

cost exceeds the value of the copper in the deposits. The large low-grade deposits are suitable projects for nuclear fracturing. Fracturing of such deposits with a nuclear explosive would permit circulation of dissolving solutions through the rock and recovery of the copper at a cost estimated to be lower than by conventional methods which require mining, concentrating, smelting, and refining. This technique could double the U. S. copper supply.

Still another concept for underground nuclear explosions, from a group of coal engineers, is to gasify thick beds of low-grade coal in a 100-square-mile area of Wyoming.

### *Development and management of water resources*

The rubble-filled chimney formed by a nuclear explosion might help develop and manage groundwater. The voids within the chimney would provide storage space for water equivalent to about 3 million gallons per kiloton of explosive yield. This space, if formed in rocks of low porosity and permeability, could store water in areas of special need, such as arid or permafrost regions and certain ocean islands. This would avoid the loss of water by evaporation which occurs in surface reservoirs. Similar nuclear chimneys could also serve as reservoirs to dispose of various types of liquid waste.

Because a rubble chimney is extremely permeable, it might also be located to create a conduit between aquifers (Figure 10). In addition, a rubble chimney might also breach partitions of a compartmented aquifer system or act as a well of very large diameter. In these applications, the purpose would be to increase the potential yield of a naturally occurring aquifer system.

### *Scientific applications*

In addition to the possible uses of nuclear explosives for various excavation and deep underground purposes the nuclear explosion has become a unique research tool that provides an extremely intense source of heat, pressure, electromagnetic radiation, radioactive isotopes, plasmas, neutrons, and subatomic particles—undoubtedly some of which are, as yet, undiscovered—a source that is far beyond the reach of the conventional scientific laboratory.