# Underwater Explosion (Part II)

## 4 Shallow underwater explosion

In shallow water, the pressure field in the water is usually complicated by reflections from the surface and bottom. The resultant pressures observed is a superposition of the direct and reflected waves.

Problem: Figure 1 sketches a 100 kiloton underwater nuclear explosion (2 seconds after the detonation). Is this a shallow, or deep, underwater explosion?

Solution:

Unit exchanges:

1ton = 2000 lb

1mile = 5280 ft

The yield of the explosive is

100 kiloton = $2\times10^8$ lb of TNT.

Therefore, $W = 2\times10^8$.

In Figure 1, the explosive is placed about

0.1 mile = 528 ft

under the water level. Therefore, $d = 528$.

Since

$$\frac{d}{W^{1/3}} = \frac{528}{\left(2\times10^8\right)^{1/3}} = 0.9,$$

This can be treated as a shallow underwater explosion.

Below are the phenomenon observed 2 seconds after the detonation of a shallow underwater nuclear explosion.

- In a shallow underwater explosion, a bubble of intensely hot gases and steam is formed which will burst through the surface after detonation. As a result, a hollow column of water is shot upward. In Figure 1 the plume reaches a height of over 5,000 feet in 2 seconds.
- The gaseous bomb residues are then vented through the hollow central portion of the water column.
- The shock (or pressure) wave produced in the water by the explosion travels outward at high speed. In Figure 1, the shock wave has propagated more than 2 miles at the end of 2 seconds.
- The expansion of the hot gas and steam bubble also results in the formation of a shock (or blast) wave in the air. This air blast moves less rapidly than the shock wave in water. In Figure 1, the front is some 0.8 mile from surface zero.
- Soon after the air blast wave has passed, a dome-shaped cloud of condensed water droplets, called the condensation cloud, may form for a second or two.

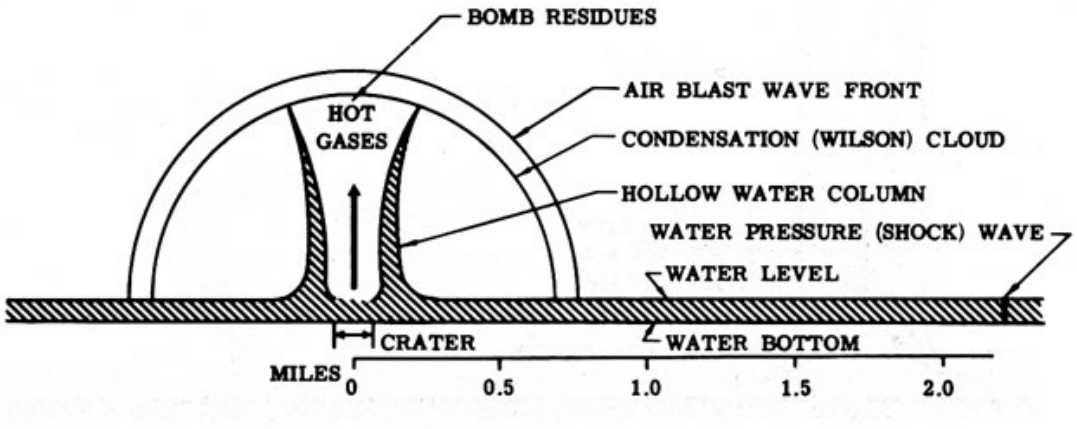


Figure 1. A shallow underwater nuclear explosion 2 seconds after the detonation (from Glasstone, 1964).

## *Some phenomena*

**Crater**

In shallow underwater explosions, the crater formed at the water's surface is large in comparison with the depth of the explosion.

**Plume**

Plume is a hollow column of water, as shown in Figure 1.

An explosion or gas bubble is formed when an underwater explosion takes place. Due to inertia, this bubble will over-expand and thereafter collapse. If this collapse takes place near a free water surface, the high-speed jet will then be directed away from the free surface and a water plume will be formed on the surface.

**Spray dome**
A mound of water and spray, called the spray dome, formed at the water's surface which became more columnar as it rose.

In Figure 2, a 20 kiloton warhead was detonated in a lagoon which was approximately 200 feet (60 m) deep.

Since

$$d = 200$$

$$W = 20\times10^3\times2200$$

So

$$\frac{d}{W^{1/3}} = \frac{200}{\left(20\times10^3\times2200\right)^{1/3}} = 0.57$$

Therefore, this is a shallow underwater explosion.

Figure 2. An example of a shallow underwater explosion. (from wikipedia)

## References

Glasstone, S. (1964) The Effects of Nuclear Weapons, USAEC, Washington, DC.