraphy has tacitly assumed slow, gradual sedimentation, accepting the premises of Nicolaus Steno (1638–1686) as congenial to deep time, in-situ fossil preservation, and the globally correlative geologic timescale. As Professor Gabriel Gohau of the French Geological Society wrote in his book A *History of Geology* (1990, p. 192), "Time is measured by the interval required for sediments to deposit, a fact upon which everybody is more or less agreed, and not by orogenesis or 'biological revolutions.' "

Gohau (1990) mentioned in his work how Charles Lyell was influenced in the construction of the geological timescale by his belief in "biological revolutions" occurring over 240 million years. It was the geological timescale, giving the impression that there was a succession and change in fossilized species, which led Darwin to formulate his theory of evolution. In the twentieth century, Lyell's age was replaced by a radiometric date of 542 million years for the base of the Cambrian Era. What Professor Gohau wrote is perfectly correct, because fossils are buried in sediments. Therefore, it is the time of sedimentation that determines the age of fossils and not a chronology based on "biological revolutions," interpreted now as "biological evolution." Biostratigraphy has proven no more successful than other modern stratigraphic methods, because they all are heavily weighted by assumptions that cannot be demonstrated. Thus, the stratigraphic approach has now reached the extreme of proposing to define age boundaries by fiat through the use of global stratotype sections and points (Gradstein et al., 2004).

As regards radiometric dating, Professor Aubouin stated in his *Précis de Géologie* (1967, Tome 1, p.193):

> Each radioactive element disintegrates in a characteristic and constant manner, which depends neither on the physical state (no variation with pressure or temperature or any other external constraint) nor on the chemical state (identical for an oxide or a phosphate).

Rocks form when magma crystallizes. Crystallization depends on pressure and temperature, from which radioactivity is independent. So, there is no relationship between radioactivity and crystallization, absent assumptions that the "clocks" are set at zero time upon crystallization. Consequently, radioactivity does not date the formation of rocks. Moreover, daughter elements contained in rocks result mainly from radioactivity in magma, where gravity separates the heavier parent element from the lighter daughter element. Thus radiometric dating has no chronological significance. It seemed to me, therefore, necessary to study the basis of the stratigraphic scale that depended upon the stratification of sedimentary rocks.

Steno was the founder of stratigraphy. It was in 1667 that he introduced in his work *Canis Calchariae* the postulate; "layers of sub-soil are 'strata' of ancient successive 'sediments'" (Steno, 1667, p. 27 C.II). From this partial interpretation, he drew three initial principles of stratigraphy, formulated in his work *Prodromus* (1669).

(1) **Principle of superposition**
At the time when one of the high stratum formed, the stratum underneath it had already acquired a solid consistency. At the time when any stratum formed, the superincumbent material was entirely fluid, and, due to this fact at the time when the lowest stratum formed, none of the superior strata existed (Steno, 1667, p. 30, CII. 3.d).

(2) **Principle of continuity**
Strata owe their existence to sediments in a fluid. At the time when any stratum formed, either it was circumscribed on its sides by another solid body, or else it ran around the globe of the earth (Steno, 1667, p. 30, CII.3c).

(3) **Principle of original horizontality**
At the time when any stratum formed, its lower surface, as also the surfaces of its sides, corresponded with the surfaces of the subjacent body and lateral bodies, but its upper surface was (then) parallel to the horizon, as far as it was possible (Steno, 1667, p. 30. C.II. 3.4.).

The sedimentological model corresponding to these three principles is, therefore, the following. In a fluid covering the earth, except for exposed land, a precipitate deposits strata after strata, covering all of the submerged earth. After the deposition of each stratum, the sedimentation is interrupted for the time it takes for the stratum to acquire a solid consistency. The stratum being contained between two parallel planes indicates that the sedimentation rate of the precipitate is uniform around the submerged earth.

Deficiencies of Steno's Stratigraphy

The first part of the definition of the principle of superposition is, "At the time when one of the highest stratum formed, the stratum underneath it had already acquired a solid consistency" (Steno, 1667, p. 30, CII. 3.d). A stratum between 50 cm and 1 m is considered thick. Consequently, submarine drillings should encounter solid strata in the stratified oceanic sediments after a few meters. However, the results of sea-bottom drilling have shown that the first semi-consolidated sediments occur between 400 and 800 m. Isolated, hardened chert beds have been found under 135 m of unconsolidated sediment near oceanic transform faults (Logvinenko, 1980). Steno's definition, therefore, which would significantly extend the total time of deposition by his concept of successive hardening, is not supported by these sedimentological observations.

As regards the principle of continuity, clearly no sedimentary layer extends globally. As concerns the principle of original horizontality, seismic readings and submarine coring demonstrate that strata in oceanic sediments are not always horizontal and that the rate of sedimentation is not uniform on a global scale in Earth's oceans.

Steno (1667, p. 30, CII.3c) said, "Strata owe their existence to sediments in a fluid," but he said nothing about the action of the fluid on the sediments, so that the relative stratigraphic chronology resulting from his principles did not take flow velocity into account (the subsequent principles of paleontological identity and uniformitarianism changed nothing in this respect). Currents exist in present-day oceans, which erode, transport, and deposit sediments, as shown by Strakhov in 1957.

Charles Lyell adapted Steno's principles to his theory of uniformitarianism, giving as an example layers deposited in fresh water in Auvergne. Observing that the layers were less than 1 mm thick, he considered that each one had been laid down annually. At this rate, the 230-m thick deposit would have taken hundreds of thousands of years to form. In the next section (and also Figure 1), I show that these layers, which are laminae, do not always correspond to annual deposits and may be generated in a time interval much less than that which is indicated by the modern geological timescale.

Geologists have now recognized sequences of facies (conglomerate, sandstone, shale, limestone, evaporate) that correspond to marine transgressions and regressions. This is the object of study in sequence stratigraphy today. Diagrams in this discipline, however, give no indication of the current velocity during these transgressions and regressions. However, this information can be derived from the size of particles of sediment in a sequence, which corresponds to a minimum current velocity needed to erode and transport particles.

Major Stages of the Laboratory Research

The two principal stages of program investigated the following two lines of research: lamination and stratification.

Lamination

Berthault (1986) described the deposition of heterogranular sediments in water. These sedimentation experiments were conducted in still water with a continuous supply of heterogranular material. A deposit was obtained, giving the illusion of successive beds or laminae (Figure 1). These laminae are the result of a spontaneous periodic and continuous grading process, which takes place immediately following the deposition of the heterogranular mixture.

Figure 1. Lamination resulting from sediment flowing into water.

The thickness of the laminae appears to be independent of the sedimentation *rate* but increases with extreme differences in the particle size in the mixture. Where a horizontal current is involved, thin laminated layers developing laterally in the direction of the current are observed.

Further experiments demonstrated that in still water, continuous deposition of heterogranular sediments gives rise to laminae, which disappear as the height of the fall of particles into water increases and apparently their size. Laminae follow the slope of the upper part of the deposit. In running water, many closely related types of lamination appear in the deposit, even superposed (Berthault, 1988).

Stratification

Experiments in stratification were conducted at Colorado State University with professor of hydraulics and sedimentology Pierre Julien (Figure 2). A flume with recirculating water was used to track the progress of a sediment-laden current. Current velocity was varied, as Hjulstrom (1935) and his successors had defined the critical sedimentation rate for each particle size. It was discovered that varying the current velocity resulted in the superposed stratification based on the segregation of particles by size, not on the time of deposition. Thus, Steno's principle of superposition as an indication of relative time did not apply in this case.

Instead, the flume experiment showed that in the presence of a variable current, stratified superposed beds form *simultaneously* in the direction of the current. This mirrors conditions observed in the field, on the scale of facies, to Golovkinskii, Inostrantzev and Walther's law (Walther, 1894; Middleton, 1973; Romanovskii, 1988). According to this law, the progression of

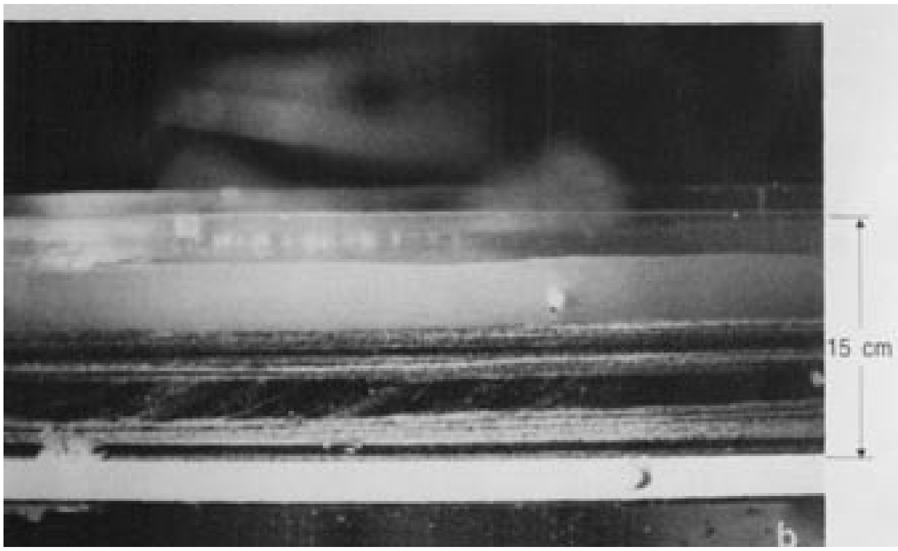

Figure 2. Typical longitudinal view of deposition (flow from right to left).

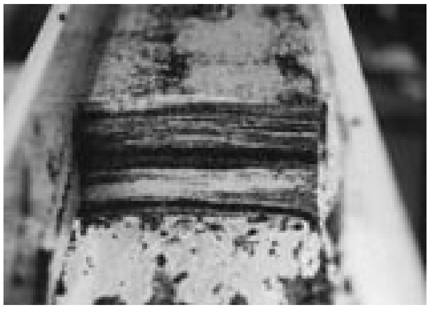

Figure 4. Typical cross-sectional view of deposit.

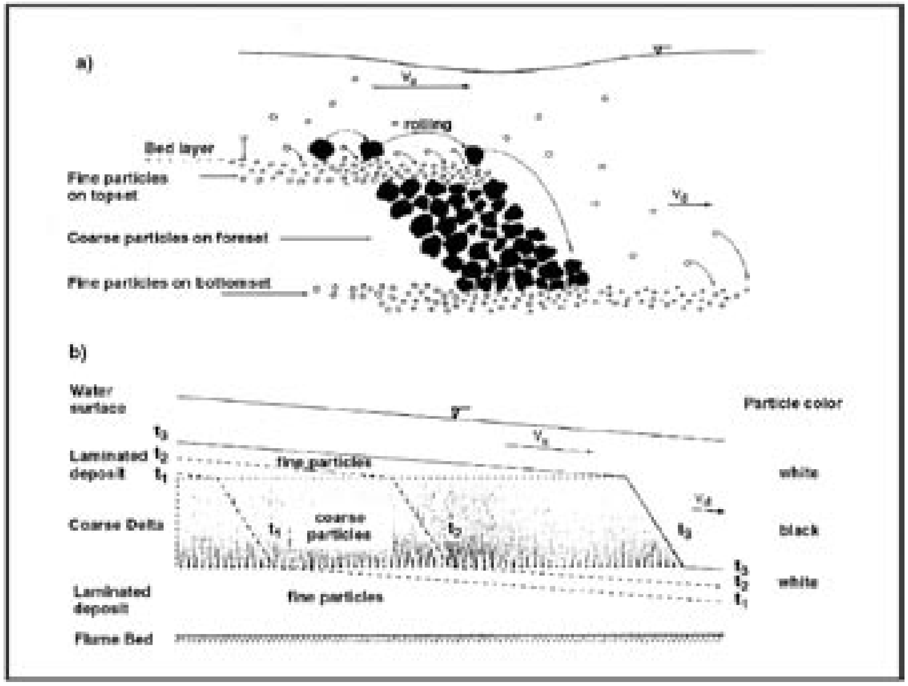

Figure 3. Results of experiments. (A) schematic formation of graded beds. (B) time sequence for depsosit formation for $t_1 < t_2 < t_3$.

facies of a specific sequence is the same in both a lateral and vertical direction (Figure 3).

Laboratory experiments on the desiccation of natural sands also show the preferential fracturing (or joints) at the interface of layers of coarse and fine particles. This shows that what is often interpreted as sedimentary bedding in the field can form merely as a result of dewatering in beds formed by the segregation of varying grain sizes. So, in the experiment, apparent successive sedimentary layers are, in fact, joint planes that form based on the mechanics of the deposition. Therefore, given a continuous supply of heterogeneous sandy mixtures in a current of varying velocity, laminae are created by the natural segregation of the particles according to their size, graded beds are created by nonuniform flow (Figure 4), and apparent parallel bedding boundaries are formed by desiccation at the interface between layers of different particle size (Figure 5). Superposed strata are not, therefore, necessarily identical to successive sedimentary layers, as was thought by Steno.

The report of the flume experiments was published in the Bulletin of the Geological Society of France (Julien et al., 1993). The results of both sets of experiments (lamination and stratification) were presented to several sedimentological congresses and recorded in the video *Fundamental Experiments on Stratification* (Julien and Berthault, 1993). These results contradicted the principles of Steno by showing that up to the limit of the angle of repose (30° to 40° for the sands), the lamination of a given deposit is parallel to the slope (Figure 6). Thus, the principle of original horizontality does not apply universally, as has often been assumed by geologists. Field examples that were thought to show tectonism after deposition tilting the originally horizontal sediments may

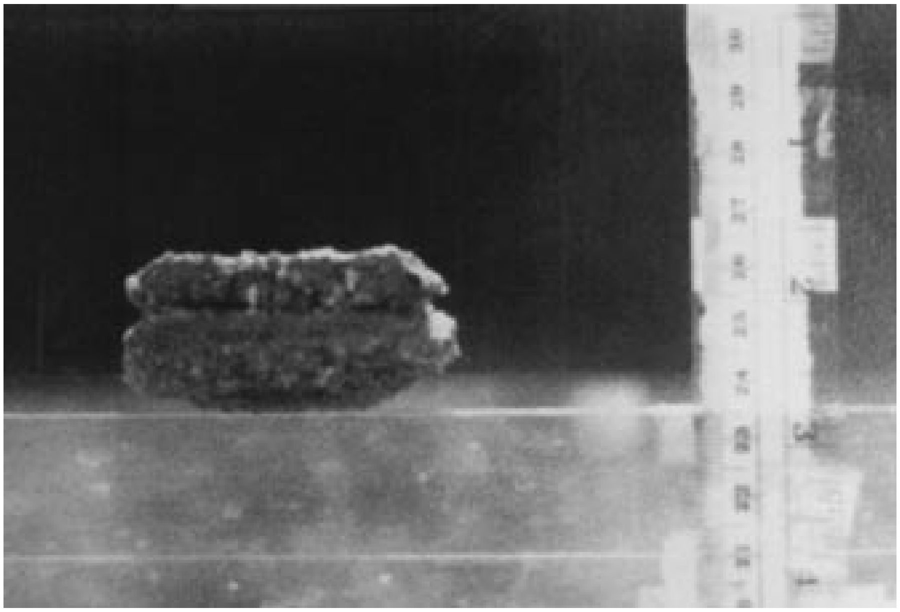

Figure 5. Horizontal fracturing of the Bijou Creek sand.

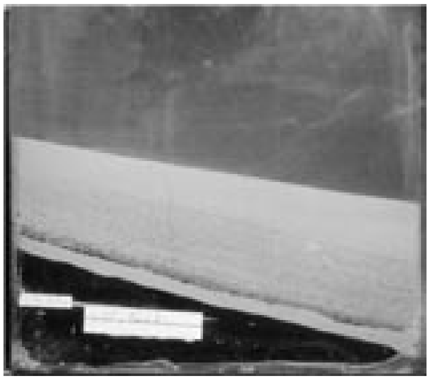

Figure 6. Lamination parallel to slope of 15°.

actually instead simply show deposition along an original slope.

Paleohydraulic conditions

Application of Steno's principles has led to the development of stratigraphy absent a careful evaluation of paleohydraulic factors. However, during the twentieth century, sedimentologists began to investigate these factors. The relationship between hydraulic conditions and the configuration of deposits (submarine ripples and dunes and horizontal beds) in contemporary deposits has been the object, especially recently, of well-known observations and experimentation. Rubin and McCulloch (1980) investigated bed forms in San Francisco Bay (Figure 7) and Southard and Boguchwal (1990) in flume experiments.

Following the pioneering work of Hjulstrom (1935), Lebedev (1959), Neill (1968), Levi (1981), Maizels (1983), Van Rijn (1984a, 1984b), and Maza and Flores (1997) determined minimum current velocities needed for the erosion and sedimentation of different size particles at varying water depths (Table I).

Geologists attribute the large-scale deposition of sediments to marine transgressions and regressions. The relationships shown in Table I can be applied particularly to detrital rocks, such as sandstone, during the first stage of a

Table I. Maximum permissible velocities for nonerosive or noncohesive grounds, in m/s (according to Lebediev, 1959).

Avg. particle diameter (mm)	Average flow depth (m)					
	0.40	1.0	2.0	3.0	5.0	>10
0.005	0	0	0	0	0	0
0.05	0	0	0	0	1	1
0.25	0	0	1	1	1	1
1.0	1	1	1	1	1	1
2.5	1	1	1	1	1	1
5	1	1	1	1	1	2
10	1	1	1	1	1	2
15	1	1	1	2	2	2
25	1	1	2	2	2	2
40	2	2	2	2	2	3
75	2	2	3	3	3	4
100	2	3	3	4	4	4
150	3	3	4	4	4	5
200	4	4	4	5	5	5
300	4	4	5	5	6	6
400		5	5	5	6	6
>500			5	6	6	6

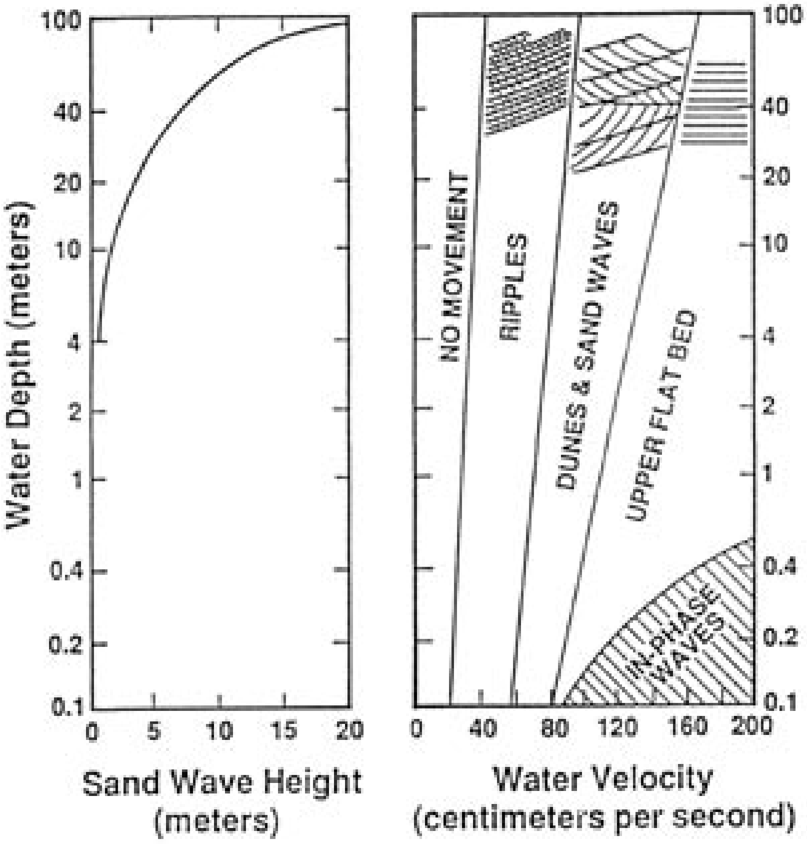

Figure 7. Graphs of (a) water depth versus sand-wave height and (b) water depth versus water velocity, showing bedforms in fine sand expected under different water conditions. The thickness of cross beds observed in fine-grained sandstone is used to estimate sand-wave height. Then, sand-wave height is entered into the graph (a) to estimate the water depth where the sand wave formed. After a water depth is estimated on graph (a), the depth is transferred to graph (b), where the minimum and maximum velocities of water are indicated for the specific water depth.

transgressive marine sequence. As rocks are eroded, transported, and deposited by powerful currents in relatively shallow water, the resulting grain sizes can supply information about those hydraulic factors. The paleovelocity of a current below which particles of a given size are deposited and the corresponding *capacity* of that current to transport sediments can be determined based upon these data. Current speed and carrying capacity can then help determine the time needed to create a particular deposit.

Similar relationships between current velocity, water depth, and sedimentary processes have been determined for different types of rock and sediment (Tables II and III). These are described in more detail in Berthault (2002).

The next step was to arrange a new series of experiments (Table IV) to measure the erosion of different types of rocks (sandstone, limestone) at higher current velocities (up to 27 m/s). This was especially important in understanding the paleohydraulic properties of conglomerates, which are typically the basal sedimentary unit of a clastic transgressive sequence. This work was done with the St. Petersburg Institute of Hydrology.

Initially, a water current moving at a velocity of around 25 m/s was run parallel across the surface plane of the sedimentary sample. At this velocity and orientation, there was no observed erosion during periods of less than 10 hours. However, when the period reached 18 hours, approximately 2 grams of material was eroded. In Experiment 25, the sedimentary rock was oriented so that the flow was at an angle of 2.5° to the direction of the current. Changing this parameter caused the erosion of 6.6 grams of material in 18 hours. These experiments are being continued, particularly in regard to flow that is not strictly parallel to the sedimentary sample.

Paleohydraulic analyses are not restricted to the laboratory. A team of Russian sedimentologists directed by Alexander Lalomov (Russian Academy of Sciences, Institute of Ore Deposits) has applied paleohydraulic analyses in conformity with Newtonian mechanics to geological formations in Russia. An investigation of sedimentary formation on the Crimean Peninsula (Lalomov, 2007) concluded that the current velocities derived from sedimentary particle analysis would have resulted in the deposition of the entire sedimentary sequence in a very short period of time, rather than the millions of years implied by a stratigraphic analysis using the geological timescale. Additional research of sandstones on the Northwest Russian Plateau in the St. Petersburg region shows that the time of sedimentation was only 0.01% of that attributed to it by the stratigraphic timescale. Results of the research are awaiting publication in *Lithological and Mineral Resources* under the auspices of the Russian Academy of Sciences.

Finally, in concert with the Institute of Geology of Kazan, the same team undertook an investigation into the time of sedimentation of the local transgression sequence in the Kama region studied in 1868 by Golovkinskii, founder of sequence stratigraphy (Berthault et al., 2008) The result is similar to the time of

Table II. Maximum permissable velocities (V, m/s) for rock soils (from Central Administrative Board on Hydraulic Energetic Building).

Lithology	Average Depth (m)							
	Rough Bottom Surface				*Smooth Bottom Surface*			
	0.4	1.0	2.0	>3.0	0.4	1.0	2.0	>3.0
A. Sedimentary Rocks	V (m/s)							
marl, shale, clay	2.1	2.5	2.9	3.1				
porous limestone, stratified								
limestone, sandstone with lime	2.5	3.0	3.4	3.7	4.2	5.0	5.7	6.2
massive limestone, dolomite								
sandstone, siliceous limestone	3.7	4.5	5.2	5.6	5.8	7.0	8.0	8.7
B. Crystalline Rocks	V (m/s)							
marble, granite, gabbro	16	20	23	25	25	25	25	25
porphyry, andesite, basalt								
diabase, quartzite	21	25	25	25	25	25	25	25

Note: Velocities calculated for unweathered massive rocks. Velocities decrease proportionately with weathering and fragmentation down to those of unconsolidated soils.

Table III. Maximum permissable velocities *(V, m/s)* for rock soils.

Lithology	Average Depth (m)					
	1	3	5	10	15	20
Loose siltstone	1	1	1	1	1	1
Siltstone, moderately hard	1	1	1	2	2	2
Hard siltstone	2	2	2	2	3	3
Marl	3	3	3	4	4	5
Porous, stratified, dolomitic limestone	4	4	5	6	6	6
Solid, massive, siliceous limestone	5	6	7	8	9	9
Sandstone with lime cement	4	4	5	6	6	6
Dolomitic sandstone	5	6	7	8	9	9
Granite and other instrusive rocks	>15	>15	>15	>15	>15	>15

sedimentation of rocks in the St. Petersburg region. The report was presented to the Thirty-third International Congress of Geology, held in Oslo in August 2008, and to the Fifth Conference on Lithology in Ekaterinburg (Russia) in October 2008.

Conclusion

The geological chronology has been established on two pillars: stratigraphy and radiometric dating. Stratigraphy was built on the principles of Steno, and early geologists interpreted Steno to imply vast lengths of time for the creation of rock strata. However, Steno's crucial failure was in not accounting for the effects of moving water on sedimentary particles. When the principles of hydraulics are applied to the mechanics of sedimentation, several interesting conclusions demonstrate the gaps in Steno's approach. These include: (1) the natural segregation by grain size of heterogeneous particles in a moving current, (2) the lateral, not vertical, development of sedimentary bedding in a variable current, and (3) the creation of apparent bedding planes by desiccation. Thus, a major pillar of deep time—stratigraphy—needs to be reevaluated from a sedimentological and hydraulic perspective. Radioactivity is independent from the physical or chemical state of the sample and thus is not influenced when a sample changes from magma to rock. Consequently, as the radiometric dating process is not linked to the solidification of the magma, it cannot date the

Table IV. Erosion of different types of rocks at higher current velocities.

			Mass of the container and with water sample (g)		Mass (dry sample post-experiment, pre-stabilization, g)			Loss of dry mass of sample (t = 18° C)	
Experiment	Sample & Side	Dry Initial Mass (g)	Before experiment	After experiment		Flow vel. (m/s)	Duration (hours)	Visual	By weight ΔG, (g)
1	2;A	6759.8	8576.0	8652.1	-	25.9	13.2	No	-
2			8652.1	8657.0	6760.0	25.9	9.3		0.0
3	5;A	6571.3	8349.9	8374.9	-	25.8	8.2	No	-
4			8374.9	8375.9	6570.8	25.6	7.3		0.0
5	3;A	6631.2	8482.9	8559.5	-	26.0	8.0	No	-
6			8559.5	8585.5	6631.2	25.9	10.0		0.0
7	1;A	6322.9	8159.0	8217.9	-	25.8	13.5	Yes	4.7
8	1;B	-	8217.9	8227.9	6318.2	25.8	21.7	No	-
9			6979.9	7068.2	-	22.5	10.5		-
10	4;A	4802.8	7068.2	7049.2	-	17.3	15.0	Yes	-
11			7049.2	7028.0	-	10.9	16.0		-
12			7028.0	7022.9	4650.0	7.8	17.5		152.8
13	3;B	6613.6	8471.7	8543.9	6613.8	25.7	9.0	No	0.0
14	3c;A	6589.6	8475.3	8523.1	6589.5	25.9	5.7	No	-
15	3c;A	6589.6	8519.5	8548.3	6589.5	26.0	17.3		0.0
16	4k;B	4692.5	6951.5	7036.0	4674.5	4.4	7.0	Yes	<18.0>
17	3c;B	*Demonstration Experiment*							
18	4k;A	4674.5	-	-	4673.0	5.5	18.0	No	1.7
19	1;B	6317.2	-	-	6315.1	25.9	18.0	No	2.1
20	4k;A	4673.0	-	-	4671.5	13.2	18.0	No	1.3
21	1;A	6315.1	-	-	6313.1	25.9	16.0	No	2
22	4k;A	4671.5	-	-	4669.0	19.6	18.0	Yes	2.5
23	1;A	6313.1	-	-	6311.2	23.8	18.0	Yes	1.9
24	4k;A	4669.0	-	-	4668.0	8.4	18.0	Yes	1.0
25	1;A	6311.2	-	-	6309.9	19.2	18.0	Yes	0.8–1.3
26	3c;B	5897.8	-	-	5891.2	20.1–25.8	18.0	Yes	6.6

formation of metamorphic or volcanic rocks (Pontcharra, 2009).

Paleohydraulic analysis can approximate the time required for the sedimentation of a sequence much more accurately than conventional stratigraphy, which tends to grossly overestimate the time required. Since evolution depends in part on a sufficient quantity of time for life to develop from nonlife and for present life-forms to develop from a common ancestor through innumerable genetic mutations over hundreds of millions of years, then the paleohydraulic approach to sedimentary strata not only invalidates conventional stratigraphy but also eliminates the time required for biological evolution (cf. www.sedimentology.fr).

Paleontologists may object based on their ability to "show" evolutionary sequences in stratigraphic intervals. However, as present marine species live in different ecological zones, according to sea depth, latitude, and longitude, this interpretive evolutionary sequence of different fossils that appear to support stratigraphic superposition may correspond instead to paleoecological distribution in depth and to migration patterns.

By calling into question the principles and methods upon which geological dates are founded, and in proposing the new approach of paleohydrology, I hope to open a dialogue with specialists in the disciplines concerned who are able to appreciate the implications and propose a geological chronology in conformity with experimental observation based upon time of sedimentation—time that is insufficient for the evolution of species, as conceived by the proponents of the evolutionary hypothesis.

References

Aubouin, J. 1967. *Précis de Géologie*. Dunod, Paris, France.

Berthault, G. 1986. Sédimentologie: Expériences sur la lamination des sédiments par granoclassement périodique postérieur au dépôt. Contribution à l'explication de la lamination dans nombre de sédiments et de roches sédimentaires. *Comptes Rendus de l'Académie de Sciences* 303(17):1569–1574.

Berthault, G. 1988. Sédimentation d'un mélange hétérogranulaire. Expériences de lamination en eau calme et en eau courante *Comptes Rendus de l'Académie de Sciences* 306:717–724.

Berthault, G. 2002. Analysis of the main principles of stratigraphy on the basis of experimental data. *Lithology and Mineral Resources* 37(5):442–446.

Berthault, G. 2004. Sedimentological Interpretation of the Tonto Group Stratigraphy (Grand Canyon Colorado River). *Lithology and Mineral Resources* 39(5):504–508.

Berthault, G., V.G. Izotov, A.V. Lalomov, L.M. Sitdikova, and M.M. Akhmetshakirov. 2008. Analytical expression of Golovkinsky-Walther's law with reference to research of Permian strata of Volga-Ural region. Proceedings of the 33rd International Geological Congress, Oslo, SES-01 General Contributions to Sedimentology, CD-ROM.

Ellenberger, F. 1975. *Histoire de la Géologie*, vol.1: *Technique et Documentation*, pp.232–315. Lavoisier, Paris, France.

Gohau, G. 1990. *A History of Geology*. Rutgers University Press, New Brunswick, NJ.

Gradstein, F., J.G. Ogg, and A.G. Smith (editors). 2004. *A Geologic Time Scale 2004*. Cambridge University Press, Cambridge, UK.

Hjulstrom, F. 1935. Studies of the morphological activity of rivers as illustrated by river Fyris. *Bulletin of the Geological Institute Uppsala* 25:89–122.

Julien, P.Y., Y. Lan, and G. Berthault. 1993. Experiments on stratification of heterogeneous sand mixtures. *Bulletin Géologique de France* 164(5):649–660.

Julien, P.Y., and G. Berthault. 1993. *Fundamental Experiments on Stratification*. Video, Sarong Ltd., Monaco.

Lalomov, A.V. 2007. Reconstruction of paleohydrodynamic conditions during the formation of Upper Jurassic conglomerates of the Crimean Peninsula. *Lithology and Mineral Resources* 42(3):298–311.

Lebedev, V.V. 1959. *Gidrologiya i Gidravlika v Mostovom Dorozhnom Stroitel'stve* (Hydrology and Hydraulics in Bridge and Road Building). Gidrometeoizdat, Leningrad, Russia.

Levi, J. 1981. *Bed-Load Transport: Theory and Practice*, pp.303–355. Water Resources Publication, Garden City, MI.

Logvinenko, N.V. 1980. *Morskaya geologiya* (Marine Geology). Nedra, Leningrad, Russia.

Maizels, J. 1983. *Paleovelocity and Paleodischarge, Determination for Coarse Gravel Deposits*. John Wiley & Sons, New York, NY.

Maza, J.A, and M. Garcia Flores. 1997. Velocidades medias para el inicio del movimiento de particulas. In *Congresso Nacional de Hydraulica*, pp. 70–88. Guadalajara, Mexico.

Middleton, G.V. 1973. Johannes Walter's law of correlation of facies. *Geological Society of America Bulletin* 84:979–988.

Molyavko, G.I., V.P. Franchuk, and V.G. Kulichenko. 1985. *Geologi I geography. Biblio-graficheskii spravochnik*. Nauk, Dumka, Kiev, Ukraine.

Neill, C.R. 1968. Note on initial movement of coarse uniform material. *Journal of Hydraulic Research* 6(2):157–184.

Pontcharra, J. 2009. Are Radiodating Methods Reliable? In Conference Proceedings, *A Scientific Critique of Evolution*, pp. 31–46. Sapienza University, Rome, Italy.

Romanovskii, S.I. 1988. On the problem of the history of discovery and authorship of main facies law. *VIET* 4:87–94.

Rubin, D.M., and D.S. McCulloch. 1980. Single and superposed bed forms: a synthesis of San Francisco Bay and flume observations. *Journal of Sedimentary Petrology* 26:207–231.

Southard, J., and J.A. Boguchwal. 1990. Bed configuration in steady unidirectional water-flows, part 2: synthesis of flume data. *Journal of Sedimentary Petrology* 60(5):658–679.

Steno, N. 1667. *Canis Calchariae*. Ex typographia sub signo Stella, Florence, Italy.

Steno, N. 1669. *Prodromus*. Ex typographia sub signo Stella, Florence, Italy.

Strakhov, N.M. 1957. Theoretical lithology and its problems. *Izv. Akad. Nauk SSSR, Ser. Geol.* 11:15–31.

Van Rijn, L.C. 1984a. Suspended load. *Journal of Hydraulic Engineering* 10(11):1613–1641.

Van Rijn, L.C. 1984b. Sediment transport: bed-load transport, part I. *Journal of Hydraulic Engineering* 10(11):1431–1456.

Vassoevich, N.B., V.L. Librovich, N.V. Logvinenko, and V.I. Marchenko. 1983. *Spravochnik po litologii*. Nedra, Moscow, Russia.

Walther, J. 1894. *Einleitung in die Geologie und Historische Wissenschaft*. Verlag von Gustav Fisher, Jena, Germany.