

Evaluation of protection systems for the lower extremity against the shock and blast effects resulting from anti-personnel mines using the Surrogate Lower Leg (SLL)

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THE THREAT OF ANTI-PERSONNEL LANDMINES, ERW AND CLUSTER SUBMUNITIONS

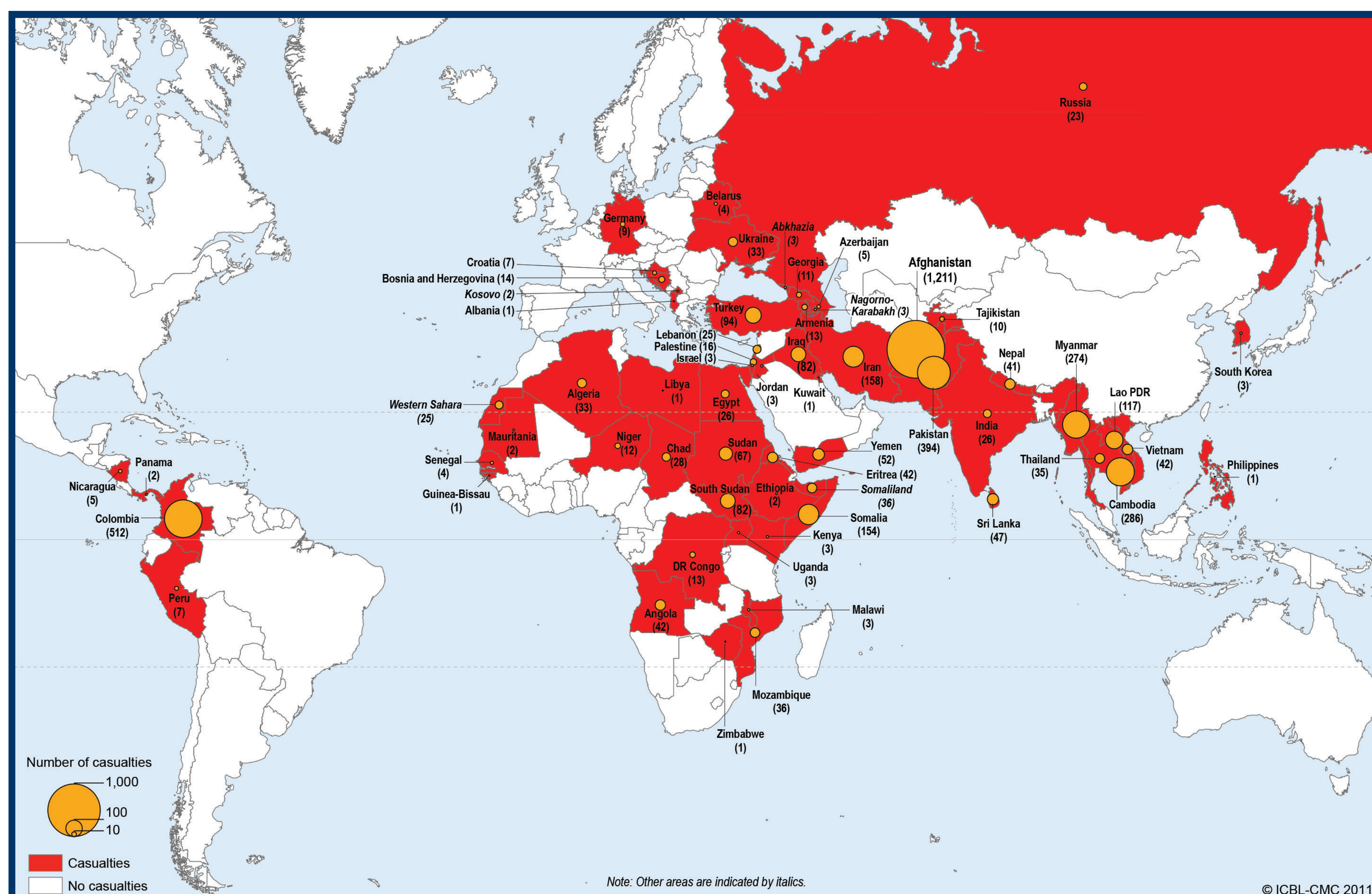


Figure 1: Mine, Explosive Remnants of War (ERW) and Cluster Submunition Casualties in 2010^[1]

The International Campaign to Ban Landmines (ICBL) stated that even though the Mine Ban Treaty has 160 signatory parties, three countries are still actively laying antipersonnel mines, while twelve countries have been identified as active antipersonnel mine producers. As of August 2011, twenty countries within the African continent remain mine affected.

QUANTIFYING INJURY CRITERIA

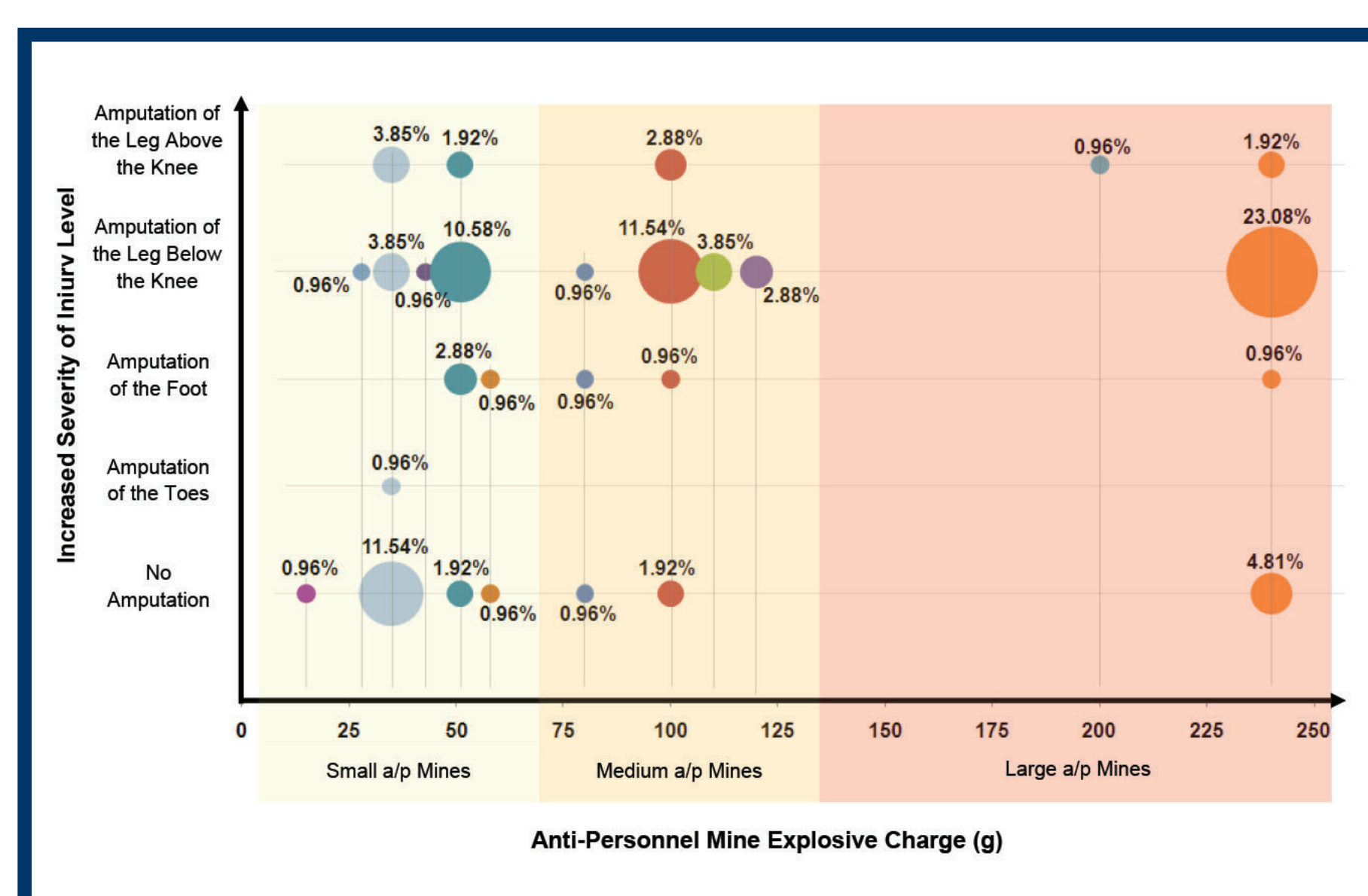


Figure 2: Anti-personnel injury level severity and injury percentage occurrence as a function of antipersonnel mine charge mass.^[2]

The Demining Accidents Database (A. Smith, 2009) houses a detailed record collection of 104 anti-personnel landmine incidents where victims stepped on mines. The data are summarised in Figure 2 above. Table 1 illustrates the Mine Trauma Scoring system developed during the Lower Extremity Assessment Program (LEAP) in order to categorise landmine injuries.

Injury assessment	Mine trauma score	Injury
No major injury	0	
Salvageable limb	1	Closed
	1A	Open contained
	1B	Open contaminated
Transibial amputation	2	Closed
	2A	Open contained
Transibial/transfemoral amputation	2B	Open contaminated
	3	
Transfemoral amputation	4	

SURROGATE LOWER LEG DEVELOPMENT

The Surrogate Lower Leg (SLL) approximates an actual human leg in terms of geometry and materials of construction. The SLL is intended for destructive testing in order to assess the degree of tissue and bone damage sustained, as well as estimating the level of amputation.

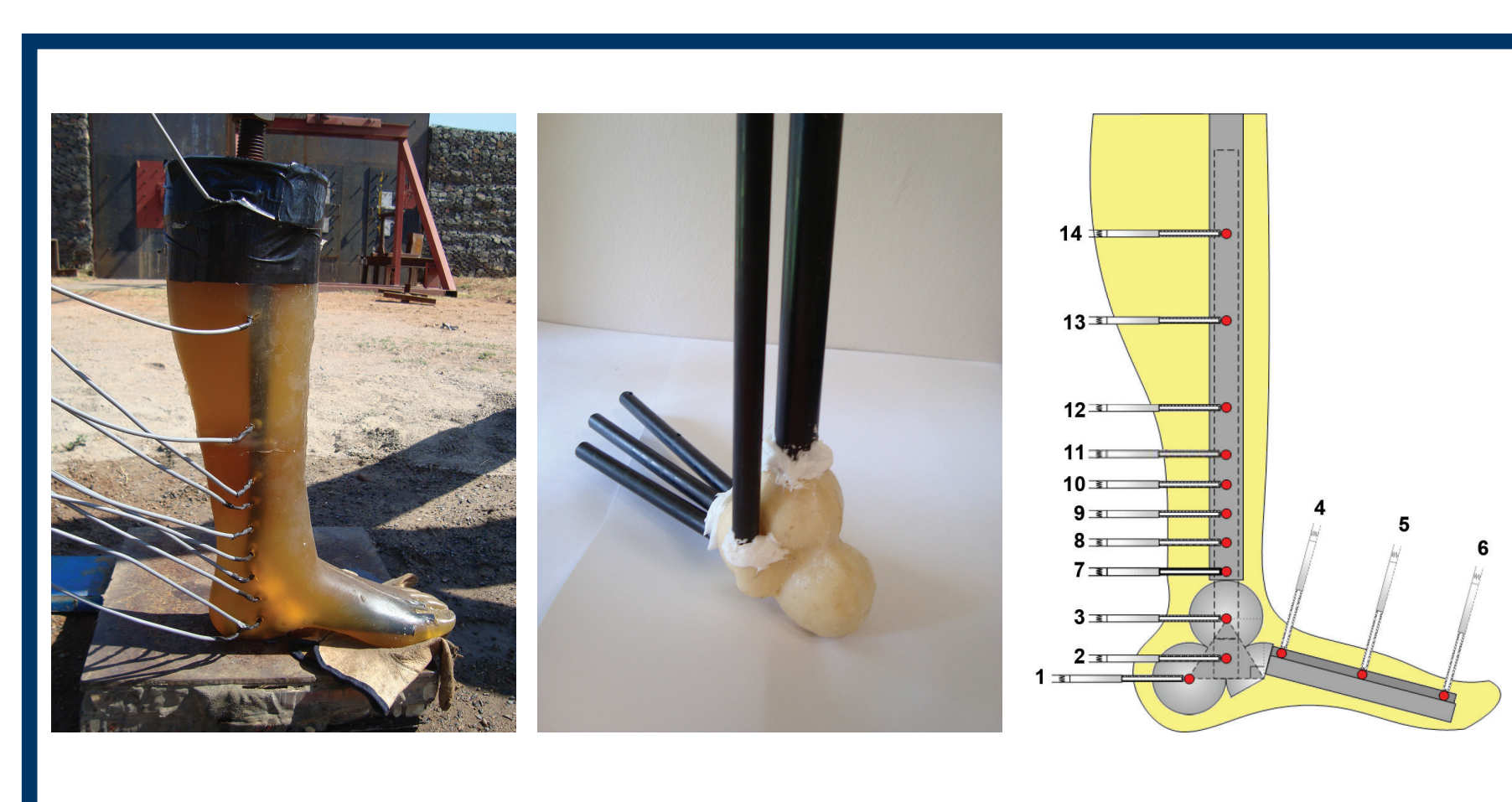


Figure 3: The Surrogate Lower Leg

EXPERIMENTAL TESTING & EVALUATION

The sequence of events that occur during blast testing is shown in Figure 4. Protective footwear may be evaluated against small (50 g), medium (100 g) or large (200 g) anti-personnel charges. To assess the amount of protection rendered by footwear, zero protection levels have been established for small, medium and large anti-personnel mine charges (Figure 5).

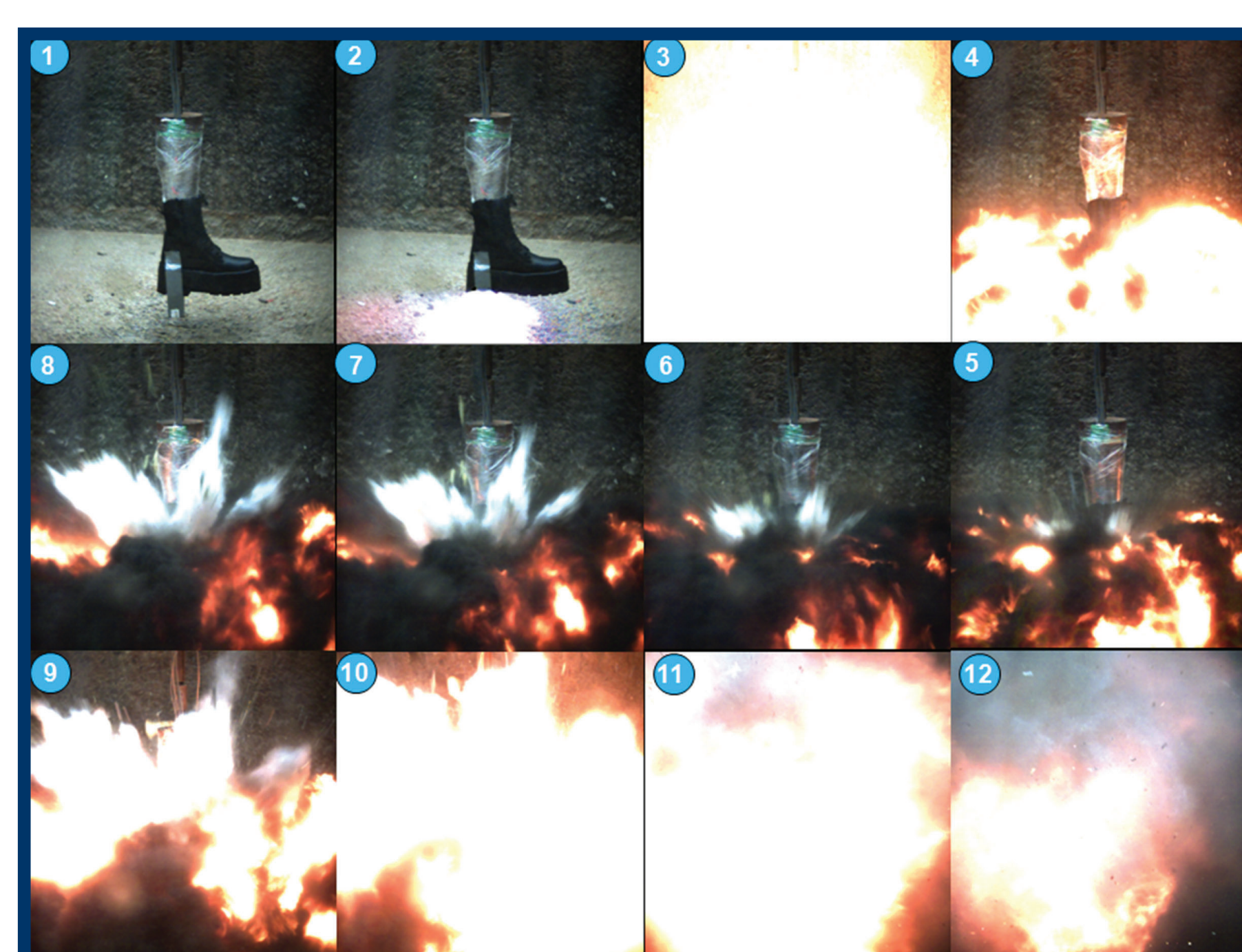
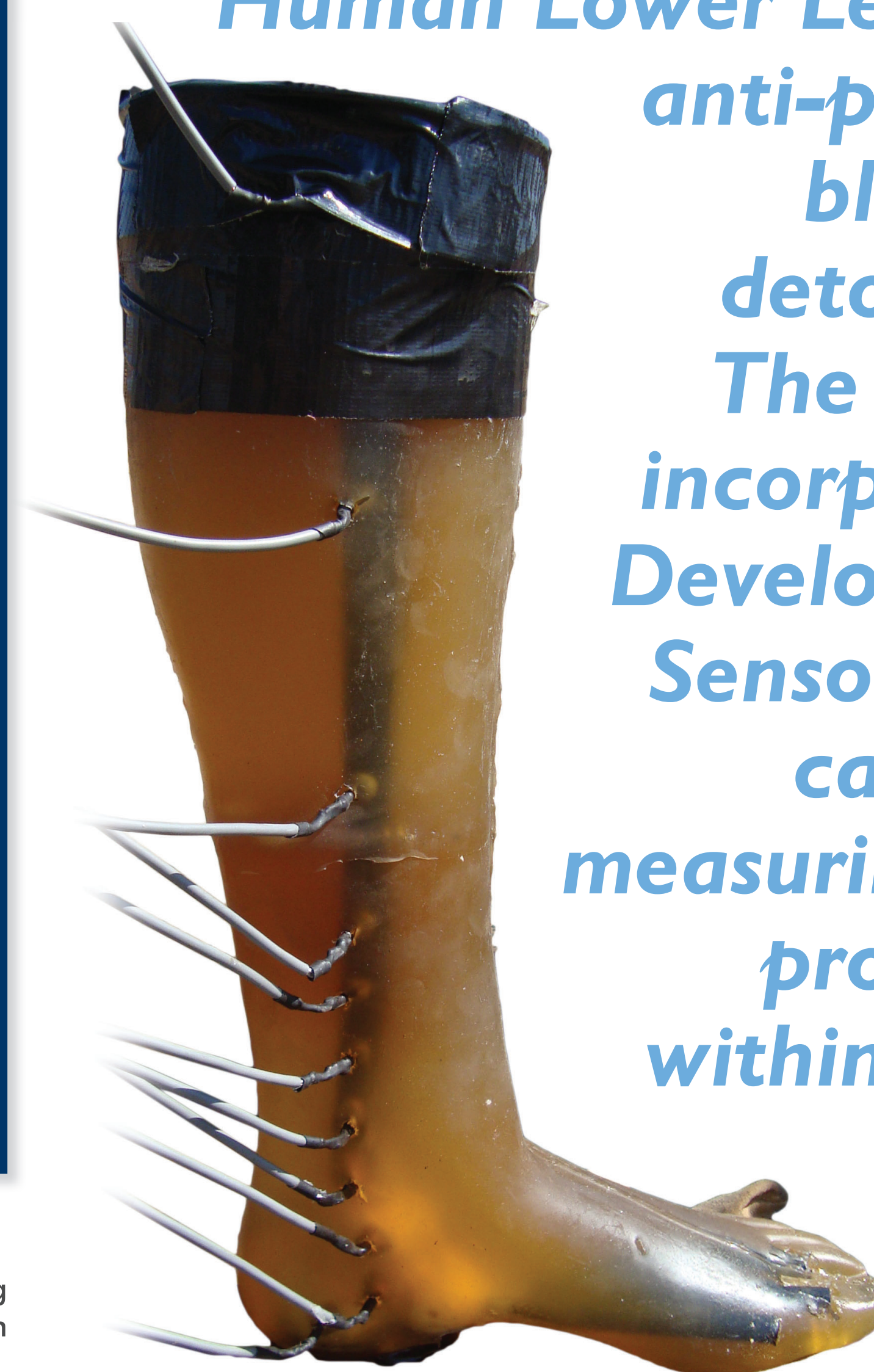


Figure 4: Sequence of explosive testing conducted with the SLL

The Surrogate Lower Leg (SLL) accurately represents the behaviour of the Human Lower Leg during anti-personnel blast mine detonations. The SLL also incorporates a Developmental Sensor System capable of measuring shock progression within the SLL during mine events.



POST-BLAST ANALYSIS

The zero protection levels for small, medium and large anti-personnel mine charges are shown in Figure 5. Small a/p mines usually result in the partial or entire loss of the heel portion of the foot. Medium to large a/p mines often result in the entire loss of the foot and ankle. The Mine Trauma Score for small, medium and large a/p mines are evaluated as 2B, 2B and 3 respectively. The SLL is in good agreement with the injury criteria reported in Figure 2.

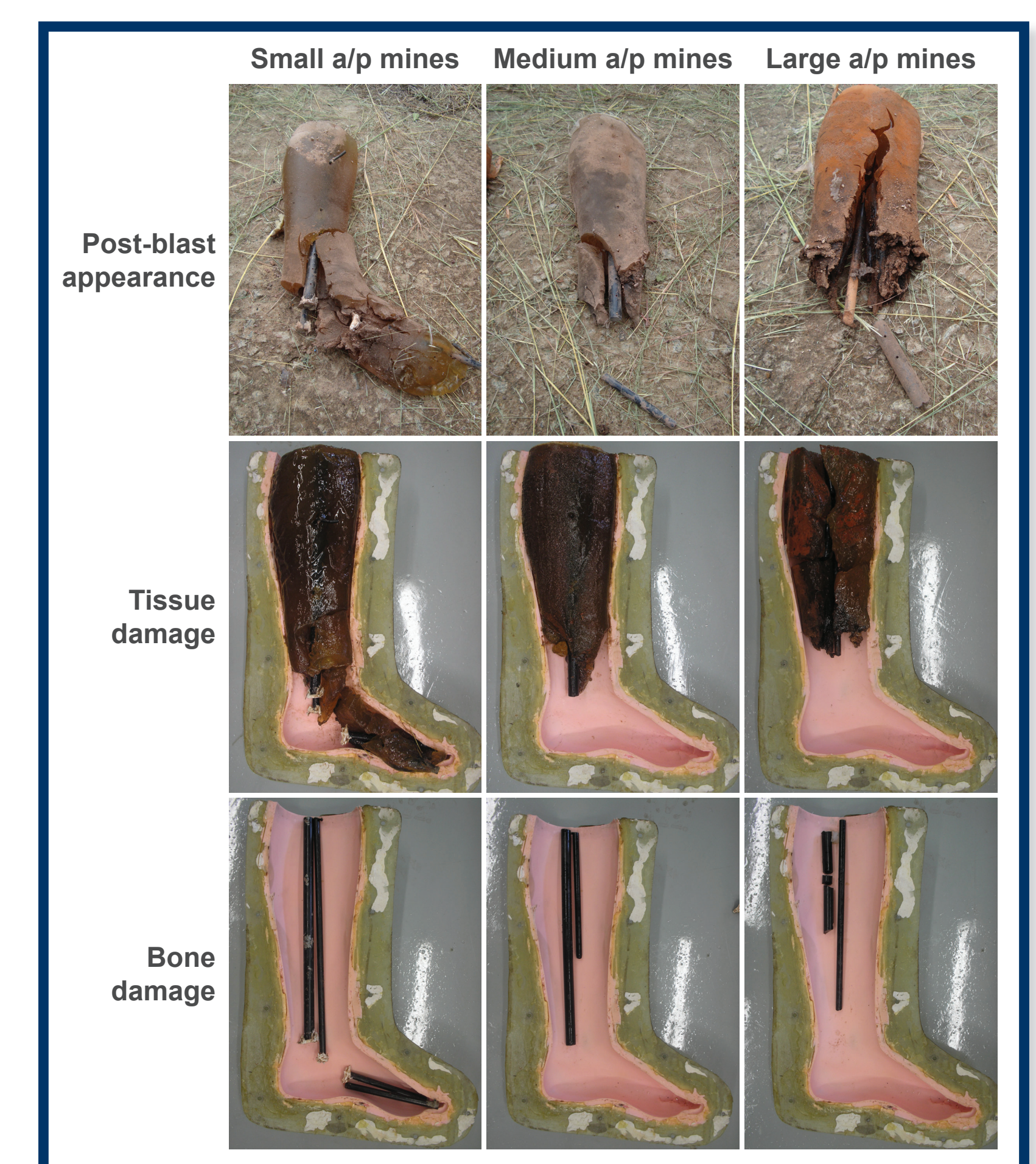


Figure 5: Post-blast autopsy results of the SLL for small, medium and large a/p landmine detonations

REFERENCES

- [1] Landmine Cluster and Munition Monitor, (2010). "Mine, Explosive Remnants of War (ERW) and Cluster Submunition Casualties in 2010". Available from: <http://www.the-monitor.org/index.php/publications/display?url=cmm/2011/maps/casualties.html>
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- [3] Harris R., Rountree M., Griffin L., Hayda R., Bice T., Mannion S., (2000). "Final Report of the Lower Extremity Assessment Program (LEAP 99-2)". U.S. Army Institute of Surgical Research Extremity Trauma Study Branch, Fort Sam Houston, Texas.