CAVITATION: AN INTEGRAL AGENT OF ENERGETIC GEOMORPHOLOGICAL PROCESSES

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INTRODUCTION

Probably the gamut of geomorphological structures observed today were generated by the recession waters of the Genesis Flood. However geomorphology addresses only one aspect of structural geology. The etiological processes associated with sedimentary and igneous stratigraphy addresses yet an even more important study of Flood Geology. The general Flood model usually consists initially of a global fracture event occurring simultaneously with a global vapor canopy collapse, generating very energetic hydrodynamic processes — not the least of which is *cavitation* phenomena.(1) This explosive phenomenon (cavitation), resulting from exceedingly intense procession and recession of Flood waters, probably generated pressures well in excess of 200,000 psi(2) and is postulated to have occurred in the precession and the recession phases of the Flood. The paper is divided into two sections: 1. Cavitation Inception and 2. Cavitation Reduction.

The purpose of this investigation is to demonstrate the probability that cavitation existed as in *intrinsic* phenomenon of the Genesis Flood. There appears no way to obviate the necessity of cavitation processes, especially when considering calculations using Barnes' minimum cavitation velocity, as well as Ehrenberger's steep slope velocity. Further, the damage propensity presented in section two demonstrates that the Flood velocities are **not** required to be high in order for cavitation occur.(3) This will be demonstrated via interpretation of data obtained from the work conducted at the California Institute of Technology, using comparatively low flow velocities, is related to surface tensile strengths, including the granitic types. However, a brief mathematical approach using the Bernoulli formula for constant mass flow is in order.

CAVITATION INCEPTION

Barnes and Ehrenberger Velocities

A mathematical approach using the Bernoulli equation helps in appreciating the relationship between cavitation *inception*, and hardened surface damage — *cavitation reduction*. The former occurs in high dynamic fluid flow pressure zones (with corresponding low static pressures). The latter in low dynamic pressures and high hydrostatic pressures. It is important not to confuse cavitation *inception* with cavitation *reduction* since the fluid pressure environments are opposite. The mathematical formula used to predict both environments and the likelihood of cavitation is (4)

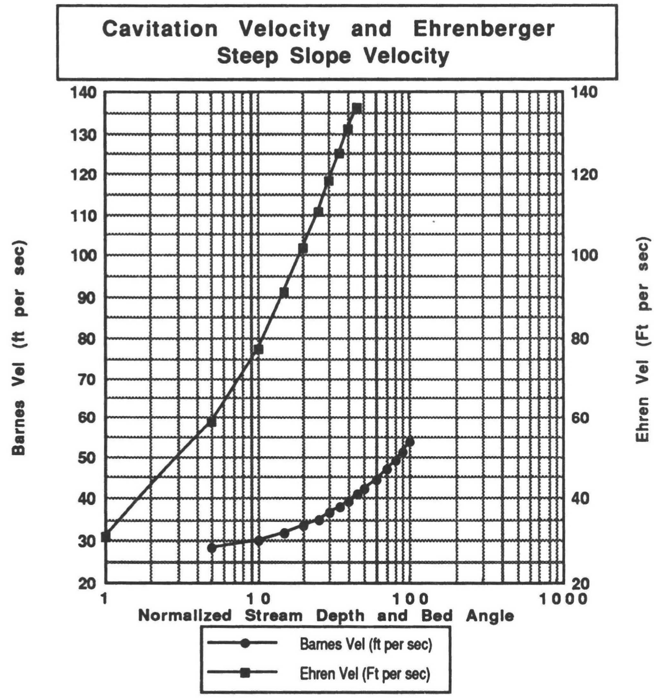
$$\frac{V_{1^2}}{2g} + \frac{P_1}{Y} = V_{2^2} + \frac{P_2}{Y} \qquad \text{Bernoulli Formula} \qquad (1)$$

where

V_1 = initial stream velocity (ft per sec)
V_2 = velocity at cavitation inception (ft per sec)
g = acceleration of gravity (32.2 ft per sec^2)
P_1 = absolute pressure (14.7 lbs per in^2)
P_2 = fluid vapor pressure (0.36 lbs per in^2)
Y_1 = specific weight of water (62.42 lbs per ft^3)
Z_1 = stream depth (feet)
Z_2 = stream elevation = 0 (datum level assumed)

With the above boundary conditions V_1 may be calculated. V_1 is Barnes' estimate of velocity(5) required for cavitation inception. The following graph (Graph 1.1) is produced using Barnes' formula showing stream velocity versus Ehrenberger's steep slope velocity (as a function of stream bed angle).

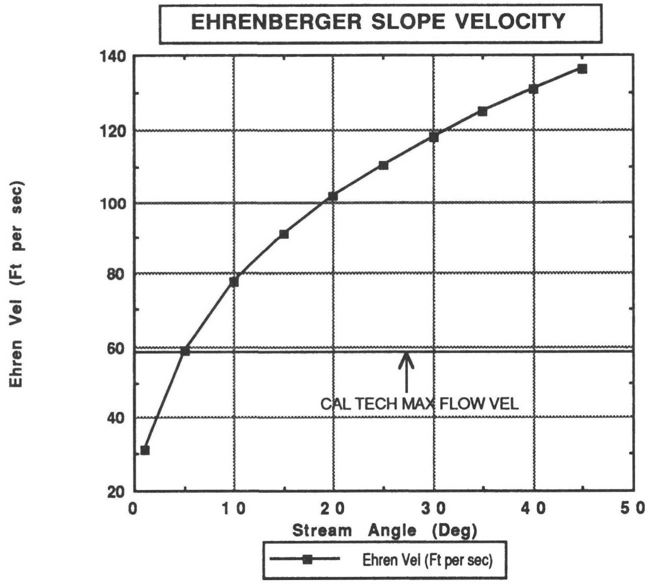
$$V_1 = 4.6(33.1 + Z_1)^{.5} \qquad (2)$$



Note that the Ehrenberger steep slope velocity (as a function of stream bed angle) exceeds the Barnes' minimum velocity required for cavitation. Even at a stream depth of only five feet, with Barnes' required velocity for cavitation being 28 feet per second, the Ehrenberger velocity (32 feet per second) already exceeds the required cavitation velocity when assuming only one degree of bed angle! A closer look at the steep slope velocity will help to clarify its effect on cavitation inception. The Ehrenberger Steep Slope Velocity(6) is

$$V_E = 97R^{.52}(\Sigma)^{.40} \qquad (3)$$

where Σ is the sine of the angle of the stream bed and R is the hydraulic radius (ratio of stream area to wetted perimeter of flow). Graph 1.2 shows the relationship of Ehrenberger velocity singularly as a function of stream angle. Hydraulic radius is assumed at 2.5:1. The highest flow velocity used by Cal Tech is 59.9 feet per second, which produced a supercavitated flow condition.(7) The term supercavitation is used to describe cavitation flows which exceed the length of the immersed object (pebbles, boulders, etc.) We conclude that since the majority of Flood recession stream bed angles probably exceeded ten degrees, most recession flows were supercavitated.



CAVITATION REDUCTION

Comparative Tensile Strengths and Cavitation Losses

Table 1 shows a variety of physical parameters of interest to the study of cavitation loss. The losses are measured as functions of material composition, ambient temperature, tensile strength, yield point, and material hardness. Lower tensile strengths and hardness are included in the lower table. The objective of the use of these data is to depict the relatively low tensile strengths (with commensurate high loss susceptibility) of the granites. **If chrome steel is reduced by cavitation processes, then certainly granite (of much lower tensile strength) is significantly more affected.**

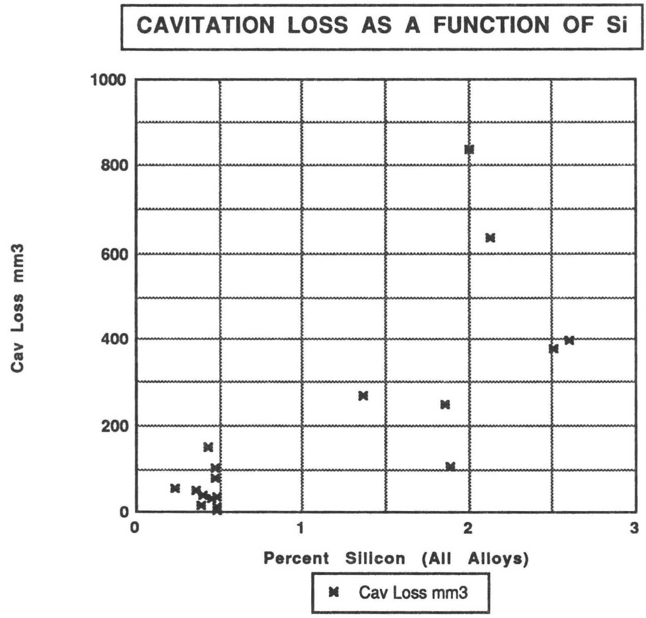
Table 6.03 and Table 6.04 reveal some of the information presented in Figure 6.05 and 6.06. Further, note that those types of materials which possess large amounts (greater than .47%) of silicon (Si) are significantly more affected by cavitation than those types with low concentrations of silicon. **Silicon (Si) based materials appear susceptible to cavitation.**

Graph 1.3 shows cavitation reduction as a function of percent silicon content. Included are tensile strength, Brinell hardness, and yield.

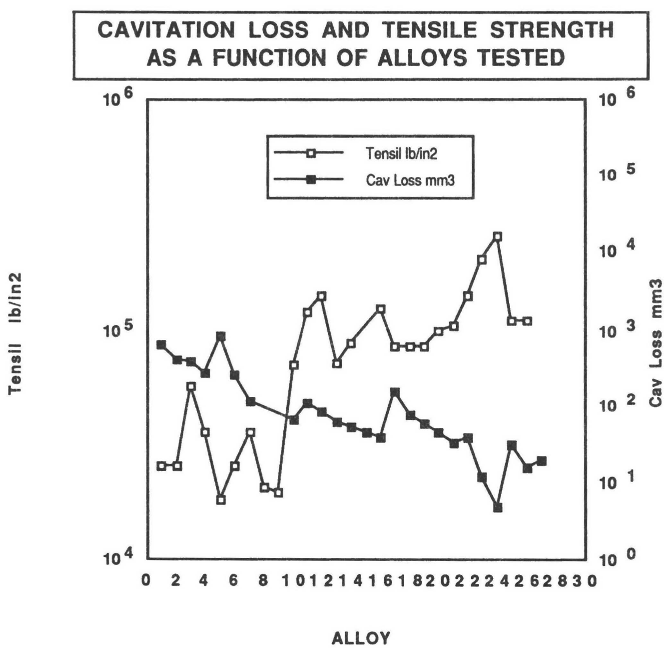
The alloy number refers to the different metal alloys depicted in Table 6.03. Note that those alloys strong in Si, particularly 11, 12 and 21 through 24 all exceed 100,000 psi tensile strength. Yet as Si content decreases as a function of alloy number, so does cavitation loss. The reason for this effect may be due to the resonance nature of silicon dioxide (SiO_2) coupled with piezoelectric type processes.

Another salient point to be considered is the *duration* of the tests which were conducted at the CIT. The maximum test duration is 16 *hours*. The Genesis Flood procession and recession phases are on the order of *years*! The energy which may be released in terms of cavitation processes over so long a period would be phenomenal.

Graph 1.4 shows cavitation singularly as a function of Si content (all alloys).



Graph 1.5 depicts the susceptibility of cavitation reduction to tensile strength of materials. It is this graph which correlates the high propensity of the granites to cavitation processes since their tensile strengths are much less than the harder surfaces indicated.



Since the granites are on the order of 10^3 psi (see Table 6.04) it is difficult to imagine that these materials would not be reduced by cavitation. Notice that cavitation loss is already severe at 10^4 psi. Since granites contain significant amounts of SiO_2 we expect these types of stream bed surfaces to be rapidity eroded.

SUMMARY AND CONCLUSION

Cavitation should be considered an integral part of Flood Geology. There should be doubt stream velocities need not be excessively high, nor beds abnormally inclined, to attain prime cavitation conditions. If the Barnes' prediction for incipient cavitation is accurate to a first order; and if velocities as functions of stream bed slope are also first order correct, then cavitation inception should occur. Other variables would enhance the process. For example, and not mentioned in this paper, are(8)

- reduction of water tensile strength as a function of increased temperature
- decrease of ambient atmospheric pressure due to collapse of the vapor canopy with resultant lower cavitation number(9)
- resonance (acoustic) cavitation occurring as a function of shock impact against SiO_2.(10)
- disintegration of hardened surfaces, hydrodynamic plucking forces as a function of stream flow, with resultant angular bed surfaces inducing more cavitation

Although the physics behind an apparent susceptibility of SiO_2 type surfaces to cavitation is not understood, the general answer probably has to do with the resonance frequency of silicon dioxide crystal lattices and impacting shock frequencies. Further study is required to assess this correlation. Certainly the measurements made at the California Institute of Technology does confirm that cavitation reduction is directly proportional to tensile strength. Since the granites have tensile strengths on the order of 10^3 psi, we may expect these surfaces to be far more susceptible to cavitation than the 10^4 and 10^5 psi strengths of Table 6.03, although these stronger materials were also susceptible to cavitation over the 16 hour flow times.

REFERENCES

1. C.A. Paiva, *Cavitation in Macro-Fluvial Processes and the Implications for Geologic Time*, A Thesis, Institute for Creation Research, p. 1, 1988.

2. G.W. Sutton, *A Photoelastic Study of Strain Waves Caused by Cavitation*, Journal of Applied Mechanics, Vol. 24, pt. 3, pp. 340-348, 1957. Actually this number is often exceeded, for example when surface tension is increased as a function of decreased temperature, and cavitation occurs in high velocity flows. In any case it is due to the equivalence of the fluid static pressure to its vapor pressure, which results in minute cavities, hence the term cavitation.

3. F.R. Young, *Cavitation*, McGraw-Hill Book Company, London, 1989, pp. 198-199.

4. Ibid., 3, pp. 188-189.

5. H. Barnes, *Cavitation as a Geologic Agent*, American Journal of Science, Vol. 254, August 1956, pp. 493-505.

6. R. Ehrenberger, Zs. Osterreich Ischen Ing. und Arch. Heft 15/16, (1926).

7. Ibid. 3, p. 199. Fully extended (supercavitation) would be expected as the norm in Flood recession processes since theses v velocities would exceed 60 ft sec^{-1}.

8. Ibid. 1, pp. 37-40.

9. This number is commonly designated as $\Sigma = \frac{P\,[(ambient) - P\,(vapor)]}{.5\ \partial\ v^2}$ where ∂ and v are the fluid density and velocity respectively. The lower the cavitation number the higher the probability of cavitation.

10. Ibid. 3. This process takes up more than 180 pages of Young's text. Basically if the ambient pressure of the fluid drops below the fluid's vapor pressure (as in hydrodynamic cavitation) due to rapidly expanding shock fronts (from bubble implosion), the induced rarefaction regions behind the front may also cavitate with a net result of amplification of the phenomenon.

DISCUSSION

Mr. Paiva has not clearly demonstrated in his first part that cavitation can be achieved at low stream velocities. His referenced works and equations may indeed support such an assertion, but the author does not present a logical argument. Ignoring the steel-to-granite extrapolation as well, there is little of substance left to salvage. I had hoped that this paper would be more polished because creationist literature needs more contributions on the subject of cavitation, but the quality of papers needs to be as high as that required by all reputable scientific journals.

The author should, however, be encouraged to continue his research into this important area. Perhaps Mr. Paiva could document the durability of various rock species under cavitation. We need those numbers. We also need laboratory measurements of cavitation as water flows over recently laid basalt barriers, because hot water cavitates better than cold. He should carefully document his threshold speeds for cavitation if indeed they need not be large.

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Mr. Paiva's paper distills the findings from the first large scale study of cavitation from a creation-science or flood geology perspective. It should be read along with the two other papers on cavitation and the Clark and Voss paper, "Resonance and Sedimentary Layering in the Context of a Global Flood." All were given at the 1990 International Conference on Creationism.

Most people might agree that cavitation occurring in moving fluids would be globally significant if a combination of high velocity, rough surface, weak materials and long time frames were operative, but Mr. Paiva shows that significant if a combination of high velocity, rough surface, weak materials and long time frames were operative, but the author shows that significant cavitation reduction needs not even one of these factors. Much of this paper is based on actual lab tests of cavitation acting on very strong materials. Given the abundance of silicon in the crust of the earth, it is significant that cavitation influence goes up with and increase in silicon content. The possibility that silicon content increases the vulnerability to resonant influences calls for investigation of this factor.

Mr. Paiva's paper helps provide the needed explanation of a process that can reduce the pre-flood crust to all the sediment needed to form the sedimentary layer, and in a short time.

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While it is true that if the post flood streams had bed angles greater than 1 degree, cavitation would be a widespread phenomena, it is quite unlikely that any stream could have had the required gradient. The Mississippi River falls about 1,000 feet from the source to the mouth over a straight line distance of about 1,225 miles. This yields an average bed angle of .008 degrees: a value that is much smaller than the value of 1 to 10 degrees assumed by Dr. Slusher and Mr. Paiva.

Even if one were to assume a 10 degree gradient for the river beds, this would require an impossible and unrealistic source elevation for any moderately long stream. A 10 degree slope on the Mississippi River requires a source elevation of 212 miles. Even a 1 degree slope requires a 21 mile elevation.

What needs to be explained is why are we to expect the immediate post-flood topology to be so steep?

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CLOSURE

Mr. Paiva did not respond to his reviewers.