201 Highland Avenue
Upper Montclair, N.J. 07043
December 19, 1979

Dr. Don E. Crabtree
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Kimberly, Idaho 83341

Dear Don:

Congratulations on the honorary Doctorate! For your particular contributions, for your inspiring stimulation of all who have had contact with you, and for your broadening the whole field of study of man's past - I can't think of anyone who would have deserved the honor more.

I am a bit embarrassed for writing to you with such a delay. I suspect it may relate to my slow progress in lithics research. It seems I have been simply overwhelmed by the vast amount of literature in fracture mechanics that I have been unaware of. Much of it is relevant to flint-working - and in some cases in quite surprising ways!

Anyway... I am still working as an engineer and expect to remain in that profession. It has become very clear by now that I will limit my interest in archeology to mechanics of flaking. Although this is indeed very narrow, I presently see problems to work on for perhaps 10 lifetimes! I hope to be spending a few decades on these problems. Since I will not be working professionally as an archeologist, and because of my particular background, I hope I can contribute more by this kind of specialization. I know I will enjoy doing that anyway.

As a first step in my ambitious long-range goal, I see that I must become much more familiar with fracture mechanics literature. (This may take me another 5 years!) At the same time I think it will be useful for me to review the state-of-the-art on the mechanics of flaking from archeological literature, to attempt a state-of-the-art review of the relevant fracture mechanics literature, and to "merge" the two for suggesting possible answers to particular questions on flaking. But most importantly I hope such surveys can serve as a bridge - for understanding flaking - between archeologists and engineers, physicists, etc. Although I have no need for a degree, I hope to use the above work for an anthropology dissertation at NYU. (Degrees aside, I hope the above work will be my initial step in an ambitious, long-term effort.) Believe it or not, I have still not taken a "candidacy exam" required before writing the thesis. I have been postponing it for years, but expect to have a try at this oral exam in the next few months - with 3 archeologists and 2 fracture mechanics experts.

When I visited Prof. Fréchette at Alfred College of Ceramics in '78 fall, I also asked if he would serve on my dissertation committee. He agreed! Also, Dr. Stephen Freiman of the National Bureau of Standards (Fracture and Deformation Division) agreed to be on the committee.

I have had discussions on flaking with Dr. Freiman on several trips to Washington. Passingly I mentioned about heat-treatment. He seemed to take

particular interest in that. Later I sent him some references on it. When I met him a few weeks ago, he had already met Barbara Purdy!

By the way, my contacting Prof. Fréchette is not perhaps a coincidence. I heard his name first from you at Kimberly, and recalled now that he must have taken some interest in flintworking. So, when I searched this geographical area for fracture mechanics experts who might be interested in my research efforts, he naturally became a prime candidate. On my visit to Alfred in '78, I was afraid that quite a bit of urging would be needed to invite him to serve on my dissertation committee. As I popped the question, he simply threw up his arms and said - how can I refuse! He seems to be one of these rare, broadminded scholars who can immediately grasp the significance of his work beyond his own discipline. I hope to meet him at my oral exam in New York, as soon as it is convenient for him and Dr. Freiman to make the trip. Late spring, I hope to make another trip to Alfred.

Now, regarding some problems on flaking. Back in 1978, I accidentally observed some fracture markings in flaking that have not been mentioned (as far as I know) in archeological literature. I was looking systematically at many accidental breakages of ~~obsidian~~ glass blades I had produced. On the surfaces of these accidental fractures I occasionally saw what is called "mist" in fracture mechanics literature. (For example, in the paper on fracture markings by Prof. Fréchette, this is described. I believe you have this paper.) The surface really looks "misty" or "foggy" to the naked eye. Under magnification, short "radial grooves" are seen to give this appearance. "Mist" only appears when the crack velocity is sufficiently high, in the neighborhood of roughly 1000. meters/second, as I recall. Therefore, we really expect to see "mist" only on "accidental" breakages in flintworking.

I have later seen "mist" (1 case only) on an accidental break of a point as I fouled up in fluting. I "overground" the platform and simply broke the (obsidian) point in two by too heavy a blow.

I expect that "mist" should be also present sometimes when one accidentally shatters a core from too hard a blow. Prof. Fréchette and others note that, as the crack speed increases gradually to a sufficiently high value, you first get this "mist", then "hackle" beyond mist (not to be confused with the "hackle" or fissures normally on flake surfaces), and finally crack branching. Crack branching may relate to "shattering."

For a while I was optimistically excited about this "mist." In fracture mechanics, they have been empirically relating mirror radii (distances from origin of fracture to mist boundaries) to other parametes. Since the relationships have been observed to be temperature dependant (for some temperature ranges, at least), I thought there would be a remote possibility of telling the temperature during these breaks from various measurements and lab tests. This would have been very significant for archeology (seasonality). Unfortunately, it now seems that this is not possible, in most cases at least.

As I was abandoning hope on the above problem, another interesting and very important one came up. Getting more and more into fracture mechanics literature, it is becoming clear that water has a very significant effect on the force (and stress) required to start a crack in glass and many other materials. (Incidentally, do you recall that Rob Bonnichsen was telling at the Calgary conference that dunking Mt. Kineo felsite (of Maine) into water worked "like heat treatment.") For example, suppose that we want to remove a flake with the "lightest" possible blow - for a given "platform" preparation,

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core or biface geometry, etc. According to highly controlled laboratory tests, wetting the contact region should help significantly. Alternatively - turning the problem around - we might ask, for a given "kind" of blow, what is the maximum amount of edge rounding we could have, e.g., for "platform" preparation in fluting a point to be able to start the flake. Again, the fracture mechanics literature implies (for obsidian and probably other materials) that if you wet the platform (e.g. "spit" on it), then you can get away with more rounding (overgrinding or too much rounding without wetting). Incidentally, I once gave a demonstration of "spit-fluting." (Of course, a single case in flintworking does not demonstrate anything.)

I have been aware of this effect of water for couple of years now. But the really exciting point is that there just may be a way of detecting the use of water or wetting from the markings on a flake (probably obsidian only) surface. I will be working on this problem, and should have a better idea regarding this possibility within 6 months. If this is fruitful, it will be due to the research of Prof. Frechette and his colleagues at Alfred in fracture mechanics.

Another problem of interest: some highly contolled laboratory experiments of Dr. Freiman (and his colleagues) on glass indicate that the direction of grinding is important. (Grinding introduces tiny flaws. A fracture always starts at some, usually microscopic, flaw.) For example, if grinding is parallel to a biface edge, a smaller force is required to start the crack (other parameters remaining unchanged). Although this particular case is probably of little or no interest, the idea may be of interest in other contexts - e.g. grinding the "platform" for fluting.

Another problem: I have been considering the effect of a flake (or blade) cross-sectional geometry on the configuration of ripples (and fissures). See the attached figures. I have been looking into this question in the light of mechanics theory and controlled lab experiments by others. Although some more theoretical work is needed (and lots of experimental observations), the theoretical predictions, in a qualitative sense, lend support to the tendencies noted in the attached figures. But there are factors other than geometry that somewhat confuse the issue - e.g. how forces are applied.

I am also getting into many other questions on the mechanics of flaking: directions of forces, etc., etc. I am working on a number of problems simultaneously. Usually, it is like banging my head against the wall. But I rebound, go to another problem for diversion, and come back again to the same problems with new ideas. And my flintworking keeps on generating many new problems of mechanics...

I do hope that I can meet you some time in the future to discuss some of these problems.

I would like to ask you the following questions. (I'll give you a call after you have received this letter.)

1. Have you observed any effect of water (wetting, "spitting") on flaking?

2. Have you observed any effect of the direction of grinding in platform preparation?

3. Back at the 1973 Flintworking School, you mentioned that you had noted some effect of temperature on flaking. What temperatures or temperature ranges do you have in mind? What materials? Obsidians? Other?

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4. Does there seem to be any correlation between the amount of grinding (or edge rounding) you like to use with the nature of the material you are flaking? For example, coarser versus finer cherts.

Best wishes for Christmas and the New Year.

I hope to be talking to you soon.

Sincerely,

Are Tsirk

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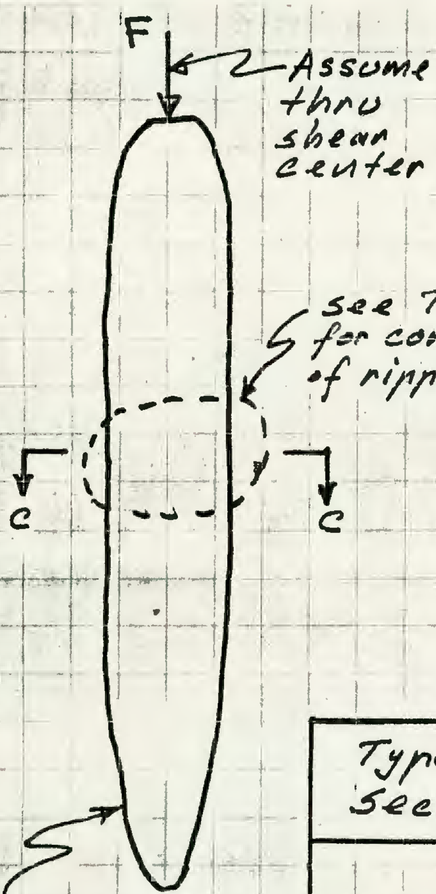
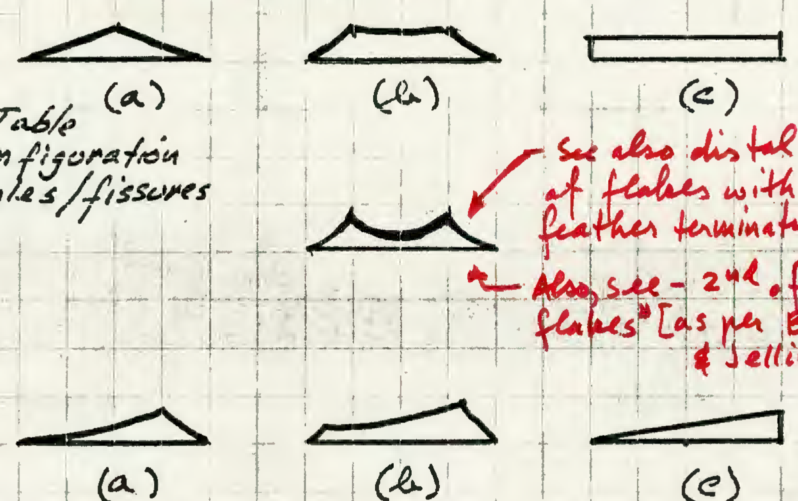


see Table for configuration of ripples/fissures

A blade (a long, roughly parallel-sided flake) or a flake of other shape

(Idealized) Sect. C-C



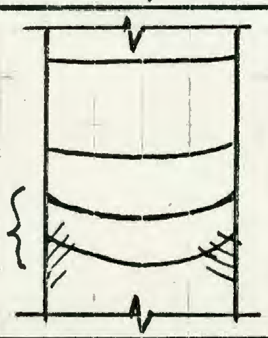
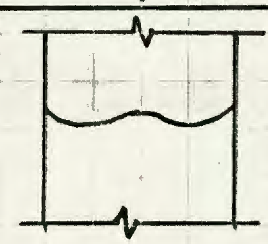
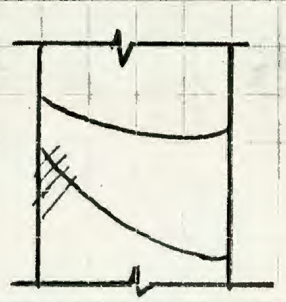
Symm. Cases (1)

see also distal portions of flakes with feather terminations.

Symm. Case (2)

Also see - 2nd of "double flakes" [as per Bradley & Jellinek]

Asymm. Cases (3)

Type of Sect. C-C	Approx. Configuration of Ripples & Fissures (Observed or Expected Tendencies)
(Symm.) Cases (1) — c ↓? b ↓? a	
(Symm.) Case (2)	
(Asymm.) Cases (3)	

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