



SEISMOLOGY

Nepal disaster presages a coming megaquake

Rupture in quiet region of crust suggests Himalayan threat was underestimated

By Eric Hand and Priyanka Pulla

As rescuers searched for survivors of a devastating earthquake in Nepal on 25 April, geophysicists made a disturbing discovery. An initial assessment suggests that the underground rupture responsible for the magnitude-7.8 quake extended deep below the Himalayas, into a region that many scientists had deemed impervious to tearing. The unexpected extent of the rupture suggests that, as awful as the present disaster is, future earthquakes in the Himalayas could end up being mightier—and more calamitous—than modelers assumed.

The discovery “is going to radically change how we predict and interpret future and historic earthquakes,” says Roger Bilham, a geologist at the University of Colorado, Boulder. And it adds a new level of foreboding to seismologists’ conclusion that last Saturday’s event released only some of the strain that has been building in the crust beneath Nepal, raising the odds of another great earthquake in the coming decades.

The ultimate driver of Himalayan earthquakes is the slow-motion collision of the Indian subcontinent with mainland Asia, which is also pushing the mountains skyward. Some 15 kilometers below the surface, a nearly horizontal thrust fault marks the plane where the In-

dian plate is plunging beneath southern Tibet at a rate of about 18 millimeters per year. Microearthquakes—most of them too small to feel at the surface—cluster along a line that trends east to west across this plane. Most of the region’s substantial earthquakes have occurred south of the line, where the plates are locked together and strain builds up. North of this “lock line,” however, the Indian plate dives downward and the character of the rock slab changes. Under higher temperatures and rising pressures, the brittle rocks become more plastic, and they creep past the Tibetan crust without rupturing. Or so researchers had thought.

The 25 April earthquake followed an ominous new rupture path. Analyzing seismom-

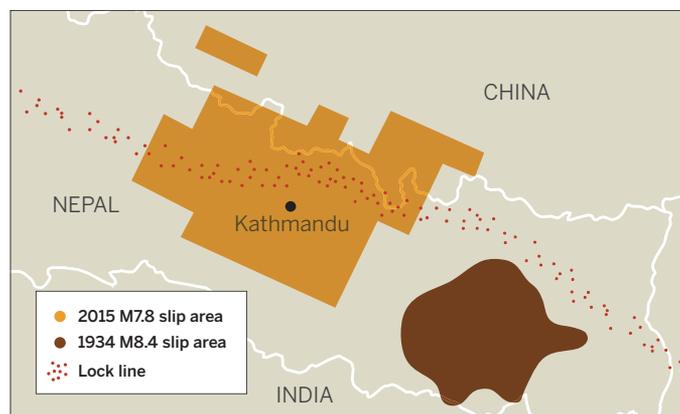
eter recordings in the immediate aftermath of the earthquake, Gavin Hayes, a geophysicist at the U.S. Geological Survey in Golden, Colorado, found that the temblor ruptured crust well north of the lock line, suggesting the potential for future quakes with a far larger rupture area than seismologists had thought possible. “We therefore have the potential for bigger earthquakes than we might have otherwise expected,” he says. The calculation will become more certain in the coming weeks, Hayes says, as he and colleagues fold in measurements of surface movements taken by satellites and GPS stations.

It will be “a big deal” if the discovery holds up, says Michael Taylor, a geologist at the University of Kansas, Lawrence. “A lot of people will be very interested in this,” he says. The find raises the specter of earthquakes as large as magnitude 9, he says—larger than any quake ever recorded in the region.

Last week’s earthquake was long overdue. The segment that ruptured hadn’t seen a quake since 1344 C.E., says Laurent Bollinger, a geologist from the French Alternative Energies and Atomic Energy Commission who has studied historical earthquakes in the region. In 1934, however, a magnitude-8.4 quake struck 150 kilometers east of Kathmandu. Bollinger notes a precedent: The 1344 quake, too, was preceded by one farther to the east, in 1255 C.E., suggesting

An alarming slip

Crust ruptured north of a “lock line” marked by microearthquakes, where rock was expected to move plastically—and quietly.



Last Saturday's earthquake buckled roads in Kathmandu.

that the latest quakes were not the first time that central Nepal has been visited by a one-two punch within a century.

A still more brutal blow could be coming. Although the Nepal quake released some of the seismic energy in the locked plates, more strain west of the 25 April epicenter must be released, Bollinger says. The timing, however, is impossible to predict, says Vinod Gaur, a geophysicist at the CSIR Fourth Paradigm Institute in Bangalore, India. "It may rupture tomorrow, or it can rupture 75 years from now," he says. Bilham says the westward quake could end up as powerful as a magnitude 8.4. "The region to the west is definitely overdue because we haven't seen one for quite some time," he says.

Even though the Nepal earthquake's epicenter was 80 kilometers northwest of Kathmandu, some of the worst shaking occurred in the densely populated capital. Situated on an ancient lakebed, the Kathmandu Valley's soil is soft and liquefies easily. "The ground motion gets amplified," says Vineet Kumar Gahalaut, a geologist at the National Geophysical Research Institute in Hyderabad, India.

Bad weather, landslides, and aftershocks are compounding the suffering caused by the original shock. Another concern is that landslides in the mountainous region may have blocked rivers, damming them to form earthquake lakes. When the dams fail, the lakes can cause catastrophic flooding downstream, says Marin Clark, a geologist at the University of Michigan, Ann Arbor. By correlating maps of ground shaking and topography, Clark has identified six areas that are at high risk for landslide dams and flooding. She is searching satellite images for signs of newborn lakes, but clouds have obscured the sites. "We're waiting for a clear view," she says.

As *Science* went to press, the earthquake's death toll had surpassed 4300. In the midst of the devastation, it was clear that the losses could have been even more horrific. Many modern buildings remained standing while historical ones tumbled into rubble, suggesting that tighter building codes and recent efforts to reinforce hospitals and schools had made a difference. The Nepal disaster "could have been much worse had engineers not sprung into action to retrofit critical facilities in Kathmandu," says Bilham, who has long sounded an alarm over the Himalayan earthquake hazard. But with an even greater threat looming, Nepal and its neighbors will have to take a hard look at their earthquake preparedness. ■

INFECTIOUS DISEASES

In Guinea, a long, difficult road to zero Ebola cases

The country could soon be the epidemic's last holdout

By Martin Enserink, in Conakry

The most striking thing about the Ebola treatment unit in the center of this West African capital is how quiet it is. When *Science* visited on 24 April, the center was home to just a single confirmed Ebola case—the only known patient in this teeming city of almost 2 million. (Four other patients at the unit were suspected cases awaiting test results.) Tents designated for family visits were empty, washing machines stood idle, and staff seemed relaxed. That's a huge shift from late December, when 55 confirmed patients crowded the small tent village, set up by Doctors Without Borders at a former

last one in January, that were invariably followed by flare-ups. From a six-story office building overlooking Conakry's rusty seaport, Keita is collaborating with multiple international partners to plot a path to zero cases.

Liberia, another country hit hard by the epidemic, appears to have accomplished that feat already; its last case—a woman assumed to have become infected through the semen of her partner, an Ebola survivor—was reported more than a month ago. The third country stricken, Sierra Leone, had only 12 cases last week.

Although the epidemic started in Guinea in late 2013, it has had far fewer cases than the other two countries: just over 3500,



An experimental Ebola vaccine produced by Merck and NewLink Genetics is currently being tested in Guinea.

parking lot of the Donka Hospital.

Guinea is where some of the last embers of West Africa's Ebola epidemic are smoldering. It had only 21 new Ebola cases in the past week, 16 of them in the city of Forécariah, a 3-hour drive from the capital. Guards at many official buildings still routinely point the Thermoflash, a contactless, revolver-shaped thermometer, at visitors' temples, and vats full of bleach are still omnipresent. But Ebola rarely makes headlines anymore, and antigovernment protests that paralyzed Conakry last week were about upcoming elections, not the virus.

Still, Guinea's Ebola czar, Sakoba Keita, notes that there have been lulls before, the

compared with more than 10,000 in Liberia and 12,000 in Sierra Leone. The 66% mortality rate, however, is far higher. And while the other two countries saw a rapid explosion followed by a steady drop in new cases, Guinea's case count has swung up and down.

Pratima Raghunathan, an epidemiologist with the U.S. Centers for Disease Control and Prevention in Atlanta who's currently supporting the Ebola effort in Guinea, notes that the virus never got out of control in Conakry the way it did in the other two capitals, Monrovia and Freetown. One reason may be that treatment centers in the Conakry region had enough beds early on, so that