ON THE STRENGTH OF THE ABA PANU METEORITE: IMPLICATIONS FOR NEO HAZARD MITIGATION

E-lightning talk, paper # 161

T.S.J. Gabriel, D. Cotto-Figueroa, E. Asphaug, L. Garvie, Md. F. Rabbi, & A. Chattopadhyay

Also check out paper #160!

Meteor breakup - a ubiquitous process

Notable events:

- **Tunguska (1908) -** ~50-190 m meteor broke up at ~5-10 km altitude, leveling ~2,150 km^2 of forest.

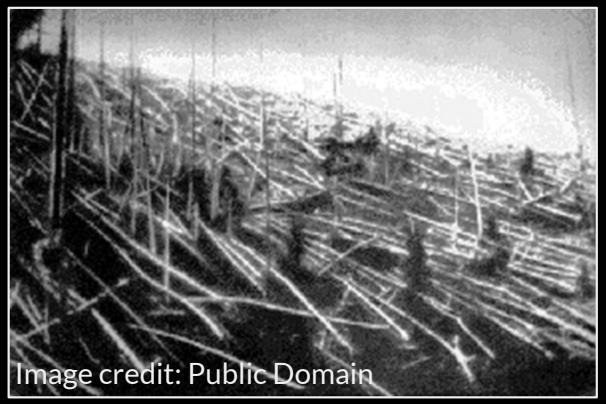

Image credit: Public Domain

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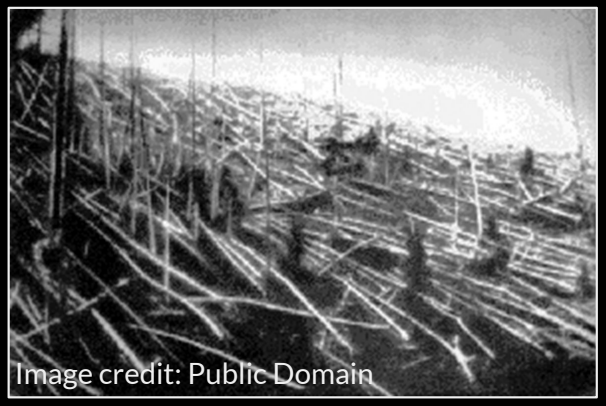

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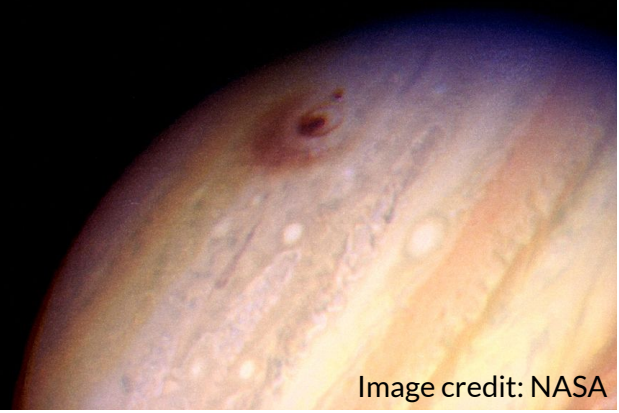

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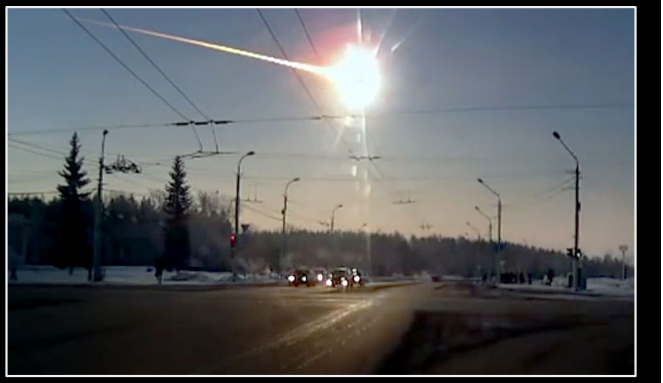

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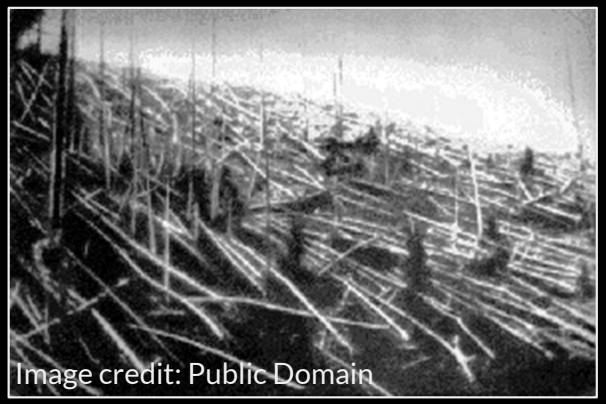

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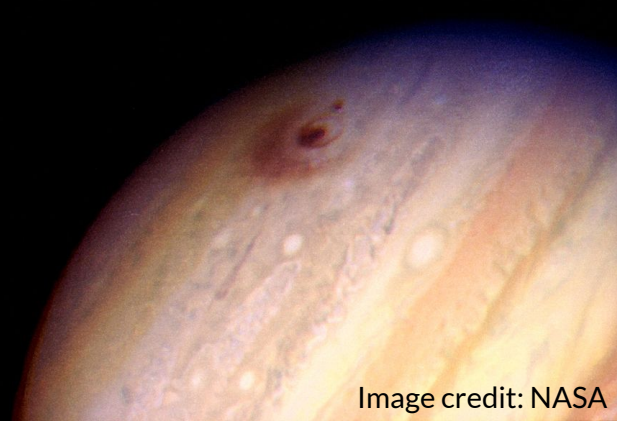

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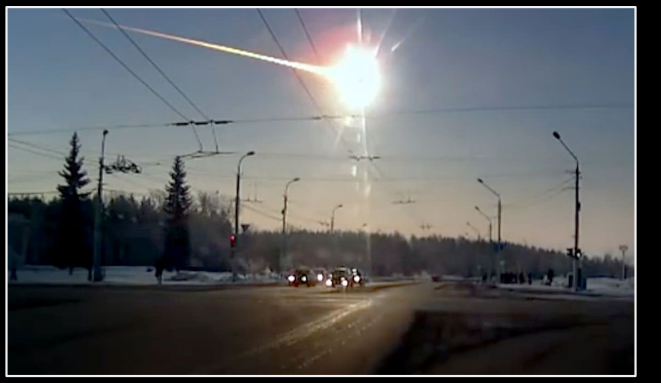

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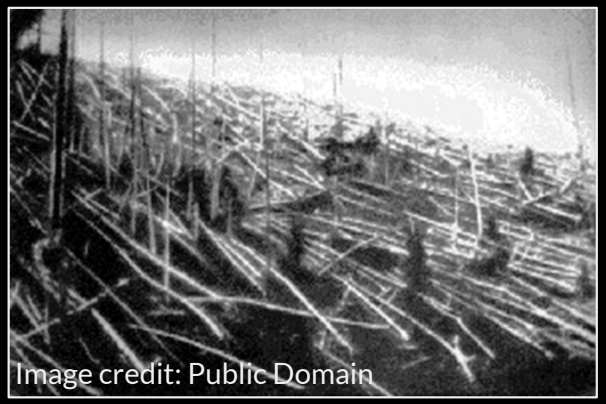

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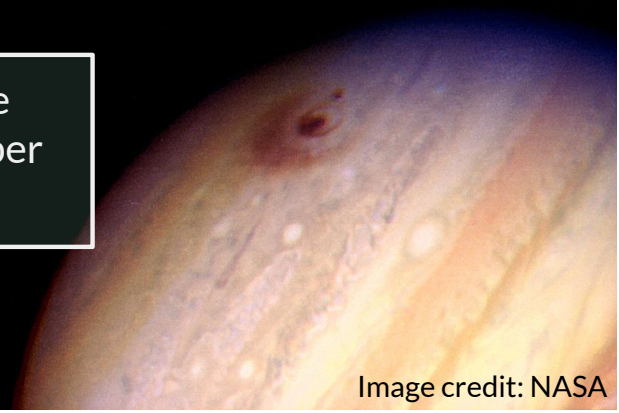
Modern estimates suggests airburst-scale meteors occur ~tens to hundreds of times per year on Earth! (Brown+ 2002)



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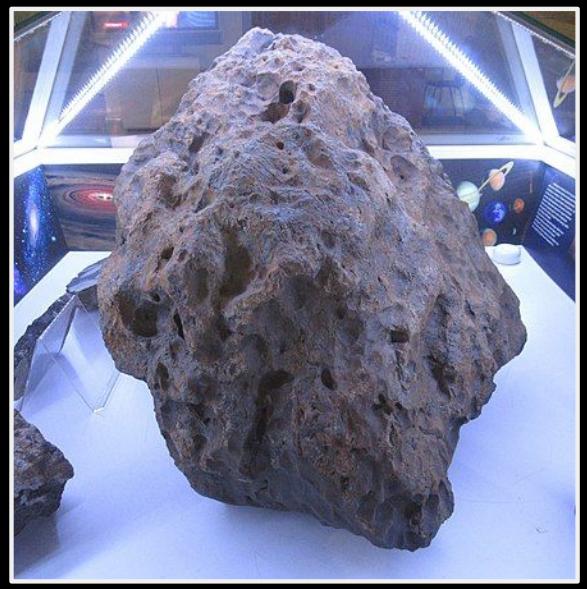
Goal: Relate breakup heights to hand samples



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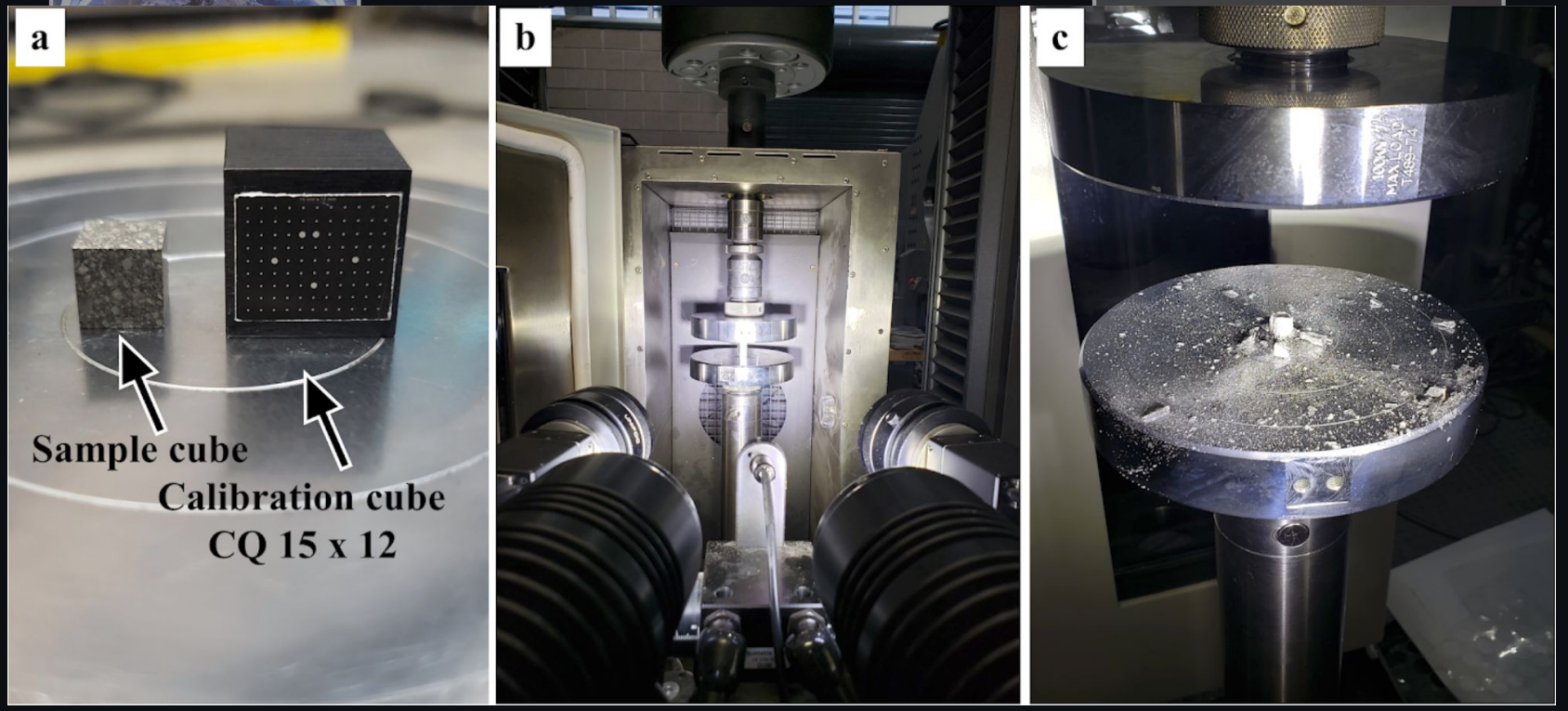

Image credit: Md Fazle Rabbi et al. (submitted)

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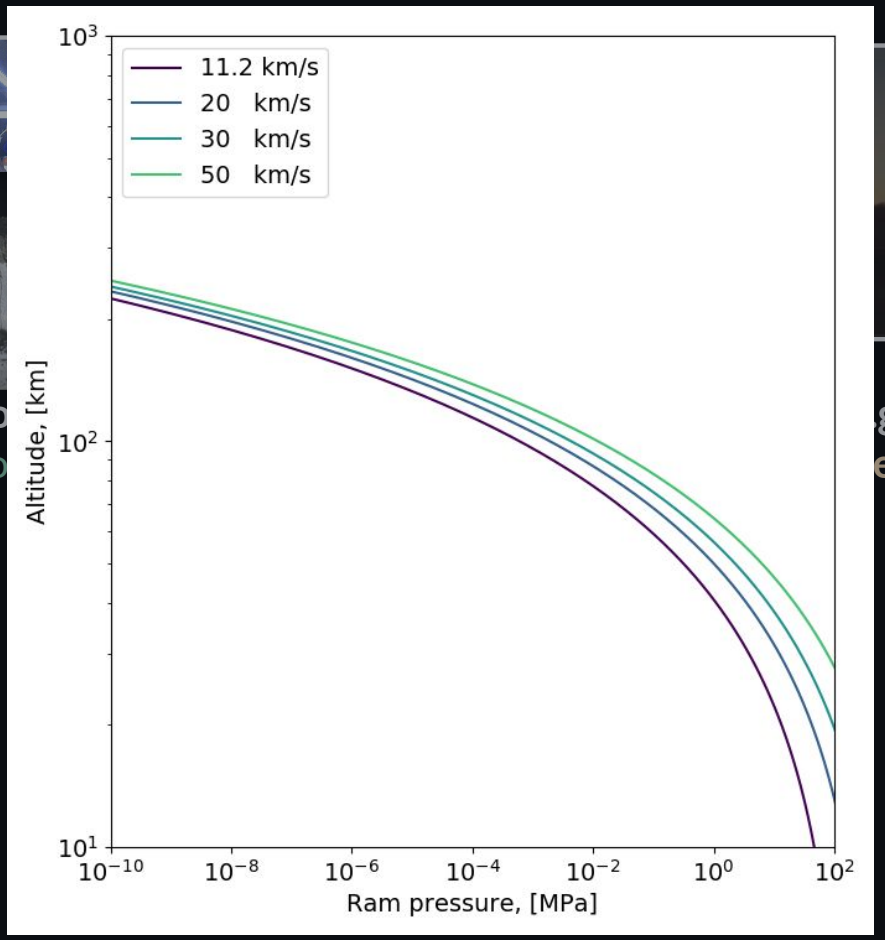

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- Airburst height (pro estimate

Image credit: T.S.J. Gabriel+ PDC 2021

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From these calculations, meteors seem to be much more weak than their meteorite counterparts!
(Ceplecha+ (1996), Borovicka+ (1998), Petrovic (2001), and many others…)

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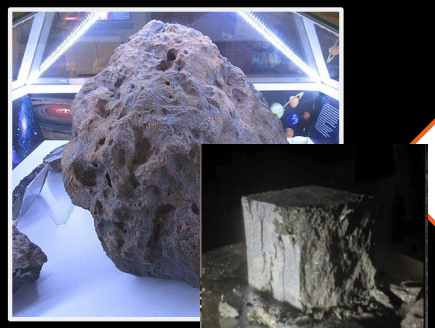
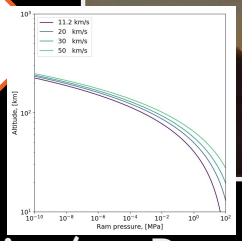


Weibull theory



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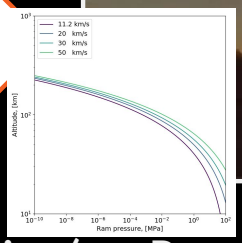

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We aim to measure Weibull parameters to help explain and model meteor breakup.

Weibull theory seems to work!

The flaw distributions at small scales extrapolated nicely to large scales, in agreement with inferred strengths from airbursts.

We now have new data from Aba Panu (L3)!

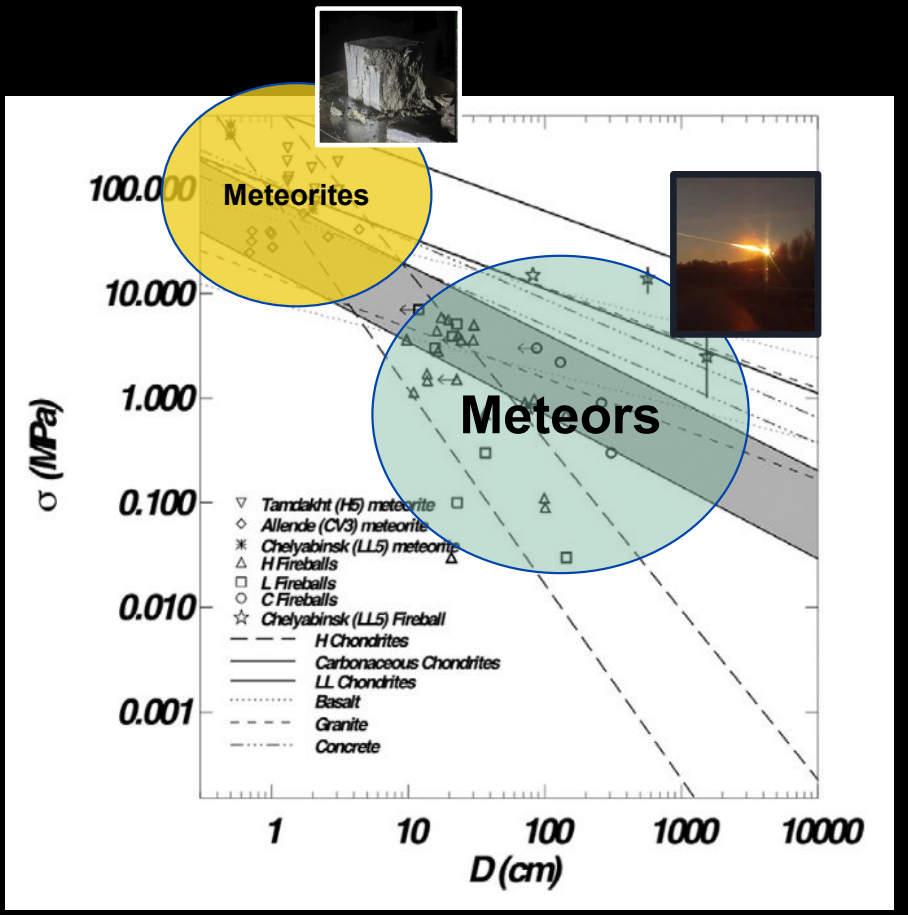


Image credit: Cotto-Figueroa+ (2016)

Results for Aba Panu (L3)

Meteorite	Bulk Modulus (GPa)	Shear Modulus (GPa)	Elastic Modulus (GPa)	Bulk Density (g/cm^3)	Porosity (%)	Weibull modulus, m	Compressive strength, MPa
Tamdakht (H5)	11.2	8.8	19.2	3.5	9.5*	1.7	~25-250
Allende (CV3)	6.1	7.8	15.6	2.9	23*	4.5	~24-58
Aba Panu (L3)	**31.3**	**26.5**	**55.5**	**3.4**	**3.8**	**5.9**	**~261-578**

*Flynn et al., 2018

Cotto-Figueroa+ (2016)
Md Fazle Rabbi+ (submitted)

Weak & heterogeneous

Weak & homogenous (& porous)

Strong & homogeneous

Image credit: Woreczko Jan & Wadi

Image credit: Cotto-Figueroa+ EPSC/DPS 2019

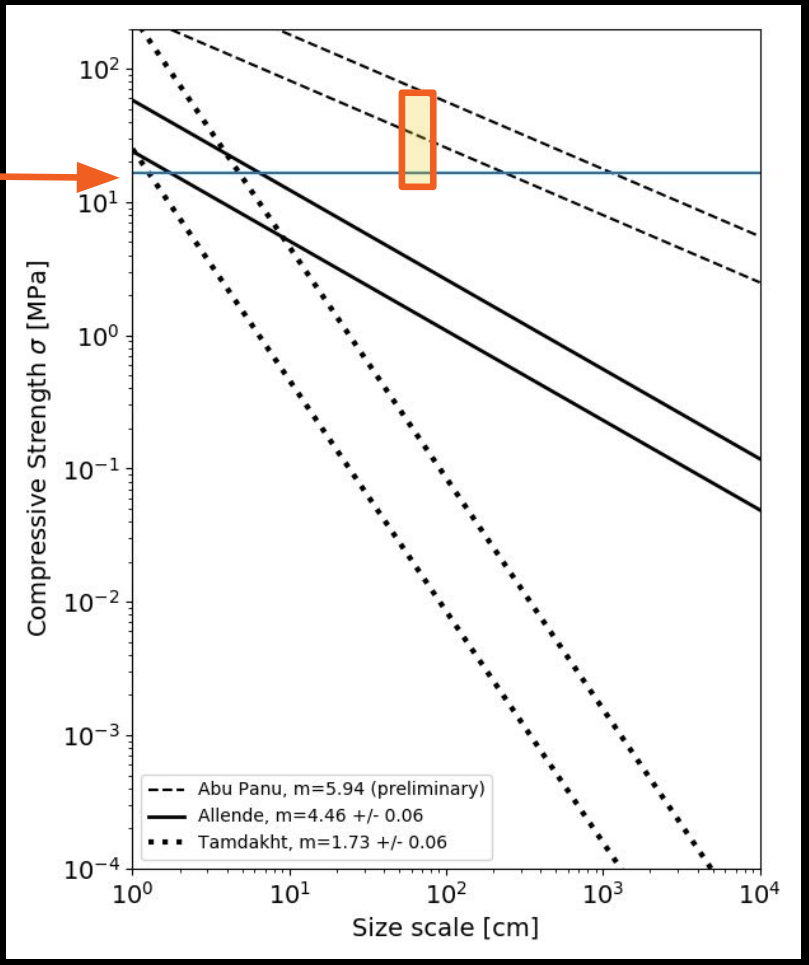
Results for Aba Panu (L3) seems consistent with breakup altitude and imperfect sampling.

Ram pressure estimates predict a slightly weaker compressive strength than predicted by Weibull.

However…

- Accounting for vaporization and imperfect sampling readily accounts for this difference.

This suggests the Weibull assumption used throughout the impact modelling community should be robust **assuming appropriate material parameters!**



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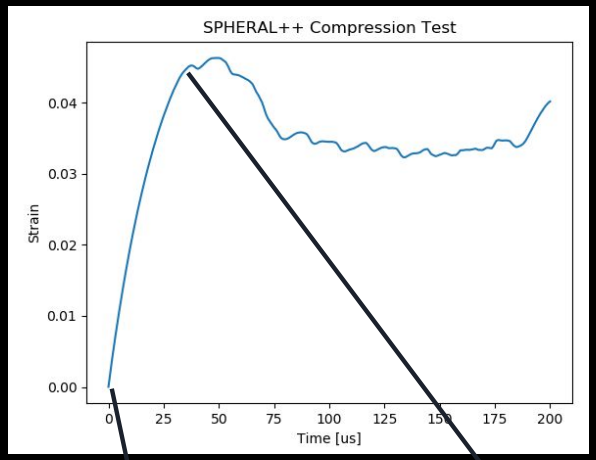
Using the SPHERAL++ tool developed at LLNL, we're starting to perform compression test validation and eventual full-scale simulation.



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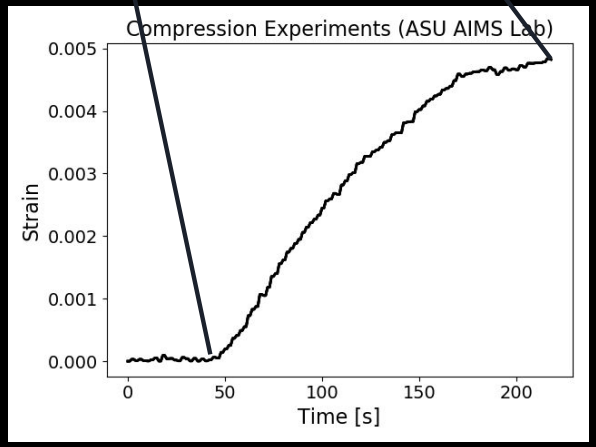

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Thank you!

Acknowledgements

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