Old crust grows short, wide as it descends

Scientists are increasingly confident in their understanding of the formation and surface movement of oceanic crust, but some critical details of its destruction elude them. For instance, what fate befalls old crust when, cold and brittle, it dips steeply into vast submerged trenches called subduction zones, and heads back towards the earth's middle? Is movement of crustal material in the mantle—the portion of the earth between the thin upper crust and the core — confined to the uppermost of two distinct layers? Or does the slab of descending crust maintain its strength, penetrating through a boundary between the upper and lower mantle, 670 kilometers below the earth's surface?

Definitive maps of the features and movement in the mantle still are forthcoming (SN: 4/30/83, p. 280), but studies of the distribution of the deep earthquakes that mark a slab's movement are beginning to yield results. Two Harvard University scientists have described the ways in which the western edge of the Pacific crustal plate north of New Zealand is deformed as it plunges downward at a rapid geologic clip of seven centimeters per year. By charting the locations of 49 earthquakes deeper than 400 km, they find that as the plate approaches the 670 km boundary, it grows shorter and thicker as it fractures and telescopes in upon itself.

The researchers, Domenico Giardini and John H. Woodhouse, chose to study the Tonga arc, where the crust is descending at an angle of 50 to 60 degrees. This angle, as well as the fact that the crust there is old and brittle and descending rapidly, means that the slab fractures at great depth, whereas younger, more pliable crust moving on a shallower slope does not. Their findings appear in the Feb. 9 NATURE.

If a slab is envisioned as a brick standing on end, the lower part of the brick is subject to higher compression than the top, because of the weight of the upper portion. Eventually, the brick would be expected to break along a plane dipping downward at an angle of 45 degrees. The studies are so new that these planes in a crustal slab have never been observed, Woodhouse says. What he and Giardini in fact have identified is a series of nearly vertical and horizontal faults. The faults are outlined by the pattern of earthquakes that occurs, they say, as the slab descends, slowing and spreading out sideways as it approaches the 670 km boundary.

"This is extremely consistent," Giardini says. "All of the seismicity is mainly located on these two kinds of structures. All of the material moving is on the sides. There is nothing going down once you reach 650 km." The finding "favors the view that subduction does not continue into the lower mantle." This contention is debatable, even by Giardini and Woodhouse, because they base it only on seismic data, all of which disappears at 670 km. They write, "we clearly cannot infer the fate of the subducted material after it ceases to be seismically active."

Researchers are not sure exactly what causes the 670 km boundary. It may be that the minerals change form, or phase, at that depth and pressure, and are transformed into a less fluid substance. Or the material below the boundary may have a different chemical composition from that above, making it less permeable. While the Harvard researchers suggest that there may be no circulation through the boundary, others believe that it simply happens very slowly. For instance, Brad Hager, a geophysicist at the California Institute of Technology in Pasadena, agrees that the material slows down as it approaches the boundary, but he is not persuaded that it stops. He bases his conclusions on his studies of variations in the earth's shape and gravity field, and on flow models he developed several years ago. Neither his calculations of the gravity field nor those conducted using the flow models work out if the subducting slab does not penetrate into the lower mantle, he says. He adds that if the slab were stopping at 670 km, it would have to change its direction of movement and come back toward the ridges where new crust ultimately resurfaces. However, he says, "it looks as though material still is continuing to go pretty much straight down at that point."

—C. Simon

Teen drug use drops, but problem remains

The percentage of high school seniors who smoke marijuana daily fell by nearly half over the last five years, but the proportion of students who have used illicit drugs remains substantial, according to an annual survey by the University of Michigan Institute for Social Research (ISR) in Ann Arbor.

The survey, sponsored by the National Institute of Drug Abuse (NIDA), found that daily marijuana use fell from nearly 11 percent of high school seniors contacted in 1978, to 5.5 percent of the class of 1983, the lowest level since the survey began in 1975. This means that about one out of 18 students in the sample admits to daily marijuana use. The proportion of seniors who used marijuana during the year prior to the survey dropped from a peak of 51 percent in 1979 to 42 percent in 1983.

"This is an encouraging sign that the downturn in drug involvement, particularly in the case of marijuana, is real and continuing," says Lloyd Johnston, who conducted the survey with fellow social psychologists Patrick O'Malley and Jerald Bachman, all of ISR. They polled over 16,000 seniors in 130 public and private high schools across the country.

The use of illicit stimulants such as amphetamines declined for the first time last year. Other drops were reported in the use of Quaaludes, barbiturates and LSD. Five percent of the seniors used barbiturates last year, less than half of the number reported in 1975.

But teenagers' use of tranquilizers, heroin, nitrites and PCP generally remained steady after earlier declines. Cocaine use also held steady after sharp rises in the late 1970s. One in six seniors, or 16 percent, say they have used cocaine, 9 percent have used opiates other than heroin and 1.2 percent have tried heroin.

Although drug use has moderated among high school seniors, the researchers note that nearly two out of three young people surveyed, or 63 percent, say they have tried an illicit drug, with four out of 10 having used an illicit drug other than marijuana. Another 40 percent say they used an illicit drug in the year before the survey.

"I know of no other developed country in the world where such a large proportion of youth become involved with drugs," says Johnston. His view is echoed by William Pollin, head of NIDA. The drop in daily marijuana use is "extremely welcome news," he says, but there is still a problem. Not only teenagers but adults in the workplace report substantial levels of drug use. NIDA data show a steady increase in emergency room treatment for reactions to heroin and cocaine from 1980 to 1983.

The responses to the latest survey reveal "a greater caution about the regular use of marijuana," says Johnston. Last year, 63 percent of the seniors thought that regular marijuana use is physically or psychologically harmful, up from 35 percent in 1978. A majority disapproves of even occasional marijuana use. Decreased availability does not explain marijuana's loss of popularity: The researchers found that 86 percent of the seniors said they could get marijuana if they wanted to.

The findings also indicate that teenagers are not substituting alcohol for illicit drugs. The proportion of daily drinkers dipped slightly to 5.5 percent in 1983. But "party drinking" is still prevalent, says Johnston, since 41 percent of those contacted said they had imbibed five or more drinks at a time during the two weeks before the survey. The proportion of teenagers using alcohol during the month before the survey was 69 percent, slightly lower than in previous years.

Unfortunately, says Pollin, cigarette use among teenagers has not declined since the late 1970s. Daily cigarette use has held steady at about 21 percent over the last four years.

—B. Bower