

to the amounts shown in the right-hand drawing. The amount of radioactivity released is relatively independent of the explosion size. These fallout patterns indicated the dose of external gamma radiation a person living outdoors for a lifetime could receive at the specified distances from the excavation. For comparison, the average external gamma dose that a person in the United States receives from natural sources of radiation is about 0.1 roentgen per year.

Two other safety hazards in cratering explosions are the seismic shock and the characteristic acoustic wave. Projects must be located some distance from built-up areas to avoid structural damage from seismic motion. The acoustic wave is an *air blast* that can cause structural damage close to the explosion and sometimes more distantly when the acoustic waves become focused by atmospheric conditions.

Radioactivity, seismic shock, and acoustic waves tend to limit applications of peaceful nuclear explosions, but, fortunately, as will be noted next, construction projects suited best for nuclear excavation tend to be located naturally in sparsely populated areas.

Excavation applications

Geography has often tantalized man by forcing him to travel long sea routes because he was cut off from his destination by a narrow ribbon of intervening land such as the Isthmus of Panama or the Isthmus of Suez. The first breaching of one of these major obstacles, the Suez Canal, required 10 years to build not quite 100 years ago. The Panama Canal also required 10 years to build, excluding a 9-year false start, and was opened about 50 years ago. The Panama Canal required a complex lock system and was the engineering marvel of its time, but, in the 54 years since it opened, the Panama Canal has become inadequate. Many ships are now too large for the locks, and ship traffic exceeds the capacity of the canal. Ships are often delayed, waiting their turn to make the tedious single-lane crossing through the locks. A sea-level canal with no locks, wide and deep enough to permit two-way traffic for the largest ships across the American isthmus, would solve the problem. Such a solution may be possible with peaceful nuclear explosions. Preliminary studies indicate that such a gigantic construction project might be completed in possibly three-years construction time at a cost possibly less than one billion dollars.

Certainly the number of such grand canals to connect oceans is limited, but one need only look at a map to envision numerous possible