ON THE SHOCK BEHAVIOUR AND RESPONSE OF *OVIS ARIES* VERTEBRAE

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Introduction

When investigating a biological system during shock loading, it is best practice to isolate different components to fully comprehend each individual part [1,2] before building up the system as a whole. Due to the high acoustic impedance of bone in comparison to other biological tissues [3] the majority of the shock will be transmitted into this medium, and as such can cause large amounts of damage to other parts of the body potentially away from the impact area.

Methods

One-dimensional shock waves were induced by a single stage light gas gun was employed, as detailed in [1,2]. To monitor the profile of the shock wave manganin pressure gauges on both the front and rear surface were employed as in [1] and [2] with calibration of the gauges following the methodology by Rosenberg *et al.* [4].

Results

Table 1 displays the data obtained from the experiment on the vertebrae for the *Ovis aries*. This is plotted graphically in Figure 1, with additional data for a synthetic bone simulant known as Synbone®[5]; and scapula also for *Ovis aries* for comparative purposes.

Particle Velocity (u_p) mm/µs	Shock Velocity (U_S) mm/µs	Pressure GPa
0.38	2.17	1.25
0.46	2.13	2.00
0.56	2.28	2.60
0.67	2.29	3.00
0.82	2.45	No data

Table 1: Experimental data for the vertebrae of Ovis aries under shock loading.

Discussion

As can be seen in Figure 1, a linear equation of state, known as the Hugoniot is observed. This linear behavior (with different coefficients) is observed for the majority materials while under shock loading. Equation 1 is the empirically derived equation of state for the *Ovis* aries vertebrae, where U_S is the shock velocity and u_p is the particle velocity.

$$U_S = 1.87 + 0.67u_p \qquad (1)$$

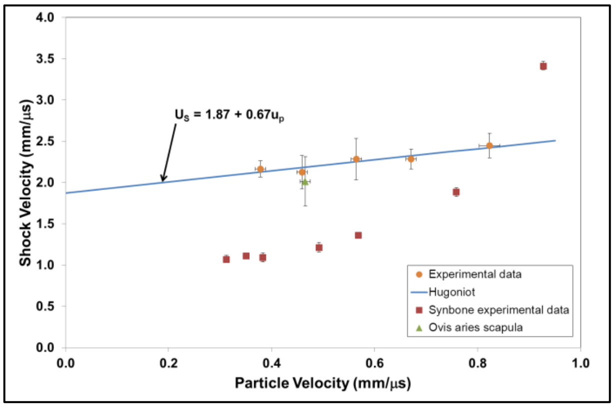

Figure 1: Hugoniot in the shock velocity-particle velocity plane for Ovis aries vertebrae, with comparisons of Ovis aries scapula and Synbone®.

A single experimental data point for *Ovis aries* scapula is also shown on Figure 1, and is found to agree well with the obtained data for the vertebrae. This implies, with the caveat of a limited data set, that at least for these two types of bones from the same species, that the shock response is similar. By contrast the data for a synthetic bone simulant known as Synbone® (also included in Figure 1) was found to be substantially different in its shock behavior, when compared to the bone from *Ovis aries*. The behavior Synbone® exhibits has a two-tiered response, due to its porous nature. This would mean that for dynamic based events (*e.g.* blast loading) Synbone® is not an appropriate simulant. Another key difference between the *Ovis aries* vertebrae and Synbone® is the lack the need to use a porous compaction model in the former case [5] to describe the shock equation of state. Comparable behavior was also seen in the pressure-particle velocity plane, which is not displayed here due to space.

References

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Acknowledgements

The author's would like to thank Andrew Roberts for his assistance on the experiments conducted as part of this project.