# IMPACT-GENERATED STRESS WAVES AND SPALL IN WATER

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Experiments have been conducted to investigate stress waveforms due to impact onto water as a preliminary analysis tool to the understanding of spallation in rock targets. The use of water allows photographic visualization of shockwave shapes including regions of tension which produce cavitation. A Barr and Stroud framing camera operating at one million pictures/sec was used to photograph the impact of an aluminum projectile onto water. The technique has previously been used successfully to photograph explosive charges detonated in water [5]. Melosh [4] has proposed a simpfied mathematical model based upon the superposition of a stress wave reflected from the free surface with the direct compressive wave eminating from the source. The inspiration for his model was experimental evidence showing surface spall of water from buried charges [1]. Figure 1 shows a sequence from such a surface reflection of a stress wave from a buried explosive photgraphed with the Barr and Stroud camera. The tensile reflection produces small cavitation bubbles which deflect the backlighting darkening the image of the spalled region. Figure 2 is a series of photographs produced in the same manner for the impact of a 0.07-gm aluminum cylindrical impactor of diameter 0.32 cm and length 0.32 cm traveling at 3.4 km/sec. A significant difference between the buried explosive and the impact event is the inclination of the shock wavefront with the free surface, which is a requirement for tensile reflection. The wavefront for the impact event is seen to be almost normal to the surface although there does seem to be some curvature very close to the surface. From the first few shots that have been made using this technique, no evidence of cavitation (spall) was observed. This may be due to the very small spall depths expected [2], which are are not resolved or to possible time dependency of spall. In addition to enhancing the resolution of the shock wave photographs, carbon foil gauges are being used to measure stress history and arrival time. Comparison of these results with CSQ calculations for a 5 km/sec impact onto water is given in reference [3].

[1] Cole, Underwater explosions (1948) [2] Holsapple and Choe, LPSC XVIII, p 431 (1987) [3] Holsapple and Choe, these proceedings (1988) [4] Melosh, *Icarus 59*, p 234 (1984) [5] Schmidt and Voss, Shock measurement and visualization in water, *ASME Publication AMD-Vol. 83*, p 51(1987).

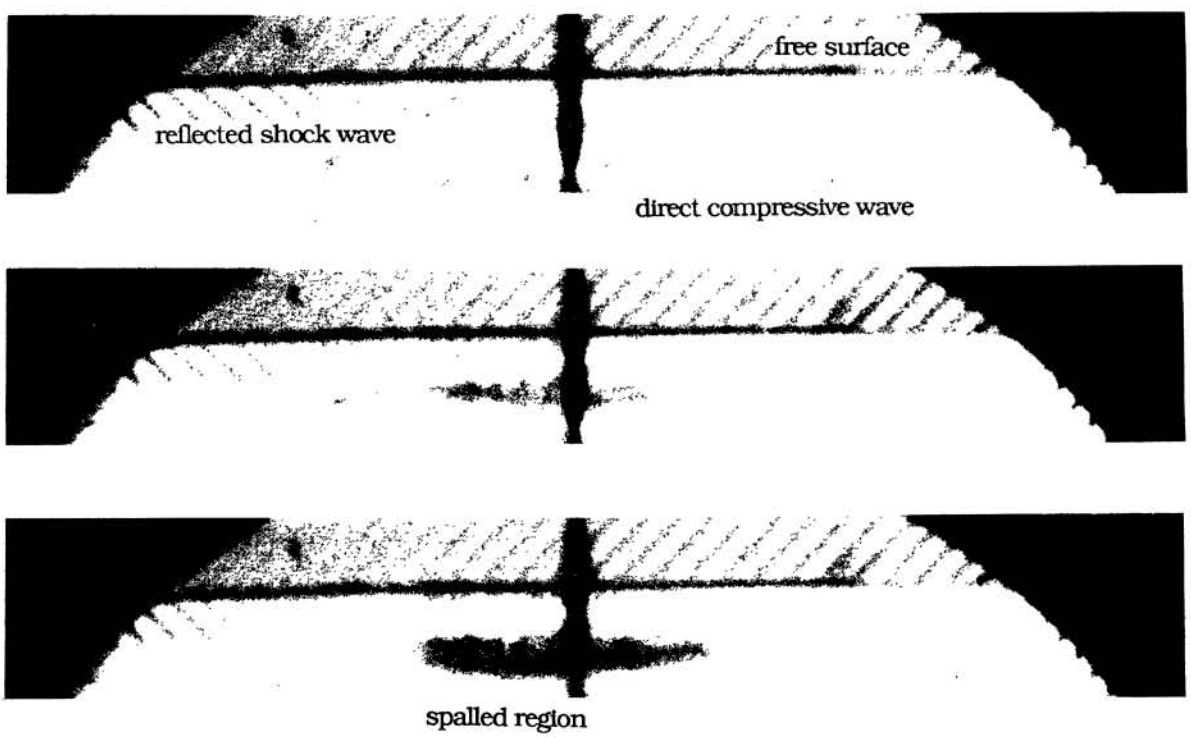


**Fig. 1. Spallation in water due to the shockwave reflection from a buried explosive charge.**

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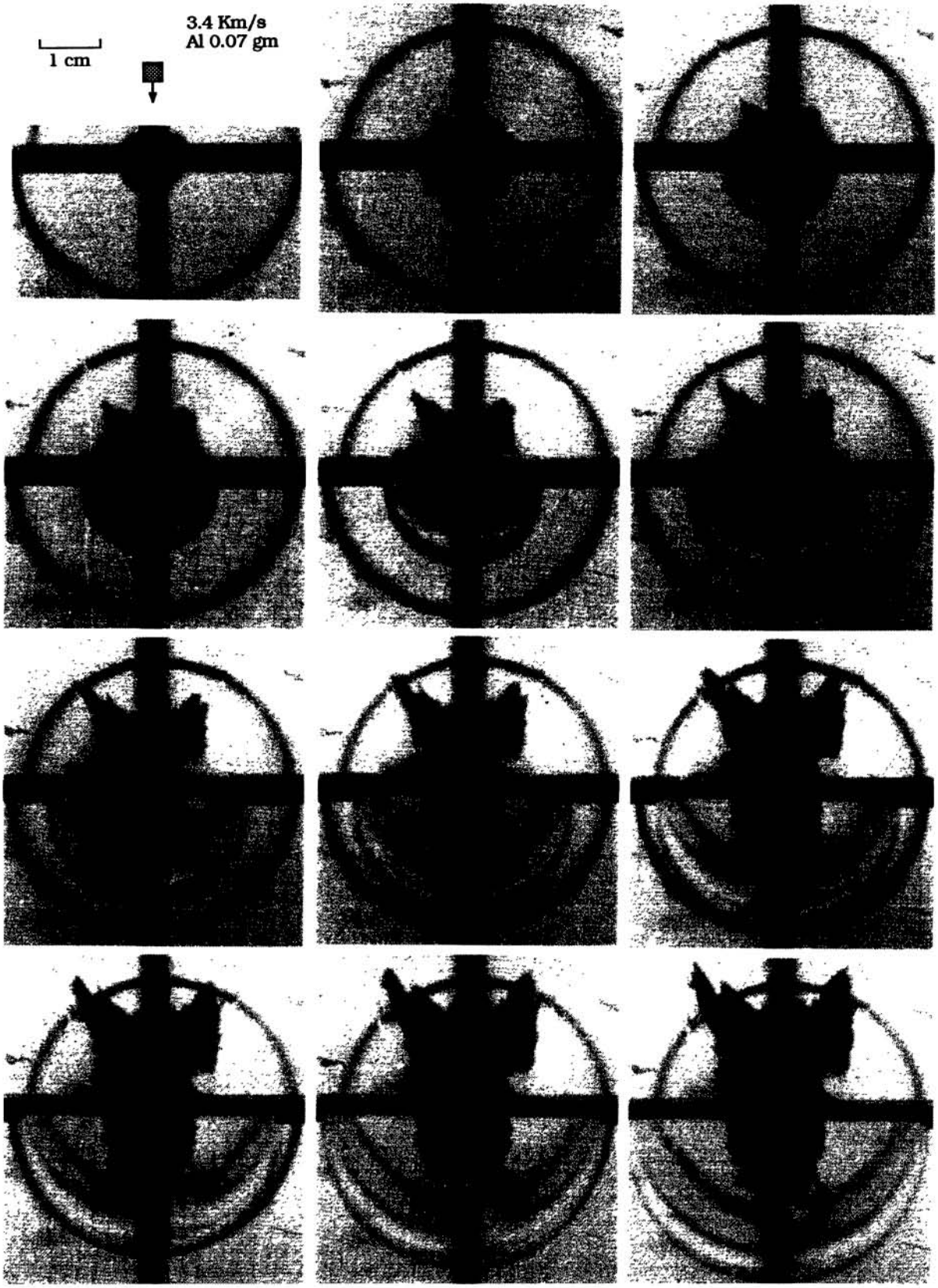


**Fig. 2. Shock wave shape and propagation in water due to a 3.4 km/sec aluminum impactor.**