



## Building on the Past

**F**OR MILLENNIA, MAN HAS EXCAVATED INTO THE EARTH. A type of excavation, quarrying, dates to prehistoric times and is typically performed to extract rock or minerals. A famous prehistoric example of quarried rock is Stonehenge in England, which dates to Neolithic times. In ancient Egypt, the need for building materials for pyramids and temples led to quarrying of basalt and other rock near the cliffs of the Nile River.

With the expansion of the Roman Empire during the 1st century BCE, the enormous demand for stone to build palaces, coliseums, military fortifications, and roads led to the development of quarries throughout what is now modern-day Europe. Massive deposits of limestone and gypsum underlying Paris, France gave rise to some of the most notable subterranean quarry tunnels in the world. The Romans began quarrying limestone south of what is currently the city of Paris around 60 BCE. As surface stone deposits became scarce and open-pit quarrying became more difficult, miners began to dig vertical wells, then excavate horizontally to extract stone deposits. Limestone was sought after as a prized building material for such structures as Notre Dame and the Louvre; gypsum was mined for plaster of Paris. Continued excavation through the 18th century led to a network that eventually comprised over 180 miles of intricately connected tunnels, passages, and caverns beneath the city.



The catacombs of Paris house the remains of Parisians transferred to abandoned underground quarries from cemeteries over 200 years ago.

**T**he extent of the subterranean labyrinth beneath the city and the geotechnical risk that it created with respect to overlying structures were only realized when the ceilings of some abandoned quarries cracked and eroded, forming "bell holes" that extended upward toward the ground surface. In 1774, a massive cave-in destroyed over 100 feet of overlying roadway, swallowing several buildings and resulting in numerous deaths. In recognition of the hazard posed by the underground tunnels, Louis XVI appointed a special division of architects and inspectors to map them and a system was developed to shore up the cavities. The Inspection General des Carrieres still inspects the tunnels today, and monitors buildings and roadways for signs of settlement.

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## Consultant's Corner

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## First Japanese Tsunami Debris Hits the United States West Coast

The first debris from the massive tsunami that struck Japan in March 2011 has reached the west coast of the United States. A black 55-gallon float bearing Japanese markings washed up onto the shore near Neah Bay at the northwest tip of Washington State in early December. The float, of a type typically used by Japanese oyster farmers, was

found by crews cleaning up the beach. Oceanographers had predicted that this type of debris would arrive first because it is buoyant and sits high in the water, thus allowing it to be carried up to 20 miles per day by wind. This is about three times faster than the rest of the debris field, which is currently located about 1,500 miles east of Hawaii and is floating easterly at a rate of about 7 mph.

The debris field has been described as a floating island, the size of which has been estimated as being anywhere from the size of California to two times the size of Texas. The crew of the STS Padilla observed the estimated 20-ton debris field in the Pacific Ocean, and reported that it contains such items as entire motor vehicles, household appliances, boats, televisions, and buoys similar to the one that recently washed up on the coast of Washington. It is predicted that large quantities of debris will begin showing up on beaches from southern Alaska to California in about a year. ■

## Building on the Past *continued from page 1*

Toward the end of the 18th century, Paris was in the midst of an epidemic of cholera, which was traced in part to contamination related to improper burials and mass graves. In 1786, it was decided to condemn several overflowing cemeteries and discreetly remove the bones to the underground quarries. Thus, abandoned quarries underlying the city became the famed catacombs of Paris, which are stacked floor to ceiling with human remains. The catacombs contain the bones of over six million Parisians, nearly three times the current population of the city.

Following more cholera outbreaks, the underground sewer and water systems beneath Paris were revamped, which led to the construction of an additional 373 miles of underground tunnels. Unlike the smaller diameter sewers constructed in the USA, Parisian sewers are almost as large as subway tunnels; in the early 20th century, they were a tourist attraction, with visitors touring them via a locomotive-drawn wagon. Today, a museum celebrating the history of the sewer system still exists. Also in the early 1900s, the construction of the Paris Metro added another 132 miles of tunnels beneath the Paris metropolitan area. Combined, the massive underground network of Metro lines, sewers, and quarry

tunnels has caused some to label the ground underlying Paris as “the Gruyere Parisian” as it is full of holes like Swiss cheese.

Despite ongoing monitoring, street collapses related to underground quarries or other tunnels in Paris average 10 per year. In 1961, part of a soccer stadium, along with several streets and numerous buildings were destroyed when the ground above a disused chalk quarry gave way in a suburb of Paris. A total of 23 buildings were destroyed and 21 people were killed. In 2001, a massive sink hole developed above an old gypsum quarry in the Montmartre District, threatening adjacent residential buildings and closing streets to traffic. In 2003, a school building collapsed as work was being performed on an extension of a Paris Metro line.

Paris has not been the only major city affected by geotechnical issues associated with underground excavations. According to a recent report, the famed British landmark known as Big Ben is sinking. The 314-foot tower, located on the banks of the Thames River at the Palace of Westminster in Central London, has developed a tilt that is approximately 1.5 feet from vertical. While the tilting has been observed and monitored for many years, it has recently reached the point that it has become discernible to the naked eye.

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# Deck it Out!



**E**ARTH SYSTEMS' employee Jennifer Barnes responded to ArtsObispo's Call for Artists for the "Deck it Out" project to create original art on blank skateboard decks. Co-sponsored by the City of San Luis Obispo Parks and Recreation department and COALITION in November 2011, "Deck it Out" was a benefit for the [SLO Skate Park](#) building fund.

Jen's inspiration for her skateboard art came from her young nephew who suggested painting Tony Cat as a play on words and homage to the famous skateboarder, Tony Hawk. Jen felt there was room for both Tony Cat and Tony Hawk, and that they probably would not be getting along. In her piece, as the hawk soars above the skateboarding cat, the cat tries to capture the hawk's board.

Jen found that there were challenges and unexpected surprises working with the medium of the blank wood deck. She used an acrylic paint and it took longer to dry on the wood than on a traditional canvas, but this allowed for more time to blend the color. She also found it interesting to play with the wood grain as it shown through the paint.

"Deck it Out" was a successful venture, with over 50 local artists involved. All of the painted skateboards were sold at auction and 100 percent of the proceeds went to support the construction of in-ground concrete skate structures at the park. Jen's involvement and her willingness to donate her time and talents have helped this effort along. ■



## Rock of the Season

### Rhyolite

**B**etween 2400 and 2200 BCE, Bronze Age inhabitants of what we now call England obtained rhyolite rock from a long outcrop of rock called Craig Rhos-y-Felin in Pembrokeshire and moved it about 140 miles to Wiltshire. They

used it to construct the first circle of standing stones in the monument we know as Stonehenge. Not until 2011 CE, was the source of the stones known. In December of last year geologists were able to match the mineral content and textural structure of the stones at Stonehenge to those at Craig Rhos-y-Felin. How the stones were moved still remains a mystery.

Rhyolite is found not only in England but worldwide. It is a volcanic rock formed from lava as it is cooled rapidly in air or underwater. Minerals that make up rhyolite

include potassium feldspar, quartz, mica, and hornblende. Because the lava cools so quickly, the crystals that form are very small to microscopic, although some crystals grow very rapidly within the cooling magma and form spherical patterns comprised of quartz or feldspar. Swirling layers of different color or granule size, known as flow banding, is also a characteristic of rhyolite. The rock is usually buff to pink, green, red or brown in color, and the more ornamental varieties are used as decorative stone and in jewelry making. ■



Multicolored rhyolite mountains showing flow banding in Iceland's Landmannalaugar, Fjallabak area

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### The Kitchen Sink



### Why We Say What We Say

**READ BETWEEN THE LINES.** Cryptography, writing in code, has been a common practice among rulers, diplomats, and military leaders for centuries. A simple form of cryptography employed the method of secreting a hidden meaning between lines of text. Invisible ink or lemon juice, which is transparent on paper but when heated becomes visible, was often used. The phrase “read between the lines” now describes inferring a meaning which has not been written or stated openly.

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**SECRETARY.** From the Latin term for secret, by the late 1300s the term “secretary” was used to describe a person entrusted with private or secret matters, and who gave counsel. In the 1400s the definition broadened to include people who kept records for the king or wealthy noblemen. Over time the significance of the title shifted to mean anyone employed to conduct the business of, or write correspondence for, another.

**PUSH THE ENVELOPE.** Although the phrase could describe a secretary’s work, the envelope in this case is a mathematical calculation used in aviation and aeronautics to describe the limits of safe flight, or the flight envelope. Test pilots who tested the limits of speed or altitude for example were “pushing the envelope.” From technical jargon the phrase entered the common lexicon after Tom Wolfe used it in his 1979 book *The Right Stuff*. Pushing the envelope now can refer to going beyond the current limits of performance in any field, or testing the acceptable boundaries of behavior. ■

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The rate of tilting has accelerated since 2003, increasing to 0.9 mm a year compared to the previous average of 0.65 mm a year. While experts disagree on the cause of the acceleration, a report commissioned by the London Underground and Parliamentary Estates Department attribute it to years of underground developments that have affected ground conditions. Among these are the construction of an underground parking structure, and the extension of the London Underground Jubilee Line. The effects of the tilting are visible in recently developed cracks in the walls and ceilings of some rooms within the House of Commons. The tilt is less than one-tenth of that of the famous Leaning Tower of Pisa, and civil engineers calculate that at the current rate of movement, it would take approximately 4,000 years for Big Ben to reach the angle of that other famous tower. ■



Big Ben, “The Tilting Clock Tower of London”

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