Solid Earth Discuss.,
https://doi.org/10.5194/se-2019-59-AC1, 2019

Solid Earth Discussions

Interactive comment on "What happens to Fracture Energy in Brittle Fracture? Revisiting the Griffith Assumption" *by* Timothy R. H. Davies et al.

Timothy R. H. Davies et al.

tim.davies@canterbury.ac.nz

Received and published: 20 June 2019

Interactive comment on "What happens to Fracture Energy in Brittle Fracture? Revisiting the Griffith Assumption" by Timothy R. H. Davies et al. Anonymous Referee #1 Received and published: 12 June 2019

Response

Introduction to Response:

We thank the Referee for these comments, but believe he or she may have misconstrued the objective of our manuscript.

Our purpose is to demonstrate that the area of new surface resulting from a brittle frag-

mentation event exceeds that possible if the Griffith assumption, that fracture energy always instantly transforms to unavailable surface energy, is valid. This demonstration ideally requires only a single data point, if the accuracy of that point is solidly established; we have chosen to report four of our data points that demonstrate the invalidity of the assumption, and further corroborate these with independent data from another source (Kolzenberg et al., 2013). These ten data points make an extremely strong case for the lack of universal validity of the Griffith assumption. In fact we also conducted experiments that resulted in the creation of fewer (in one case only two) fragments, and so did not invalidate the Griffith assumption; since these data, however, do not affect the reality of those that do invalidate the assumption, we did not report them.

Had our objective been to report on the pattern of surface area generation by failures at a range of stresses, then certainly more data would have been needed; but it was not.

Introductory comment: "These experiments with Pyrex are interesting but there may be some weaknesses." Response: We assume that the referee's numbered comments refer to the weaknesses. We reproduce the comments and respond to them individually

"1) Only four tests are performed. The other data are taken from another source (Kolzenberg et al., 2013)."

Response: As noted in our introduction above, if the objective of the research is understood this is not a weakness. Certainly, independent corroborative data constitute a strength.

"2) The kinetic energy of the fragments is not measured and thus energy considerations are not possible. The energy budget put into the system by compression should be the equal to the energy taken up by the fragments, by the acoustic, thermal energies, and by the energy used up to create new surface. Without estimating these forms of energy, it is difficult to conclude that fragments take up vibrational energy. In other words, one should demonstrate the presence of an energy deficit."

Response: Fragment kinetic energy had reduced to zero by the time we removed the shattered sample from the container. Our energy budget compares the elastic strain energy immediately prior to fragmentation with the surface energy when the fragmentation episode had finished and all the transitional energies had dissipated. The fragment kinetic energy present during the fragmentation event would have transformed to surface energy as moving fragments further fragmented, and to elastic, thermal and acoustic energies upon impact with other fragments and with the container walls; these energies may or may not have contributed to further fragmentation. We have not measured the elastic, thermal and acoustic energies emitted during the test that did not cause fragmentation; if we had done so, these would have had positive values, so the energy available to create new surface would have been less than we have assumed. The energy deficit we have demonstrated would thus have been larger, further supporting our conclusion. Our data throughout the analysis have been chosen to be consistently conservative, that is, to be as detrimental to our outcome as possible. Hence the large uncertainty of the data do not detract from our definite conclusion

"3) The figure in Fig. 8 shows the experimental data on the surface-energy plane. Three of the new data cluster at about 40 J. There is one isolated point at higher energy. This graph shows that more surface is created as consequence of energy loaded into the system. If it were only for the data from this work, one would draw a fitting line between the four points. Adding the data from Kolzenberg et al. (2013) shows that data points are very much dispersed. It becomes difficult to find a fit. The general conclusion is that new surface approximately increases with energy, which is reasonable."

Response: While it is not our objective to establish a relationship between energy available and new surface created, the Griffith theory requires that there is a positive relationship which, as the reviewer points out, appears to be the case. However this is not directly relevant to the objective of our research as pointed out above - the invalidity of the Griffith assumption about surface energy, which is unconnected with the

relationship between energy and surface area.

"4) The energy per unit surface decreases as a function of the energy put into the rod (Table 3). It is possible that fragments acquire some internal energy as suggested here in addition to the kinetic, but this is still conjectural."

Response: energy per unit surface is the gradient of the data in Fig. 8. The trend suggested by the reviewer from Table 3 thus implies that the local gradient reduces as energy input increases – this is not apparent in Fig. 8. Again, identifying such trends is not the objective of the work.

"5) Application to geological phenomena is unclear, given the level of uncertainty. The paper would be strengthened with more tests. Moreover, other important forms of energy should be measured and/or better constrained."

Response: As set out in our Introduction to Responses, there is NO uncertainty in our interpretation of the data. It is unequivocal that all the data contradict the Griffith assumption. Consideration of other forms of energy would, unless they are negative, strengthen our conclusion.

Interactive comment on Solid Earth Discuss., https://doi.org/10.5194/se-2019-59, 2019.