How a middling quake made a giant tsunami

As residents of Papua New Guinea combed its north shore for more victims of the July 17 tsunami, scientists around the world struggled to explain how a strong—but not terribly large—earthquake could have spawned waves reaching at least 7 meters high.

"It's a mystery why the waves were so big," says Costas E. Synolakis, a hydrodynamic engineer at the University of Southern California in Los Angeles and a member of a postdisaster team now searching for clues in Papua New Guinea.

Part of the explanation may emerge from seismological studies of the earthquake. Preliminary analyses suggest that it may have been a shallow quake and unusually sluggish in its development, factors known to boost the power of tsunamis.

The July 17 disaster began when an earthquake rocked the north coast of Papua New Guinea near its border with Indonesia. Because no seismometers were stationed close to the event, researchers have had trouble pinpointing the quake's exact location. Although the USGS' National Earthquake Information Center in Golden, Colo., placed the epicenter onshore, four other teams concluded that it occurred offshore, within 19 to 32 kilometers of the coast, says Stuart Weinstein, a geophysicist at the Pacific Tsunami Warning Center in Ewa Beach, Hawaii.

Harvard researchers calculated that the quake had a magnitude of 7.1 and originated at a depth of 15 km. Earthquakes of that size usually don't produce major ocean waves, but "it was a pretty shallow earthquake. That would certainly help generate a large tsunami," says Weinstein.

A quake that starts close to the ocean floor can raise or lower the sea bottom much farther than a deeply buried quake. This displaces more water and spawns larger waves.

Tsunamis bear little resemblance to the breaking waves familiar to beachgoers and surfers. Moving unobtrusively through the open ocean at speeds of about 800 km per hour, tsunamis hit the coastline like an instantly rising tide, says Synolakis.

In 1992, an initially unimpressive earthquake unleashed a series of giant waves that devastated coastal Nicaragua and taught researchers new lessons about tsunamis. The earthquake produced only moderate short-period shaking—the kind that sends people flying—but released a significant amount of energy in long-period vibrations, which move the ground less rapidly. Seismologists call this a slow earthquake. The leisurely pace was especially efficient at moving water, and so it pumped up the size of the tsunami.

Andrew V. Newman of Northwestern University in Evanston, Ill., has evidence that the July earthquake off Papua New Guinea was also slower than normal. Newman compared the energy of the first seismic waves from the earthquake, which had periods of around 1 second, with the energy of those that arrived many minutes later, which had periods of around 200 seconds.

In the Nicaraguan earthquake, the first waves were quite weak, only one-hundredth the strength that would be expected in a typical quake. The initial waves from the Papua New Guinea tremor were also relatively feeble, Newman found. These early vibrations measured about one-tenth the expected strength, partway between a normal earthquake and the slow Nicaraguan event.

The recent tremor resembles one that hit off the coast of Peru in 1996, which also generated a strong tsunami, Newman says. The waves took shoreline residents by surprise because they had not felt the earthquake.

To help officials recognize slow quakes that, at first glance, might seem too small to produce dangerous waves, seismologist Emile A. Okal of Northwestern is working to incorporate into tsunami warning systems the type of frequency analysis that Newman used.

Newman cautions that his work is preliminary. Indeed, after cursory examinations of seismic data from the recent quake, other researchers find no evidence of a slow character. More details will surface after Synolakis and his colleagues return from the beaches swept clean by the killer waves. —*R. Monastersky*

Ring around the virus: RNA packs in the DNA

The next time you struggle to stuff your clothes into a suitcase, you may well envy the skill of viruses that infect bacteria. Known as bacteriophages, these viruses create copies of themselves by building shells of protein (SN: 7/18/98, p. 38) and then cramming their DNA inside. "If the protein shell [were] an inch in diameter, the DNA would be 14 feet long. It gets stuffed in there in a few minutes. It's amazing," marvels Dwight Anderson of the University of Minnesota in Minneapolis.

Research groups led by Anderson and by his former student, Peixuan Guo of Purdue University in West Lafayette, Ind., have now deduced the unusual shape of a key packing tool employed by some, perhaps all, bacteriophages. The instrument is a ring formed by six identical strands of ribonucleic acid, or RNA, the two groups report independently in the July MOLECULAR CELL.

While scientists know that single strands of RNA can store information or act as enzymes, they hadn't realized that they could form so complex a structure. "The circular hexamer . . . implied by these experiments is something new and exciting in the world of RNA structure," says Roger W. Hendrix of the University of Pittsburgh in a commentary in the July 24 CELL.

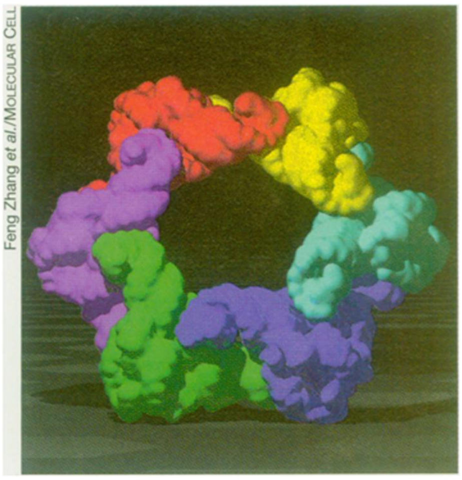
"It's the first instance in which identical subunits of RNA actually build a structure—one that does something very interesting: move DNA from the outside to the inside of a shell," says Anderson.

About a decade ago, Guo discovered that the bacteriophage phi-29 employs a short strand of RNA, dubbed packaging RNA (pRNA), to fill its empty shells with DNA. Researchers later showed that pRNA binds to a shell's connector, the ring of proteins encircling the hole in the shell where DNA goes in during packaging and comes out when the virus infects a bacterium.

While studies have indicated that phi-29 requires multiple strands of pRNA, Anderson's and Guo's groups recently found that six strands joined into a ring are both sufficient and necessary for DNA packaging. Guo's team also identified specific parts of the pRNA strand that enable it to combine with other pRNA strands.

Although this latest research doesn't resolve how phi-29's DNA packaging machinery works, researchers believe that knowing the structures of its crucial components will be invaluable. "Once you get a look at the whole machine, you can have some ideas about how it works," says Anderson.

Hendrix, for example, has theorized that a bacteriophage's DNA threads into its shell as the connector rotates like a nut around a bolt. The ring of pRNA, speculates Guo, may bring about this rotation by contracting and elongating its six strands sequentially. —*J. Travis*



Feng Zhang *et al.*/MOLECULAR CELL

A computer model of one way that six identical RNA strands can form a ring.