cate that the rock above the boundary has a more open crystal configuration, whereas the crystals in the lower mantle are squeezed into a denser arrangement. Rocks in the upper mantle might also contain chemicals that differ from those in the lower mantle.

Shearer and Masters report that their topographic map shows broad depressions in the seismic boundary beneath plate subduction zones. The low spots measure about 1,500 kilometers across and extend as much as 30 kilometers below other parts of the boundary. The clearest depression appears northwest of the Kuril-Kamchatka region, where the Pacific plate dives under the Asian plate.

These results suggest that the sinking Pacific slab does not pass cleanly down into the lower mantle, according to the researchers. Instead, they believe, the plate bends at the boundary and moves horizontally across it, forming the depression that appears on their map.

"It's clear that there is resistance to slab penetration at the 660-kilometer boundary," Shearer says.

It is not clear, however, what happens after the slab deflects horizontally and slows its descent. The cold oceanic rock could form a thick blob that continues to sink deep into the lower mantle at a much slower rate, or it might just pile up along the boundary and remain stuck in the upper mantle.

"Its ultimate fate is still in question," says Thorne Lay, a seismologist at the University of California, Santa Cruz.

The answer has important ramifications because it indicates what kind of heat engine drives the motion of the lithospheric plates forming Earth's outer shell. If slabs sink all the way to the core, then the mantle resembles a pot of boiling soup, with hot material rising from bottom to top and cold material sinking from top to bottom. Conversely, if subducting slabs do not descend much below 660 kilometers, then the mantle would resemble a double boiler, with very little mixing across the boundary between lower and upper mantle.

While seismologists in the 1970s generally thought that subducting slabs could not make it into the lower mantle, researchers discovered seismic evidence in the late 1970s and 1980s suggesting that subducting plates in fact penetrated deep into the lower mantle. In the last few years, seismic studies have grown equivocal: Some show deep slabs, while others show deflected ones.

The data collected by Shearer and Masters provide a new approach to the perennial problem, Lay says.

"Trying to understand the deep structure of the Earth and the processes in the Earth is a formidable and challenging problem. We have better knowledge about the interior of the sun than about the interior of the Earth," he notes.

– R. Monastersky

Smokers suffer impaired bone healing

Cigarette smoking has been linked with a laundry list of ills, including heart disease and a variety of cancers. During the last 20 years, a number of research groups have demonstrated that smoking harms the body's ability to heal skin wounds. Now, for the first time, scientists have documented slower bone healing among smokers.

From November 1988 to August 1990, orthopedic surgeon George Cierny III of Emory University in Atlanta and his coworkers studied 29 men and women who suffered from osteomyelitis, a bacterial infection of the bone and bone marrow that can develop after a wound or fracture.

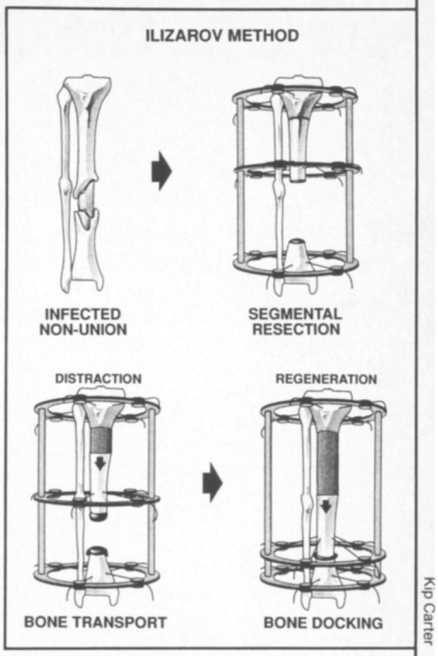
At the study's start, the researchers obtained a detailed smoking history from each participant and tested urine and blood samples for telltale markers of a smoking habit, such as cotinine, a metabolite of nicotine. Many of the recruits denied a smoking habit until their test results came back. The researchers identified nine nonsmokers, nine ex-smokers and 11 people who continued to smoke during the study.

All 29 patients underwent an operation in which surgeons cut through the skin and tissue and remove the infected segment of the tibia (shinbone). This procedure left each patient's tibia with a gap ranging from 4 to 10 centimeters in length. The surgeons then closed the incision and attached an external, circular device to the leg. This device, known as an Ilizarov apparatus, has wires that fasten to each end of the tibia, creating tension. Over time, the tension spurs one end of the tibia to regenerate, so that the bone ultimately heals.

Using X-rays to monitor bone growth, Cierny's group discovered that nonsmokers formed new bone within two months of the operation, whereas smokers showed minimal bone growth at the two-month point. Cierny presented the new findings at the annual meeting of the American Academy of Orthopaedic Surgeons, held last week in Washington, D.C.

The time from the operation until the recruits could resume normal activities ranged from eight to 18 months. When the researchers looked closely at the data, they found that smokers spent more time recuperating. On average, smokers took 2.98 months to manufacture 1 cm of new bone, while nonsmokers took 2.32 months. For nonsmokers with a 5-cm bone gap, that translates to a 10-month recuperation period, Cierny notes. For smokers, the same 5-cm gap would take 15 months to close.

"So you essentially had another half-year of disability if you were smoking during treatment," Cierny told SCIENCE NEWS.



Kip Carter

Surgery for tibial osteomyelitis: After removing the infected bone segment, surgeons attach the Ilizarov apparatus to the leg. This device puts tension on the tibia, which then starts to grow (shaded area). Finally, the two bone ends meet. New research suggests smokers who undergo this procedure can expect slower bone growth than nonsmokers.

Although ex-smokers also showed impaired bone regeneration, kicking the habit paid off: Ex-smokers took about 2.72 months to grow 1 cm of bone. Osteomyelitis patients who quit smoking before undergoing surgery can expect to recover much faster than if they continued to puff away, Cierny says.

Cigarette smoke contains thousands of harmful substances, but Cierny believes nicotine plays a key role in this drama of poor bone healing. Thomas K. Hunt of the University of California, San Francisco, agrees. In recent years, Hunt has found evidence that cigarette smoke can reduce the amount of oxygen reaching body tissues, probably through the activity of nicotine. The lack of oxygen impairs the body's ability to make collagen, a protein used to form new bone, he says.

Cierny's study demonstrates impaired bone regeneration among smokers who undergo surgery for osteomyelitis. But what about smokers who have simply broken an arm, finger or leg? Cierny believes they, too, would experience delayed healing. However, additional research must verify that suspicion, he adds. *– K.A. Fackelmann*