WRATH OF

CENTURIES OF UPHEAVAL ALONG THE ANATOLIAN FAULT

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PHOTOGRAPHS BY REZA

IF THESE DISEMBODIED HEADS could talk, they might well mock the boasts of their architect, a first-century B.C. king who declared that his monument in eastern Turkey would be "unravaged by the outrages of time." Just as earthquakes easily toppled these statues at Nemrud Dagh, last year's devastating quakes in western Turkey are reminders that geology has a long, relentless history of laying low the works of man.

THE GODS

HIS WORLD IN SHAMBLES, Mehmet Kamişoğlu commiserates with a nephew and a passerby in front of the building he lived in—and escaped from—in Gölcük. Last August 17 the segment of the North Anatolian Fault that runs under this city

produced a magnitude 7.4 earthquake, shattering the booming industrial region of northwestern Turkey. Cheaply built apartments that housed the recent influx of workers collapsed, killing thousands and leaving many more homeless.

EARTHQU IN TURKEY

THE NIGHT WAS TOO SULTRY for sleep. So at 3 a.m. on August 17, 1999, restless townspeople in Gölcük, Turkey, strolled in the park. They walked along the waterfront on the Gulf of İzmit, easternmost arm of the Sea of Marmara, and perhaps some talked of the many jumping fish spotted on the coast in recent days—or of the mysterious appearance of dead crabs and jellyfish. But İsmet Koyun and six other members of a local soccer team reminisced about past games as they sat on benches beneath a willow tree.

"Let's go home," İsmet recalls saying. "I've got to work today." As he stood, an explosion boomed over the gulf. "The earth came alive with shaking," he says. "The sky turned red, a sword of light flew out of the sea, and a wave as tall as a ship thundered toward us."

A great crack opened along the waterfront, and "like a drunk man trying to run," İsmet leaped over it and raced inland. Three of his friends climbed trees. A blinding storm of dust from collapsed buildings rose over the town and swept down toward the shore.

When the dust settled, İsmet found himself knee-deep in water. Looking back, he saw that a vast section of the former waterfront, including the park, had slumped into the gulf, sinking 30 feet or more. The lower floors of two seven-story buildings had crumbled and plunged into the gulf, killing 50 men who had been gambling in a ground-floor café.

Like everyone I met along the Sea of Marmara in the days after the earthquake, İsmet Koyun still seemed stunned as he sat on his bicycle and looked out at the submerged trees

AKE

and lampposts now well offshore. "Many bodies remain out there under the water," he said. "Also many vehicles, including a police car with two policemen inside."

Gölcük lies near the epicenter of one of the most punishing earthquakes of the past century. The magnitude 7.4 catastrophe created headlines worldwide. Tens of thousands dead. Some 250,000 homeless. And billions of dollars' worth of damage to Turkey's industrial heartland.

FORTY-FIVE SECONDS of shaking ravaged Adapazarı. Though the fault passes about five miles to the south, the city's loose alluvial soil amplified the motion. Concrete, loaded with sand to cut costs, crumbled; steel reinforcing rods, scandalously thin, buckled.

RETURNING TO TRADITION to feed their families, women in Cevizlik take homemade bread dough to be baked in a neighbor's old stone oven. On November 12 the fault ruptured here, dropping the road several feet and triggering another large quake. Damage blocked commercial food deliveries for ten days.

Istanbul, a city of more than seven million people about 50 miles northwest of the epicenter, was violently shaken. Although the heart of the megalopolis remained intact, the quake destroyed several dozen buildings in Avcılar, a neighborhood built in recent decades on the western edge of the city. And thousands of people, too frightened after the quake to sleep indoors, camped in open spaces with tents thrown together from sheets, towels, and blankets.

"This tragedy has directly touched almost everyone in the country," said my Turkish friend Aydin Kudu. "Hundreds of thousands of people from all over Turkey had moved here for jobs. We've all lost someone."

The earthquake began just east of Gölcük, about ten miles underground along a buried rip in the Earth's crust known as the North Anatolian Fault. Extending from eastern Turkey to Greece, the thousand-mile-long rip is very similar to California's infamous San Andreas Fault. Like its American counterpart, the Anatolian Fault is actually a network of smaller fault segments that divide two tectonic plates—in this case Eurasia and the much smaller Anatolian block, which carries most of Turkey on its back.

The edges of the two plates are locked together, but geologic forces are driving the Anatolia plate westward toward Greece at the rate of about eight or nine feet a century, building pressure along the juncture. When enough pressure builds, one or more fault segments unlock in a violent jerk. If a small segment breaks, the ensuing earthquake might be magnitude 6 or less. But when the segment beneath Gölcük snapped, the energy released triggered ruptures along three adjacent segments—to both the east and west—creating a much larger event.

Three days after the earthquake struck, I drove with Aydin toward the epicenter, reading the morning headlines. The official death count had reached 6,800. Three provincial governors—unable to coordinate initial relief efforts—had been replaced. Rescue workers, including at least 2,000 foreigners, were giving up hope of finding anyone else alive in the

REZA, a native Iranian who lives in Paris, covered the Caspian Sea for the May 1999 GEOGRAPHIC and the Black Dragon River for the February 2000 issue.

wreckage. In the city of Adapazarı 963 people had been buried in a mass grave. The Turkish government was ordering 10,000 more body bags. The destruction of the infrastructure of one of the most industrialized regions of the country was "complete," said the general secretary of the Foreign Investors Association.

When we reached the edge of İzmit, the largest city hard hit by the earthquake, the smell of petroleum pervaded the air. Black smoke still billowed up from the Tüpras refinery complex, Turkey's largest. People walked the highway with suitcases. Relief workers carried corpses to an ice rink that had been converted into a morgue.

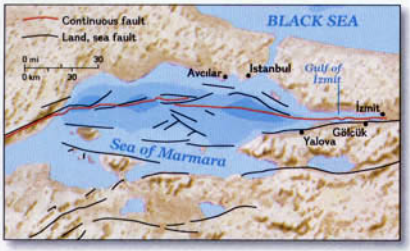
We came to an immense pile of broken concrete—the remains of a six-story apartment building. Carpeting, bedspreads, and splinters of furniture protruded from the rubble. A rescue team working with a large backhoe picked away at the debris pile.

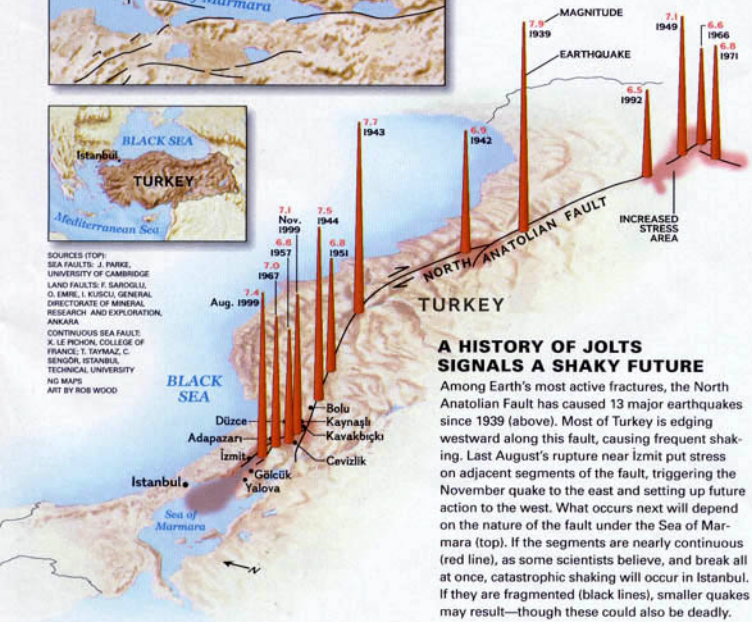
Clustered around the collapsed building were scores of people, their eyes red, their faces weary. Many clutched photo albums or stared at pictures of loved ones, hoping against all odds that they might still be breathing beneath the concrete.

A shout arose from the rescue team—a body. The workers carefully extracted the corpse of a woman; people crowded around. No one recognized her.

"It's hard," said a bystander. "The faces are so swollen and black."

I felt intrusive and helpless. "What can I say to these people?" I asked Aydin. "*Geçmiş olsun,*" he replied. "May it be over."





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A HISTORY OF JOLTS SIGNALS A SHAKY FUTURE

Among Earth's most active fractures, the North Anatolian Fault has caused 13 major earthquakes since 1939 (above). Most of Turkey is edging westward along this fault, causing frequent shaking. Last August's rupture near İzmit put stress on adjacent segments of the fault, triggering the November quake to the east and setting up future action to the west. What occurs next will depend on the nature of the fault under the Sea of Marmara (top). If the segments are nearly continuous (red line), as some scientists believe, and break all at once, catastrophic shaking will occur in Istanbul. If they are fragmented (black lines), smaller quakes may result—though these could also be deadly.

BRICKWORK CRACKED in a park near Gölcük as the underlying sediment slid toward the Gulf of İzmit. The fault that lies about half a mile offshore here also passes less than 15 miles from Istanbul. But much of that city sits on bedrock,

which offers some measure of stability. "Sediment shakes much more strongly than bedrock," explains James Dolan, a University of Southern California geologist. "Sometimes five to ten times more, so it's not a trivial matter."

An older man with bandaged head and arms arrived, and people rushed to greet him. He was Mustafa Çifttepe, one of seven people who had survived the collapse of the building. His wife and son had not. He was just back from the hospital.

"He was trapped for 17 hours," said his son-in-law, Ersin Güzey, who lives in New York City. As soon as they heard of the catastrophe, Ersin and his wife had caught the first flight available to Istanbul.

Ersin translated his father-in-law's story: "I was in bed with my wife on the second floor when the shaking began. My wife said: 'Get up! Get up!' Then a large chest landed on her. A wall fell toward me, stopping two inches from my nose. I was afraid to move, afraid if I did, everything would collapse and crush me. I just prayed and called for my son."

His son, a neighbor named Vedat Aktaş told me, was found crushed in the next room, his pants pulled halfway up his legs.

Vedat cursed the contractor who built the apartment. "This building had only half the steel it should have had," he said. "And this is supposed to be concrete," he said, dropping a chunk and watching with disgust as it shattered into bits. "It's more like sand."

Vedat's anger echoed across Turkey as the death toll mounted. The dire need for housing during recent rapid urbanization had encouraged fast, shoddy construction in thousands of new buildings. Many contractors, either through corruption or negligence, ignored building codes designed for earthquake resistance. It was those newer buildings that took the greatest hit.

As we left, I turned to the bandaged old man: "Geçmiş olsun." He nodded, his eyes filling with tears.

A BABY'S CRY guides a Japanese rescue team as they dig through the ruins of a home in Düzce. After eight hours they reached the tiny girl, but she had died. A bonfire warms homeless survivor Ayşe Gonca (standing), her daughter, father-in-law, and niece. "May God save my enemies from such destruction," she says.

WE HEADED DEEPER into the destruction zone, giving a ride to a man bound for Gölcük. His niece and her husband had died there, and he wanted to search for other missing relatives. The sun blazed. The air sweltered. And everywhere I looked I saw the heaped remains of countless shattered stores, mosques, and apartments. Most of the buildings still standing teetered on the brink of collapse. Traffic inched past bulldozers working to clear debris. Thousands of sweating, overworked rescue workers attacked concrete rubble with jackhammers. The smell of death filled the air, and, like most of the people we saw, we put on surgical masks to filter the dust, odors, and microorganisms.

Aydin and I stopped to let our hitchhiker out and met two schoolteachers—a husband and wife—sitting in a field surrounded by an upholstered couch, a dining room set, and various other pieces of furniture they had retrieved from a nearby apartment building. They pointed to where they had lived.

"We were on the fifth floor," said Gönül Güzel. "Now it's the third. The top floors fell into the first two. Everyone on the bottom died."

"I WAS AFRAID TO MOVE, AFRAID IF I DID, EVERYTHING WOULD COLLAPSE AND CRUSH ME."

"We have no idea what will happen to us," said his wife, Yücel. "People bring us food, but we have no desire to eat."

At the resort town of Yalova we met a friend of Aydin's named Hakkı Akyazı. His eyes were swollen, and in a soft, slow voice he told us he had just buried his sister, a medical doctor who had lived in a new apartment complex there. The two had been on vacation together on the Aegean. She had decided to extend her stay and had returned to Yalova for the night to pick up more clothes.

When Hakkı heard of the earthquake, he rushed to her building, which lay in ruins. No rescue teams had reached it. He figured out where her apartment would have been and for 12 hours worked alone to get inside her bedroom. When he finally did, he found her dead.

At dusk we took a ferry from Yalova back to Istanbul across the Sea of Marmara. As we left the dock, I watched dump trucks pull up to the shore and empty the rubble of so many lost lives into the water. There was no other place to put it. Our boat was packed with mourners, and the setting sun turned the water deep red. It seemed as if we had been to a thousand funerals all in one day.

THE WALK HOME **after a doctor's appointment takes Mehmet Karabulut over a toppled minaret in Cevizlik. When the shaking started, he was in a café with friends. Bricks and ceiling beams buried him, breaking four ribs and hobbling a leg. "The grocery store I ran is in ruins too," he says. "I'm thinking of raising cows."**

The next morning we visited Istanbul Technical University to speak with geologists struggling to understand exactly what had happened along the North Anatolian Fault.

"We knew that the Gölcük area was where the fault was likely to break next," said Rob Reilinger, an American geophysicist from MIT. Reilinger uses the satellite-based global positioning system (GPS) to track deformations or swellings of the Earth's surface that indicate where pressure is building underneath. "We just didn't know when this earthquake would happen or how much of the fault would break."

Scientists are able to explain some earthquake phenomena that puzzled the people of Gölcük. The flash of light that İsmet Koyun saw over the Sea of Marmara may have been methane gas exploding as it was released from sediments in the gulf. The dead crabs and jellyfish seen at Gölcük could have been killed by radon gas seeping from rock in the Earth's crust into

WATERFRONT PROPERTY NOW, a popular ice cream parlor in Gölcük used to sit well back from the Gulf of İzmit. When the fault broke here, land along two miles of this coast fell ten feet or more, and water flooded inland. Several thousand

people drowned or were crushed as buildings disintegrated. Since then, survivors who lost their homes as well as those seeking a safer place to live have moved elsewhere, and the city's population has dwindled from 80,000 to 25,000.

THE LIVING AND THE DEAD share the hills south of Gölcük. In a makeshift cemetery wooden markers bear the names of loved ones lost. Fifteen-year-old Adem Yılmaz (right) was more fortunate: All his family members survived. But they are among the half million people made homeless by the two quakes.

the water just prior to the rupture.

But there is much the scientists still do not understand, and much that disturbs them. This earthquake, explained geologist Aykut Barka, was part of a sequence that began along the North Anatolian Fault in 1939 near its eastern end. Historically each section of the fault in Turkey breaks on average every several hundred years. Before this earthquake the only stretch of the main fault that had not broken in the 20th century extended from the city of Bolu, about 90 miles east of Gölcük, to the western end of the Sea of Marmara—a distance of about 220 miles. The four fault segments that broke on August 17 account for only about 70 miles of the 220 at risk. This earthquake probably pumped additional strain into unbroken segments.

Most worrisome are about a hundred unbroken miles of the fault that lie deep beneath the Sea of Marmara, passing less than 15 miles from Istanbul. Scientists do not understand well the structure of that obscured stretch, but they know it poses dangers. Nicholas Ambraseys, a specialist in historical earthquakes at Imperial College in London, notes that 40 earthquakes of magnitude 7 and above have hit the Marmara region since the first century A.D. In 1509 and again in 1766, great earthquakes destroyed much of Istanbul. Both may have been part of a 250-year rupture cycle. Some experts now argue that one or more events at least as large as the August quake will occur in the sea south of Istanbul in coming decades.

How bad might the next Istanbul quake be? That depends in part on how far the epicenter is from the city. It also depends on whether the fault segments beneath the Sea of Marmara break together or independently. Together they could create an earthquake as strong as magnitude 7.8—about four times stronger than the August earthquake.

A week after the earthquake I received permission from the Turkish Navy to walk where the North Anatolian Fault did some of its most spectacular damage: the Gölcük Naval

Command Center, the largest naval base in Turkey. When the quake tore through the Gulf of İzmit, it devastated the compound, toppling buildings and killing hundreds of people.

"I've been in many earthquakes, but nothing like this," recalled Ercüment Doğukanoğlu, a naval captain. "When it hit, I felt helpless—like being thrown every which way in a frying pan."

Heavy rain fell as a young second lieutenant, Selçuk Poyraz, led us across the ravaged base. "The rain is nice," said Selçuk. "It washes away the smell of death, which gets into everything. I have to put cologne in my car, on my clothes."

He walked us to a green lawn and pointed at what looked like the burrow of a gigantic mole cutting across the base, creating a scarp several feet high. In its path lay the ruins of an officers' club, where scores died in their sleep.

We followed the burrow until it opened into a crack so wide I had to jump to cross it. We reached a place where the crack had split a stone wall, thrusting the south end eight feet to the west into the middle of the street it once bordered. The same crack also pushed an entire apartment building across the street several feet closer to Greece.

As the earthquake faded from the world's headlines, its miseries persisted. I returned to Turkey in late October. The official death count stood at just over 17,000, but the real toll may have been twice that. Winter was setting in, and although people were being fed adequately by organizations such as the Red Crescent, warm clothes remained in government warehouses undistributed. With more than 85,000 buildings destroyed or uninhabitable, about 40,000 families were living in 168 tent cities. Few tents were winterized.

Psychological problems were mounting. Many men remained jobless and idle. Many of the neighborhood coffeehouses they relied on for socializing were gone, replaced by scattered coffee tents. Children played and attended school in severely overcrowded tents. So many teachers died in Adapazarı that in one district only two remained to look after 2,000 children.

As a group, the women displaced from their homes may have been suffering the most. "They have no place to go to be together," said Mebuse Tekay, a relief coordinator for 128 nongovernment volunteer groups.

Despite the crisis, Mebuse pointed to positive changes the earthquake brought.

"It has collapsed some taboos," she said. "Many Turkish people thought they had no friends in the world except other Turks. But so many foreigners came to help us, we now must see a new reality. Even the Greeks proved not to be our enemies. Television showed a Greek team crying after they rescued a little girl.

"Also many of the people rushing to help were from arts groups. Now many traditional Turks have had to change their biases toward men who have long hair or earrings and women in miniskirts. It was those people who showed up first."

MANY CONTRACTORS IGNORED BUILDING CODES DESIGNED FOR EARTHQUAKE RESISTANCE.

On November 12 the North Anatolian Fault struck again. Stress from the August quake triggered a rupture along a segment of the fault east of the earlier break. The second quake measured magnitude 7.1. It hit a much less populated region but still killed more than 800 people and injured at least 5,000.

In the town of Kaynaşlı, Özgür Akbulut's father and older brother had just left evening prayers at the mosque when the temblor hit. As most of the town's buildings buckled, the mosque's towering minaret crashed down on the two men, crushing them to death.

On a cold and drizzling December morning I met 15-year-old Özgür in the nearby village of Handanoğlu, where he was living in a tent with surviving relatives. As I talked with the men of the village in the parlor of a farmhouse that had survived the quake, Özgür sat silently by the stove, warming his hands. He smiled occasionally but mostly stared vacantly ahead.

"These earthquakes are tests from God," said Mehmet Bayındır, a wizened 92-year-old. "We should build houses the old way—from chestnut wood. They don't collapse."

His grandson Hüseyin agreed. "I accept that this was a geologic event, but it can be taken as a warning. In seconds,

A LATERAL RIFT that opened under a house in Kavakbıçkı in the November quake did little damage because diagonal wooden beams absorbed the shocks. Unlike the village's three ruined concrete buildings, such traditional homes safely withstood the shaking—as they have for centuries.

billionaires can become penniless. So you must have values that you can't lose—a good heart and honesty."

Although smaller, Kaynaşlı looked like Gölcük all over again—streets lined with shattered buildings and mournful people struggling to rebuild. I headed back to Gölcük, about 80 miles away, to see how people there had coped in the intervening months.

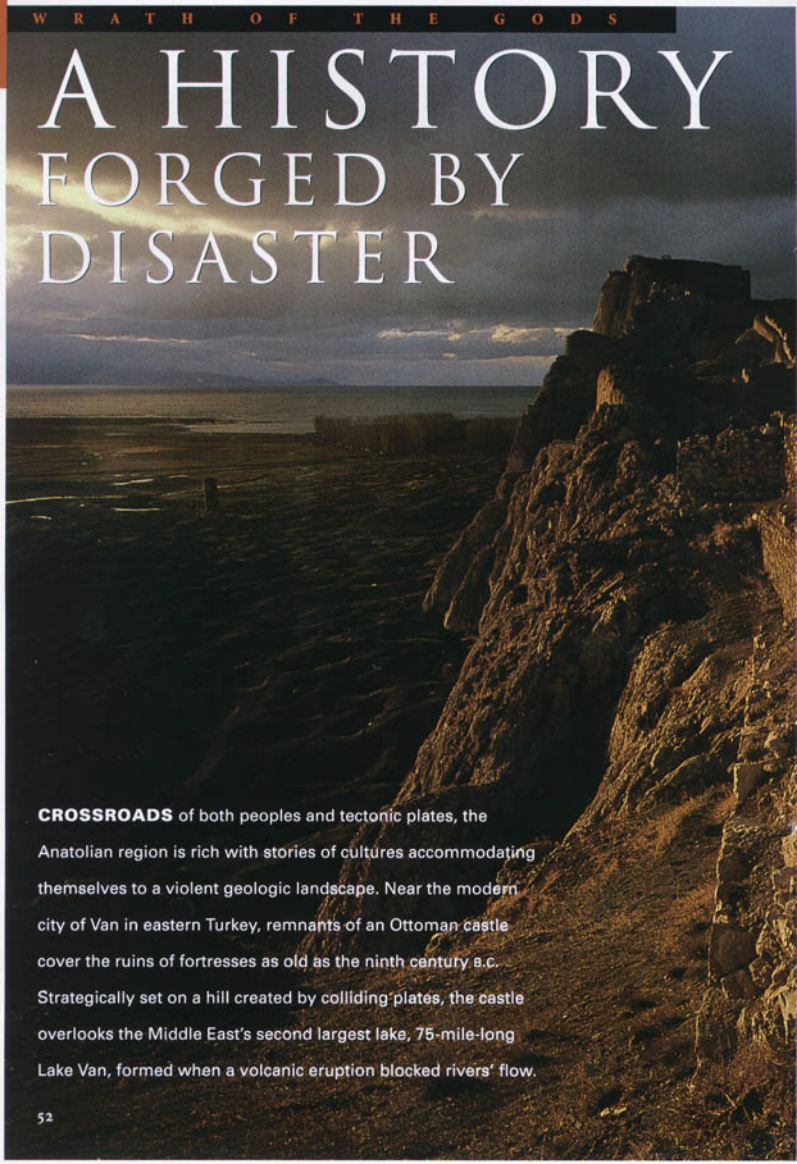
The nightmare hadn't gone away. Bulldozers had cleared most of the piles of rubble, and temporary prefabricated houses had risen rapidly outside the town. But Gölcük itself was still a city in shambles. I found İsmet Koyun again in a coffeehouse by the waterfront.

"There's not much else to do," he said as we drank tea with his friends. "Gölcük is dead. Most people have left. The government hasn't decided whether the city should be rebuilt."

At dusk, İsmet took me to the water's edge, where he had watched his city collapse. We clambered over twisted rebars and mud-caked chunks of concrete to the seven-story building where the 50 men had perished in the sunken café. We watched the water lap into what had been the building's third floor.

"Thirteen bodies were never found," he said. Darkness fell, and I could only think of one thing to say: "Geçmiş olsun. May it be over." □

A HISTORY FORGED BY DISASTER



CROSSROADS of both peoples and tectonic plates, the Anatolian region is rich with stories of cultures accommodating themselves to a violent geologic landscape. Near the modern city of Van in eastern Turkey, remnants of an Ottoman castle cover the ruins of fortresses as old as the ninth century B.C. Strategically set on a hill created by colliding plates, the castle overlooks the Middle East's second largest lake, 75-mile-long Lake Van, formed when a volcanic eruption blocked rivers' flow.

HEARTACHE HAS FOLLOWED ME from the rubble piles along the Sea of Marmara to a bleak and rocky landscape in eastern Turkey. *Geçmiş olsun*—"May it be over." I've said that phrase so many times to survivors of the killing earthquakes near Istanbul. But, in fact, I know what no one wants to hear: It will never be over. Nowhere have civilization and nature waged more persistent war than in this part of the world—from easternmost Turkey to the western tip of Greece.

In the first century B.C. a self-absorbed king named Antiochus I, ruler of the ancient land of Commagene, built an audacious tomb and monument to himself on top of a 7,000-foot-high mountain called Nemrud Dagh. There, he proclaimed, his mausoleum would be "unravaged by the outrages of time."

He constructed a conical tumulus more than 200 feet high from fist-size rocks, hauled up and assembled with unimaginable labor. On terraces around the tumulus stood a pantheon of colossal statues—gods and heroes with whom he expected to consort in the afterlife.

No doubt Antiochus's understanding of geology was as flawed as that of the driver who is now transporting me in his *dolmuş* from the Turkish town of Kâhta to Nemrud Dagh. Gesturing toward a cluster of oil wells on the rocky landscape, the driver declares: "That's why we have earthquakes. They are pumping out the oil and the land collapses."

I nod, knowing I could never convince him how little power human actions have over the titanic forces of the Earth—even with the abundant evidence I find a few hours later at the pinnacle of Nemrud. The tumulus has shrunk to 150 feet as rocks have tumbled down the mountain. And someday—an instant from now in geologic time—the king's tomb will be gone, his coffin laid bare by the ravaging tremors he thought he had risen above. I pause before great stone heads of Zeus, Heracles, Apollo—and of the vainglorious king himself. All these constructs of human imagination are laced with cracks or toppled on their sides. Surrounding me are the constructs of geology, the real ruler of this land—limestone and shale that formed at the bottom of a deep marine basin and that, over time, were pushed up into mountain ranges. Even Antiochus's statues were carved from uplifted limestone.

Humans in this part of the world have long

blamed the Earth's sudden and violent changes on supernatural agents. In 464 B.C., when an earthquake destroyed Sparta and provoked an uprising of serfs, the ancient Greeks blamed Poseidon, the earth shaker. And just last year, after an earthquake devastated suburbs of Athens, a priest at the monastery of St. Kyprianos told me the catastrophe was a divine warning: "It was sent to shake us from our sins."

Rob Reilinger, a geophysicist at MIT, provides the scientific explanation—"There's a full-scale continental collision going on," he says, "where Africa and Arabia are driving north and colliding with Eurasia." That collision, which has continued over the past five million years, creates a complex pattern of geologic processes that fascinate scientists just as they mystified and devastated ancient cultures.

The collision began in eastern Turkey and affects most of Anatolia, the peninsular part of the country. Arabia, which is moving north slightly faster than Africa, hit first, and when it shoved into the underbelly of Eurasia, it thrust up not only Nemrud Dagh but also the Caucasus Mountains.

The collision has thickened the continental crust in eastern Turkey, now about 30 miles thick, compared with some 25 miles thick farther west near Ankara. As a result the region, which lay near sea level before the collision, is now a plateau averaging more than a mile high. In some places jagged remnants of ancient seafloors that once lay between the colliding continents jut from the compressed landscape as mountains. Most of the rock in those seafloors, however, was pressed down toward Earth's mantle. This stimulated melting and the formation of magma that resurfaced through cracks to form volcanoes such as Mount Ararat, the fabled final resting place of Noah's ark.

Almost 17,000 feet high, Ararat, flanked by its smaller sister, Little Ararat, dominates vistas along the Turkish-Iranian border. No wonder the ancients believed that this ice-crowned massif would be the first land to emerge from a great flood. But today the legends that have surrounded the mountain are forgotten by residents of Doğubayazıt, the nearest town—charmless, commercial, and ravaged by years of Turkish-Kurdish conflict.

KURDS HAVE LIVED in southeastern Turkey for more than 2,000 years—still not long enough to verify the tale that Noah's ark came to rest on Mount Ararat (below, left). Though Kurds live and tend sheep in sight of the dormant volcano, the last village on its flanks was lost to an earthquake in 1840.

HERE HUMANS AND THE FORCES OF GEOLOGY HAVE COEXISTED HARMONIOUSLY AND SPIRITUALLY.

"People in the town don't know anything," says a local hotelier, Feyyaz Salman. "But my 110-year-old grandmother, who lives in a nearby village, told me the two mountains were sisters who hated each other. Little Ararat cursed her big sister, saying 'May you grow so tall you will always have snow on your head.' In turn, Big Ararat cursed her little sister: 'May you always be so close I can control you. And may you always have snakes in your hair.'"

Neither volcano has erupted in recent memory, but residents of eastern Turkey have much to fear from earthquakes. The compression resulting from Arabia's northward thrust is pushing Turkey westward in jolts, like fingers squeezing the pit from a cherry.

No city in Turkey has suffered more pain from earthquakes over the centuries than the ancient metropolis of Antioch. In A.D. 115 the Emperor Trajan blamed an earthquake that destroyed the city on the presence of Christians and had the bishop, Ignatius, thrown to the lions. Walls fell again in A.D. 458. In 526 an earthquake killed 300,000 people, according to the historian Procopius. His figures are exaggerated, but other crushing earthquakes occurred the same year. Plague hit in 542, Persian armies in 573. Another earthquake in 588 closed a devastating century.

Modern Antakya, on the site of the ancient city, still falls victim to frequent earthquakes. A third of Antakya was leveled in 1872. Geologists know that the city lies near the junction of three major faults, including one slicing up from the Dead Sea. So why do people continue to rebuild here? It's a crossroads, say some. The climate is mild and the soil is rich, say others. "We've always lived with risk," adds businessman Joseph Naseh. "If it wasn't earthquakes, it was invasions."

Indeed, invasions have been almost as common as earthquakes in Anatolia. And ironically, violent Earth forces have actually helped people in the heart of Turkey protect themselves against raiding armies. In a region called Cappadocia fiery surges of volcanic ash, cooled and sculpted by erosion over the past few million years, have covered the ground with blankets of rock so soft that humans could cut sanctuaries—even entire secret cities—into them when faced with invading hordes.

"Cappadocia coming *(Continued on page 64)*

VIOLENT GEOLOGY isn't always the enemy. In central Turkey's Cappadocia region—a thoroughfare for Persians, Romans, Byzantines, Arabs, and Turks alike—people once sought refuge from invaders by digging into soft volcanic rock. The rock erodes quickly except where protected by harder rock, producing formations resembling minarets (top). Hundreds of early Christian churches and dozens of underground cities have been found in Cappadocia, including one that is 20 stories deep. Most caves now sit empty, though some have been upgraded for modern life.

THE CRADLE HAS ROCKED

Like the fire-breathing Chimera of Greek mythology—part lion, part goat, part serpent—the area now bounded by Greece and Turkey is a mosaic of incongruous parts that come together fearsomely. Trapped between three huge, converging continental plates, the Anatolian and Aegean regions have been roaring and breathing fire for millions of years—and terrorizing humanity for millennia. "It is an exceptional place: You have extreme geologic activity—with frequent earthquakes and volcanic eruptions—in one of the cradles of Western civilization," says earthquake geologist James Dolan.

Subduction

Where oceanic plates meet continental plates, the denser ocean plate pushes beneath the continental plate, and magma rises to create volcanoes.

Extension

As crust is stretched by subduction, faults can cause it to rise or fall. On land and in the sea, valleys called grabens form and fill with sediment.

Collision

When two continental plates collide head-on, they may push crust upward, forming mountain ranges. Such a collision formed eastern Turkey's mountains.

Strike-slip fault

Plates moving past each other horizontally lock together until tension builds to a release point—an earthquake. Quakes range from barely detectable to cataclysmic.

VOLCANOES AND EARTHQUAKES IN HISTORY AND MYTH

We have known about plate tectonics for only about 40 years. Before that our imaginations—scientific or otherwise—had to make sense of the Earth's geologic forces. Like countless cultures, the ancient Greeks and Romans personified the power of natural forces in a pantheon of gods. Hephaestus (illustration below)—whom the Romans called Vulcan, the namesake of volcanism—was the god of fire and volcanoes, Poseidon the god of earthquakes as well as the sea.

IT'S ANATOLIA'S FAULT, BUT ARABIA AND AFRICA ARE TO BLAME

Imagine the Anatolian plate as a slippery seed between a finger and a thumb—the Eurasian and Arabian plates. As the Arabian plate moves northward into the Eurasian plate, it squeezes the Anatolian plate westward, causing earthquakes along the North Anatolian Fault. Farther west, the African plate is pushing beneath the Anatolian plate, stretching the Aegean Sea's underlying crust and allowing magma to rise to the surface through volcanoes.

A STRAIT'S SHAKEN GLORY

It takes either a sturdy boat or a kilometer of bridge to cross the Bosporus today, but people may have walked cattle across the Bosporus—which means "ox ford"—before Mediterranean seawater started spilling through the strait into the Black Sea Basin some 7,500 years ago (see "Black Sea Flood," page 71). It is possible that an

earthquake caused the rupture that opened the strait. Istanbul, perched on the banks of the Bosporus, has weathered dozens of major earthquakes in the 1,700 years since Roman Emperor Constantine made it the empire's new capital. Adding to Constantinople's glory, in 537 Emperor Justinian inaugurated a domed cathedral then unparalleled—Hagia Sophia, or Holy Wisdom (above, dome at left). "Solomon, I have outdone you!" legend says he declared. It only

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took 20 years for an earthquake to inflict serious damage. The building still stands, many quakes and repairs later, buttressed along the way for stability (top).

A mid-16th-century woodcut (above) depicts an earthquake's aftermath in Constantinople. Unsettling apparitions in an orderly sky, comets throughout history have embodied cultures' worst fears; this one was taken as an omen of the quake.

ALL THESE CONSTRUCTS OF HUMAN IMAGINATION ARE LACED WITH CRACKS OR TOPPLED ON THEIR SIDES.

up!" says Lars-Eric Möre, pilot of a hot-air balloon that has lifted me and a basketful of sightseers over a vista of mushroom-shaped rocks with doors and windows. Farther on we float above a canyon forested with pinnacles and spires of stone in shades of pink, white, ocher, brown, and gray. Then cliffs with churches carved into them by Byzantine monks. Here humans and the forces of geology have coexisted harmoniously and spiritually.

The volcanic avalanches of Cappadocia were generated, like almost every geologic event in the region, as Africa drew closer to Anatolia. Dense oceanic rock in front of the approaching continent subducted beneath Turkey, and as the water-rich rock dived deeper and mixed with the mantle, it created the particularly gaseous magma that exploded across Cappadocia.

Although geologists believe that epoch of volcanism has ended, the subducting of seafloor continues to the west beneath the Aegean Sea. The diving seafloor there exerts a powerful tug, pulling the Aegean crust toward Africa. That tug has stretched and thinned the Aegean, turning what once was dry land into a drowned continent. It is also opening a space into which Anatolia can move as it's being squeezed by Arabia in the east.

Much of Anatolia's westward movement occurs along a particularly dangerous geologic feature known as the North Anatolian Fault. That fault, which separates Anatolia from the rest of Eurasia, runs east to west just south of the Black Sea. About 75 miles before it reaches the Sea of Marmara, the fault forks into at least two strands. The sea, which reaches depths of more than 4,000 feet, is actually a rift, pulled apart by tension between the strands, which continue westward across the Aegean to Greece.

In the Marmara area the North Anatolian Fault has caused immeasurable devastation. In the past 2,000 years almost 600 documented earthquakes—40 of them magnitude 7 or greater—have hammered the region. İzmit has been destroyed repeatedly, and Istanbul itself has been severely damaged four times by great earthquakes in the past 500 years.

The fault may also have triggered the most catastrophic event ever seen along the Sea of Marmara—an enormous flood about 7,500 years ago that filled up the Black Sea Basin—according to Bill Ryan and Walter Pitman, geologists at Columbia University. They recently demonstrated that at the end of the Ice Age the Black Sea was much lower and smaller. Then as glaciers melted, rising seas cut a channel—today's Bosporus—from the Sea of Marmara toward the Black Sea Basin. Perhaps triggered by an earthquake, an enormous flume of water poured down an escarpment north of modern Istanbul for more than a hundred days, filling the basin to sea level. The flood must have driven settlers all along the former coast from their villages. Perhaps, Ryan and Pitman suggest, it was this sequence of events that inspired the story of Noah's Flood.

On a rainy, blustery day I head up the Bosporus to visit the spot where the fabled strait widens into the Black Sea—the presumed site of the breakthrough. The waters of the strait grow rough where the Mediterranean once cascaded. I watch waves toss fishing boats bringing in their hauls of mackerel, bluefish, and bonito—and the angry waters still seem to echo the prehistoric turmoil of the flood. No wonder the ancients feared this passage. In Greek mythology the headlands on either side of the Bosporus were great rocks that crashed continually against each other, preventing ships from sailing through to the Black Sea. Not until courageous Jason and the Argonauts passed safely through did the rocks cease their clashing forever.

The North Anatolian Fault played a role in the formation of another Turkish strait, the 38-mile-long Dardanelles, which connects the Sea of Marmara with the Aegean. I drive along the Gallipoli Peninsula, watching the ships of many nations steam toward old Byzantium in the late afternoon sun. Few places evoke such human history. Here in 480 B.C. the Persian King Xerxes built a bridge of boats to stage an

abortive invasion of ancient Greece. Alexander the Great crossed back over in 334 B.C. en route to conquering the world. Attempts to control the Dardanelles sparked desperate battles between the Turks and Allies in World War I.

Myth touches the Dardanelles too—in a tale of ancient Troy, which guarded the entrance to the Dardanelles throughout the Bronze Age. In Homer's *Odyssey,* the Greek hero Odysseus devised a trick that ended the Trojan War. Greek soldiers hid within a great wooden horse, which the Trojans unsuspectingly took within their city walls. I stand in front of one of those walls with Manfred Korfmann, an archaeologist at the University of Tübingen. Korfmann explains another theory about the Trojan horse.

"See those cracks?" says Korfmann, pointing to the heavy gray stones of the tower. "Most people regard them as earthquake cracks." Korfmann suspects that over several centuries the Greeks fought many skirmishes with Troy because Troy controlled access to sources of metal around the Black Sea. He believes that at some point an earthquake may have brought down Troy's walls, letting the Greeks in. To celebrate their victory, the Greeks may well have erected a horse to thank Poseidon for the quake—the horse being a symbol of Poseidon.

Two particularly devastating earthquakes around A.D. 500 demolished Troy once and for all. In fact, an unparalleled wave of big earthquakes from the mid-fourth to the mid-sixth centuries hit all the major cities of southwestern Turkey: Pergamum, Aphrodisias, Ephesus, Smyrna. This puzzling sequence, called the early Byzantine tectonic paroxysm, may reflect a huge shifting of plates from Palestine to Crete. "It was not a good time to be alive," says Brian Rose, an archaeologist at the University of Cincinnati. "The earthquakes kept coming."

The force that gives rise to most of the earthquakes that plague the Aegean region of Turkey is called extension. As the subducting African plate stretches and thins the crust, great cracks known as grabens open up. The grabens become valleys that fill with fertile sediments.

Extension in the Aegean has enriched the

SWIMMERS STRADDLE **fluted columns in a geothermal pool near the ancient Roman city of Hierapolis. Geology giveth—Romans flocked here to bathe—and geology taketh away: The city was destroyed by repeated earthquakes. Floating among the ruins, tourists revel in the paradox.**

SAVED BY A VOLCANO: This ancient fresco was preserved by the same eruption that destroyed the home of its creators. Buried under two stories of pumice, ash, and debris 3,600 years ago, the town of Akrotiri on the Greek island of Thera has yielded clues to Minoan and Cycladic culture.

soil of southwestern Turkey. But the same process, occurring too rapidly and accompanied by centuries of deforestation, has encouraged the buildup of too much silt in places, turning waterways into swamps and until recently encouraging the spread of malaria.

With İlhan Kayan, a geographer at Aegean University, I visit the Little Meander Valley south of İzmir. As we look out over the farmland, İlhan explains how heavily the silt has accumulated in some parts of the region: "The sediments are 88 feet deep in the center of this valley," he says. "If you could take a big vacuum cleaner and suck them all up, the sea would flow in here."

Both earthquakes and the steady buildup of silt made life difficult for the residents of Ephesus, the best preserved of the ancient cities in the region. İlhan takes me to a hill overlooking the site of the Temple of Artemis, constructed to the goddess of the hunt in the sixth century B.C.

"They probably built that great temple on the coast," says İlhan. Today I can barely see the Aegean; the encroachment of silt has shifted the shoreline five miles to the west. Being stranded so far inland destroyed the economic viability of Ephesus. That and Christians having no desire to maintain a city filled with pagan monuments. Still, the huge marble temple that once stood below us, built to honor the Greek goddess, was one of humanity's greatest achievements—and one of the seven wonders of the ancient world.

THERA FOUNDATION, PIRAEUS, GREECE

ALONG TURKEY'S southern coast the process of extension has caused land on the shore to drop into the Mediterranean. At the town of Üçağız I hire a boat to sail across a bay that once did not exist. "Scientists tell us there is a Roman amphitheater below us," says the captain, İbrahim Turan. We cross to an island named Kekova, once a Byzantine city, that is sinking into the sea. We cruise past the subsiding buildings that line the shore. Beneath the boat lie the foundations of houses.

At the same time Kekova is dropping into the water, land across the Aegean in Greece is rising rapidly. Stathis Stiros, a geologist at the University of Patras, takes me along the south coast of the Gulf of Corinth, a dramatic waterway separating the Greek mainland from the Peloponnesian peninsula. On the eastern shore of the gulf we stand on cut rocks that, around 500 B.C., were laid underwater to build a harbor at Corinth, a wealthy city renowned for its elegant pottery. Stiros points out holes that were drilled in the rocks by marine animals.

"Those holes were made underwater," he says. "Now they are nearly four feet above the shoreline."

The entire southern coast along the gulf is rising. Stiros takes me farther west to a rocky terrace where corals that lived some 30 feet underwater 10,000 years ago now stand about 20 feet above it. In the mountains that plunge to the coast we wander through the ruins of the city of Aigeira, nearly a thousand feet above sea level. About 120,000 years ago, says Stiros, we'd have been at sea level.

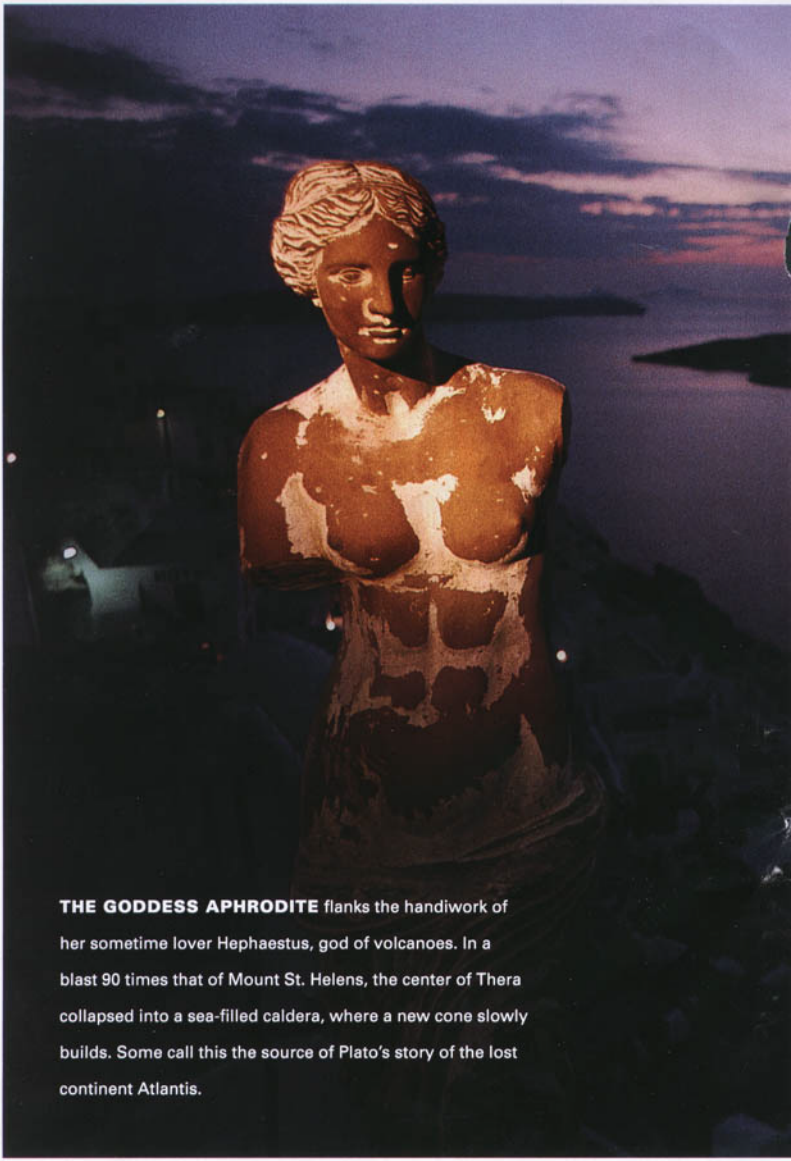
Basically the Gulf of Corinth is a deepening graben. The Peloponnesus was pulled away from the mainland by the same extension forces that stretch western Anatolia and the Aegean. But, more important, the same land is also being squeezed by a familiar culprit.

"All of central Greece is now caught up by the North Anatolian Fault," says Rolando Armijo, a geologist at the Institut de Physique du Globe in Paris. "The northern branch is driving up mountains, including Mount Olympus. The southern branch is arriving about 60 miles to the south. The Gulf of Corinth and Athens are on the front edge. The land around it is cracking as the fault approaches. We call it the damage zone."

On September 7, 1999, Athenians were surprised to learn they lived in such a place—even though the Parthenon bears cracks from earthquakes in past centuries. On that day a magnitude 5.9 quake shook Athens for 15 seconds, killing 143 people and leaving more than 50,000 homeless.

Earthquakes have struck far more frequently to the southwest of Athens in the Peloponnesus, devastating some of the great cities of ancient Greece. "There's been a lot of bloodshed here," says Iphiyenia Tournavitou, an archaeologist at the citadel of Mycenae. In mythic Greek tragedy these brooding ruins witnessed horrific human catastrophe. Here Clytemnestra murdered Agamemnon for sacrificing their daughter Iphigenia to the gods, and Orestes slew his mother for killing his father.

From this strategic palace on top of a steep hill, the elite families of Mycenae became one of the great powers of the Greek world in the 14th and 13th centuries B.C. Yet the walls of



THE GODDESS APHRODITE flanks the handiwork of her sometime lover Hephaestus, god of volcanoes. In a blast 90 times that of Mount St. Helens, the center of Thera collapsed into a sea-filled caldera, where a new cone slowly builds. Some call this the source of Plato's story of the lost continent Atlantis.

their citadel, it turned out, were as vulnerable to forces in the Earth as its rulers were to human passions.

Mycenae, like all the great citadels of the region, has suffered many earthquakes over time. "In 1250 B.C. the city experienced major destruction," says Tournavitou. "We find people crushed beneath the walls of their houses." But the citadel was quickly rebuilt and extended. Fifty years later a bigger disaster hit Mycenae. "They never quite recovered. The ruling aristocracy must have collapsed."

Invading raiders disrupting trade in the Mediterranean probably undermined the Mycenaean economy. But increasingly archaeologists see earthquakes as opening the doors to destruction, much as they might have knocked down the walls of Troy, letting in the Greeks. Most agree that earthquakes, and especially a titanic volcanic eruption around 1600 B.C. on the island of Thera, led to the decline of the powerful Minoan culture on the nearby island of Crete.

Floyd McCoy and Grant Heiken, scientists financed by grants from the National Geographic Society, have studied the Thera eruption—one of the largest in history. A smaller first eruption, which put down a dusting of ash before the main event, may have scared most of the people away—excavations have revealed no skeletons.

The second eruption began with a blanket of light pumice that buried the town of Akrotiri, downslope, many feet deep. Then seawater entered the vent of the collapsing volcano and explosively mixed with magma and gases. The enormous amount of steam generated by the water made an already violent eruption ultra-explosive, McCoy explains, "the worst kind of eruption we can get on this planet."

Thera's ash and pumice snowed down on Crete, 70 miles to the south. Tsunamis battered its north coast, perhaps sinking many Minoan ships—disaster for a seafaring culture. The ash likely destroyed crops along with the grasses that fed livestock.

This was not the first geologic catastrophe on Crete. "At least a century earlier a great earthquake destroyed the palace at Knossos, the center of Minoan power," says Eleni Hatzaki, curator at Knossos for the British School at Athens. "The Minoans rebuilt on a grand scale, and the peak of their culture followed." But another major quake seriously damaged the palace around the same time as the eruption on Thera. In the decades that followed, all the major palaces on Crete were destroyed by fire—probably set by invaders—and eventually Mycenaean Greeks took control of the island.

Earthquakes continue to ravage Crete as Africa, only 200 miles to the south, approaches. As the eastern part of the island sinks, the western part is rising dramatically. Dating the shells of marine animals that live at sea level, geographer Paolo Pirazzoli of the French Research Council finds evidence for an astounding uplift of 27 feet in one great earthquake. He thinks it occurred on July 21, A.D. 365, the date of a huge Mediterranean tsunami.

On the far west coast of Crete that incredible upthrust pushed a Hellenistic harbor named Falasarna about 20 feet above sea level. On the last day of my journey I climb the mountain behind the town. Its slope is littered with blocks cut from nearby cliffs and hauled here long ago to build foundations. The climb is strenuous, and I grow sad. So much energy went into this town, now nothing but ruins.

A blast of wind nearly knocks me off my feet. I imagine myself lashed by Poseidon's breath. No. I'm just exhausted by this journey and feeling small and powerless in the face of all the forces the earth shaker represents. I remember what I saw after the İzmit earthquake and wonder why so many people had to die. Are all our labors futile?

Another gust, and I remember Adapazarı, near the epicenter of the İzmit earthquake—I visited there three months after so much of it had collapsed. New buildings were already going up. The muddy streets throbbed with life. Even though many residents were living in tents, energy was returning. A sticker on the back window of a car read: "I love my Adapazarı and I'm not deserting it."

On that windswept mountain it occurs to me that humans are not so powerless after all. We are durable. We possess the cleverness of Odysseus, the sublimeness of Homer, even the vanity of Antiochus. We are fired by the forces of imagination and love and by the ability to cry over our tragedies and, above all, to envision a new day. That's what keeps us even with the earth shaker. We bounce back—and cloak the worst that nature can do to us with the grace of our humanity. □