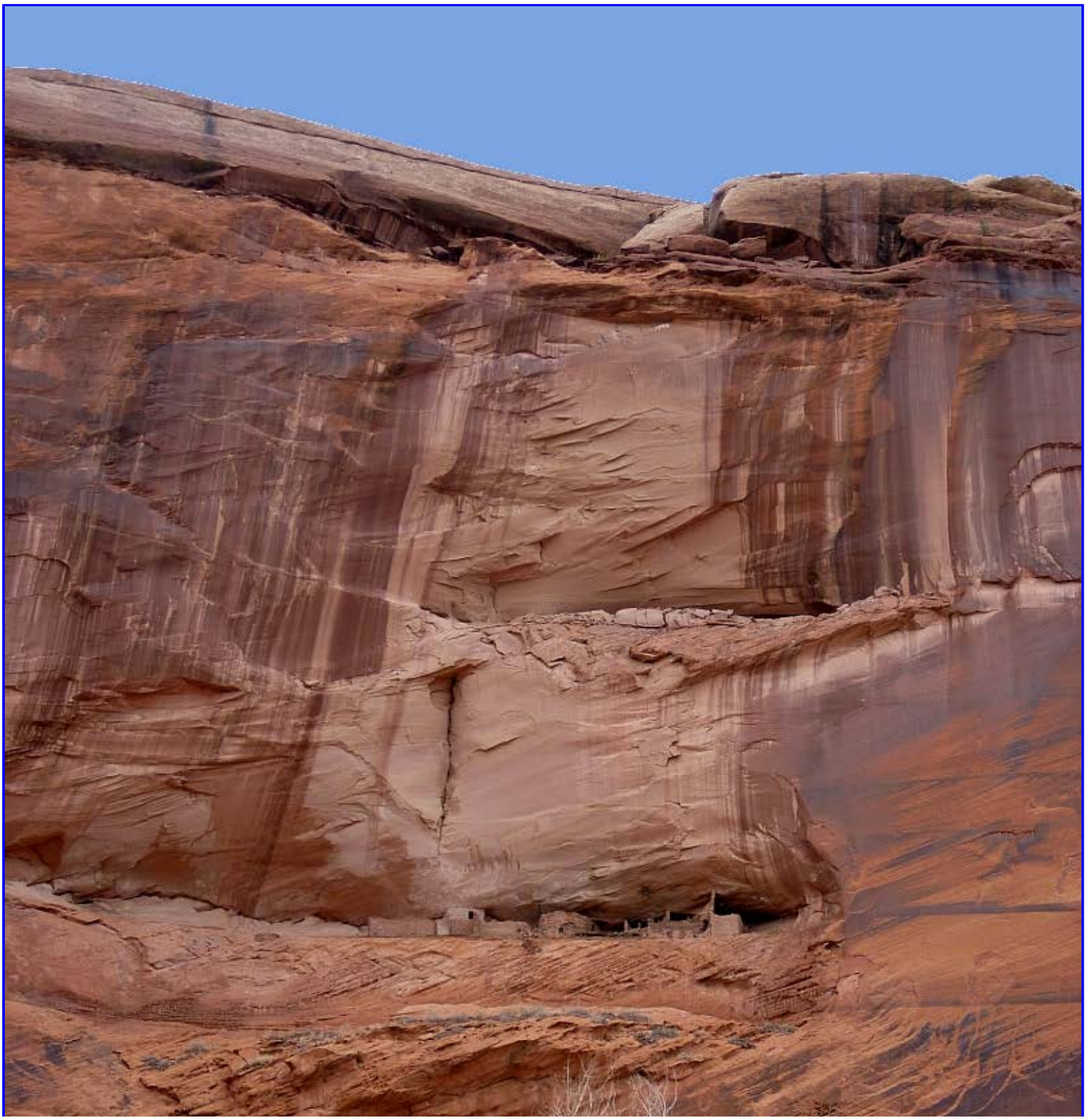
[For my December 2012 diary, go here.]

Diary - January 2013

John Baez

January 20, 2013



A few weeks ago I visited Canyon de Chelly, which is home to some amazing cliff dwellings. I took a bunch of photos, like this picture of the so-called 'First Ruin'. You can see them and read about my adventures starting with my December 21, 2012 diary entry.

Here I'd like to talk about what happened to the civilization that built these cliff dwellings! It's a fascinating tale full of mystery... and it's full of lessons for the problems we face today, involving climate change, agriculture, energy production, and advances in technology.

First let me set the stage! Canyon de Chelly is in the Navajo Nation, a huge region with its own laws and government, not exactly part of the United States, located at the corners of Arizona, New Mexico, and Utah:

The hole in the middle is the Hopi Reservation. The Hopi are descended from the people who built the cliff dwellings in Canyon de Chelly. Those people are often called the Anasazi, but these days the favored term is ancient Pueblo peoples.

The Hopi speak a Uto-Aztecan language, and so presumably did the Anasazi. Uto-Aztecan speakers were spread out like this shortly before the Europeans invaded:

with a bunch more down in what's now Mexico. The Navajo are part of a different group, the Na-Dené language group:

So, the Navajo aren't a big part of the story in this fascinating book:

- David E. Stuart, *Anasazi America*, U. of New Mexico Press, Albuquerque, New Mexico, 2000.

Let me summarize this story here!

After the ice

The last Ice Age, called the Wisconsin glaciation, began around 70,000 BC. The glaciers reached their maximum extent about 18,000 BC, with ice sheets down to what are now the Great Lakes. In places the ice was over 1.6 kilometers thick!

Then it started warming up. By 16,000 BC people started cultivating plants and herding animals. Around 12,000 BC, before the land bridge connecting Siberia and Canada melted, people from the so-called Clovis culture came to the Americas.

It seems likely that other people got to America earlier, moving down the Pacific coast before the inland glaciers melted. But even if the Clovis culture didn't get there first, their arrival was a big deal. They be traced by their distinctive and elegant spear tips, called Clovis points:

After they arrived, the Clovis people broke into several local cultures, roughly around the time of the Younger Dryas cold spell beginning around 10,800 BC. By 10,000 BC, small bands of hunters roamed the Southwest, first hunting mammoths, huge bison, camels, horses and elk, and later—perhaps because they killed off the really big animals—the more familiar bison, deer, elk and antelopes we see today.

For about 5000 years the population of current-day New Mexico probably fluctuated between 2 and 6 thousand people—a density of just one person per 50 to 150 square kilometers! Changes in culture and climate were slow.

The Altithermal

Around 5,000 BC, the climate near Canyon de Chelly began to warm up, dry out, and become more strongly seasonal. This epoch is called the 'Altithermal'. The lush grasslands that once supported huge herds of bison began to disappear in New Mexico, and those bison moved north. By 4,000 BC, the area near Canyon de Chelly became very hot, with summers often reaching 45°C, and sometimes 57° at the ground's surface.

The people in this area responded in an interesting way: by focusing much more on gathering, and less on hunting. We know this from their improved tools for processing plants, especially yucca roots. The yucca is now the state flower of New Mexico. Here's a picture taken by Stan Shebs:

David Stuart writes:

> At first this might seem an unlikely response to unremitting heat and aridity. One could argue that the deteriorating climate might first have forced people to reduce their numbers by restricting sex, marriage, and child-bearing so that survivors would have enough game. That might well have been the short-term solution [....] When once-plentiful game becomes scarce, hunter-gatherers typically become extremely conservative about sex and reproduction. [...] But by early Archaic times, the change in focus to plant resources—undoubtedly by necessity—had actually produced a marginally growing population in the San Juan Basin and its margins in spite of climatic adversity.
>
> [....]
>
> Ecologically, these Archaic hunters and gatherers had moved one entire link *down* the food chain, thereby eliminating the approximately 90-percent loss in food value that occurs when one feeds on an animal that is a plant-eater.
>
> [....]

> This is sound ecological behavior—they could not have found a better basic strategy even if they had the advantage of a contemporary university education. Do I attribute this to their genius? No. It is simply that those who stubbornly clung to the traditional big game hunting of their Paleo-Indian ancestors could not prosper, so they left fewer descendents. Those more willing to experiment, or more desperate, fared better, so their behavior eventually became traditional among their more numerous descendents.

The San Jose Period

By 3,000 BC the Altithermal was ending, big game was returning to the Southwest, yet the people retained their new-found agricultural skills. They also developed a new kind of dart for hunting, the 'San Jose point'. So, this epoch is called the 'San Jose period'. Populations rose to maybe about 15 to 30 thousand people in New Mexico, a vast increase over the earlier level of 2-6 thousand. But still, that's just one person per 10 or 20 square kilometers!

The population increased until around 2,000 BC. At this point population pressures became acute... but two lucky things happened. First, the weather got wetter. Second, corn was introduced from Mexico. The first varieties had very small cobs, but gradually they were improved.

The wet weather lasted until around 500 BC. And at just about this time, *beans* were introduced, also from Mexico.

> Their addition was critical. Corn alone is a costly food to metabolize. Its proteins are incomplete and hard to synthesize. Beans contain large amounts of lysine, the amino acid missing from corn and squash. In reasonable balance, corn, beans and squash together provide complimentary amino acids and form the basis of a nearly complete diet. This diet lacks only the salt, fat and mineral nutrients found in most meats to be healthy and complete.
>
> By 500 BC, nearly all the elements for accelerating cultural and economic changes were finally in place—a fairly complete diet that could, if rainfall cooperated, largely replace the traditional foraging one; several additional, modestly larger-cobbed varieties of corn that not only prospered under varying growing conditions but also provided a bigger harvest; a population large enough to invest the labor necessary to plant and harvest; nearly 10 centuries of increasing familiarity with cultigens; and enhanced food-processing and storage techniques. Lacking were compelling reasons to transform an Archaic society accustomed to earning a living with approximately 500 hours of labor a year into one willing to invest the 1,000 to 2,000 yours coming to contemporary hand-tool horticulturalists.
>
> Nature then stepped in with one persuasive, though not compelling, reason for people to make the shift.

Namely, *droughts!* Precipitation became very erratic for about 500 years. People responded in various ways. Some went back to the old foraging techniques. Others improved their agricultural skills, developing better breeds of corn, and tricks for storing water. The latter are the ones whose populations grew.

The Basketmakers

This led to the Basketmaker culture, where people started living in dugout 'pit houses' in small villages. More precisely, the Late Basketmaker II Era lasted from about 50 AD to 500 AD. New technologies included the baskets that gave this culture its name:

Pottery entered the scene around 300 AD. Have you ever thought about how important this is? Before pots, people had to cook corn and beans by putting rocks in fires and then transferring them to holes containing water!

> Now, porridge and stews could be put to boil in a pot set directly into a central fire pit. The amount of heat lost and fuel used in the old cooking process—an endless cycle of collecting, heating, transferring, removing and replacing hot stones just to boil a few quarts of water—had always been enormous. By comparison, cooking with pots became quick, easy, and far more efficient. In a world more densely populated, firewood had to be gathered from greater distances. Now, less of it was needed. And there was newer fuel to supplement it—dried corncobs.

Not all the changes were good. Most adult skeletons from this period show damage from long periods spend stooping—either using a stone hoe to tend garden plots, or grinding corn while kneeling. And as they ate more corn and beans and fewer other vegetables, mineral deficiencies became common. Extreme osteoporosis afflicted many of these people: we find skulls that are porous, and broken bones. It reminds me a little of the plague of obesity, with its many side-affects, afflicting modern Americans as we move to a culture where most people work sitting down.

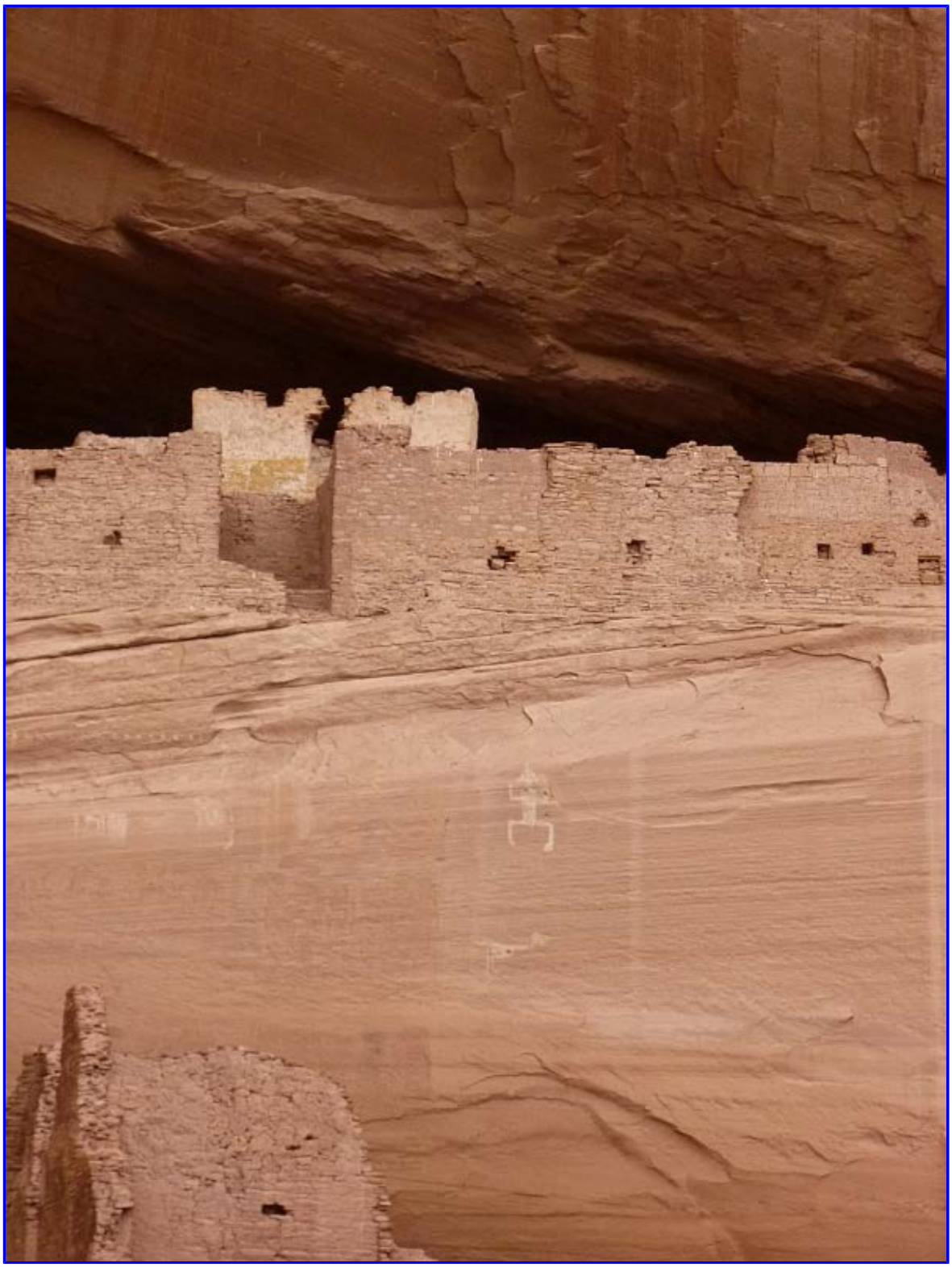
On the other hand, there was a massive growth in population. The number of pit-house villages grew nine-fold from 200 AD to 700 AD!

> It must have been an exciting time. In only some 25 generations, these folks had transformed themselves from forager and hunters with a small economic sideline in corn, beans and squash into semisedentary villagers who farmed and kept up their foraging to fill in the economic gaps.

But this was just the beginning. By 1020, the ancient Pueblo people would begin to build housing complexes that would remain the biggest in North America until the 1880s! This happened in Chaco Canyon, 125 kilometers east of Canyon de Chelly.

Next time I'll tell you the story of how that happened, and how later, around 1200, these people left Chaco Canyon and started to build cliff dwellings.

For now, I'll leave you with some pictures I took of the most famous cliff dwelling in Canyon de Chelly: the 'White House Ruins'. Click to enlarge:



January 22, 2013

Last time I told you a story of the American Southwest, starting with the arrival of small bands of hunters around 10,000 BC. I focused on the Anasazi, or 'ancient Pueblo people', and I led up to the Late Basketmaker III Era, from 500 to 750 AD.

The big invention during this time was the bow and arrow. Before then, large animals were killed by darts thrown from

slings, which required a lot more skill and luck. But even more important was the continuing growth of agriculture: the cultivation of corn, beans and squash. This was fueled a period of dramatic population growth.

But this was just the start!

The Pueblo I and II Eras

The Pueblo I Era began around 750 AD. At this time people started living in 'pueblos': houses with flat roofs held up by wooden poles. Towns became bigger, holding up to 600 people. But these towns typically lasted only 30 years or so. It seems people needed to move when conditions changed.

Starting around 800 AD, the ancient Pueblo people started building 'great houses': multi-storied buildings with high ceilings, rooms much larger than those in domestic dwellings, and elaborate subterranean rooms called 'kivas'. And around 900 AD, people started building houses with *stone* roofs. We call this the start of the Pueblo II Era.

The center of these developments was the Chaco Canyon area in New Mexico:

Chaco Canyon is 125 kilometers east of Canyon de Chelly. Unfortunately, I didn't see it on my trip—I wanted to, but we didn't have time.

By 950 AD, there were pueblos on every ridge and hilltop of the Chaco Canyon area. Due to the high population density and unpredictable rainfall, this area could no longer provide enough meat to sustain the needs of the local population. Apparently they couldn't get enough fat, salt and minerals from a purely vegan diet—a shortcoming we have now overcome!

Yet the population continued to grow until 1000 AD. In his book *Anasazi America*, David Stuart wrote:

> Millions of us buy mutual funds, believing the risk is spread among millions of investors and a large "basket" of fund stocks. Millions divert a portion of each hard-earned paycheck to purchase such funds for retirement. "Get in! Get in!" hawk the TV ads. "The market is going up. Historically, it always goes up in the long haul. The average rate of return this century is 9 percent per year!" Every one of us who does that is a Californian at heart, believing in growth, risk, *power*. It works—until an episode of too-rapid expansion in the market, combined with brutal business competition, threatens to undo it.
>
> That is about what it was like, economically, at Chaco Canyon in the year 1000—rapid agricultural expansion, no more land to be gotten, and deepening competition. Don't think of it as "romantic" or "primitive". Think of it as just like 1999 in the United States, when the Dow Jones Industrial Average hit 11,000 and 30 million investors held their breath to see what would happen next.

The Chaco phenomenon

In 1020 the rainfall became more predictable. There wasn't *more* rain, it was simply less erratic. This was good for the ancient Pueblo people. At this point the 'Chaco phenomenon' began: an amazing flowering of civilization.

We see this in places like Pueblo Bonito, the largest great house in Chaco Canyon:

Pueblo Bonito was founded in the 800s. But starting in 1020 it grew immensely, and it kept growing until 1120. By this time it had 700 rooms, nearly half devoted to grain storage. It also had 33 kivas, which are the round structures you see here.

But Pueblo Bonito is just one of a dozen great houses built in Chaco Canyon by 1120. About 215 thousand ponderosa pine trees were cut down in this building spree! Stuart estimates that building these houses took over 2 million man-hours of work. They also built about 650 kilometers of roads! Most of these connect one great house to another... but some mysteriously seem to go to 'nowhere'.

By 1080, however, the summer rainfall had started to decline. And by 1090 there were serious summer drought lasting for five years. We know this sort of thing from tree rings: there are enough ponderosa logs and the like that archaeologists have built up a detailed year-by-year record.

Thanks to overpopulation and these droughts, Chaco Canyon civilization was in serious trouble at this point, but it charged ahead:

> Part of Chacoan society were already in deep trouble after AD 1050 as health and living conditions progressively eroded in the southern districts' open farming communities. The small farmers in the south had first created reliable surpluses to be stored in the great houses. Ultimately, it was the increasingly terrible conditions of those farmers, the people who grew the corn, that had made Chacoan society so fatally vulnerable. They simply got back too little from their efforts to carry on.
>
> [....]
>
> Still, the great-house dwellers didn't merely sit on their hands. As some farms failed, they used farm labor to expand roads, rituals, and great houses. This prehistoric version of a Keynesian growth model apparently alleviated enough of the stresses and strains to sustain growth through the 1070s. Then came the waning rainfall of the 1080s, followed by drought in the 1090s.
>
> Circumstances in farming communities worsened quickly and dramatically with this drought; the very survival of many was at stake. The great-house elites at Chaco Canyon apparently responded with even more roads, rituals, and great houses. This was actually a period of great-house and road infrastructure "in-fill", both in and near established open communities. In a few years, the rains returned. This could not help but powerfully reinforce the elites' now well-established, formulaic response to problems.
>
> But roads, rituals, and great houses simply did not do enough for the hungry farmers who produced corn and pottery. As the eleventh century drew to a close, even though the rains had come again, they walked away, further eroding the surpluses that had fueled the system. Imagine it: the elites must have believe the situation was saved, even as more farmers gave up in despair. Inexplicably, they never "exported" the modest irrigation system that had caught and diverted midsummer runoff from the mesa tops at Chaco Canyon and made local fields more productive. Instead, once again the elites responded with the sacred formula—more roads, more rituals, more great houses.

So, Stuart argues that the last of the Chaco Canyon building projects were "the desperate economic reactions of a fragile and frightened society".

Regardless of whether this is true, we know that starting around 1100 AD, many of the ancient Pueblo people left the Chaco Canyon area. Many moved upland, to places with more rain and snow. Instead of great houses, many returned to building the simpler pit houses of old.

Tribes descending from the ancient Pueblo people still have myths about the decline of the Chaco civilization. While such tales should be taken with a huge grain of salt, these are too fascinating not to repeat. Here are two quotes:

> In our history we talk of things that occurred a long time ago, of people who had enormous amounts of power, spiritual power and power over people. I think that those kinds of people lived here in Chaco.... Here at Chaco there were very powerful people who had a lot of spiritual power, and these people probably used their power in ways that caused things to change, and that may have been one of the reasons why the migrations were set to start again, because these these people were causing changes that were never meant to occur.
>
> My response to the canyon was that some sensibility other than my Pueblo ancestors had worked on the Chaco

> great houses. There were the familiar elements such as the *nansipu* (the symbolic opening into the underworld), kivas, plazas and earth materials, but they were overlain by a strictness and precision of design that was unfamiliar.... It was clear that the purpose of these great villages was not to restate their oneness with the earth but to show the power and specialness of humans... a desire to control human and natural resources... These were men who embraced a social-political-religious hierarchy and envisioned control and power over places, resources and people.

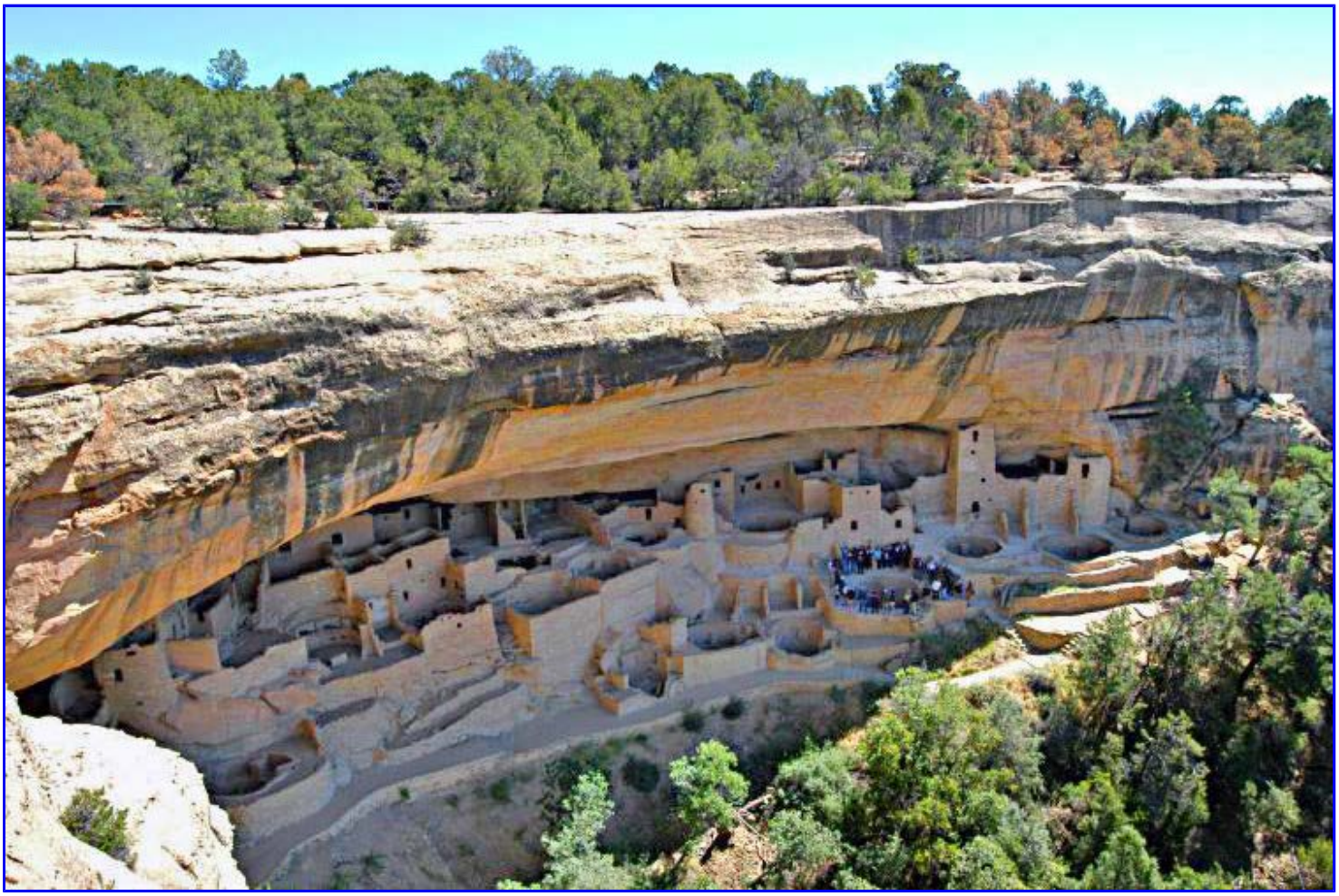
These quotes are from an excellent book on the changing techniques and theories of archaeologists of the American Southwest:

- Stephen H. Lekson, *A History of the Ancient Southwest*, School for Advanced Research, Santa Fe, New Mexico, 2008.

What these quotes show, I think, is that the sensibility of current-day Pueblo people is very different from that of the people who built the great houses of Chaco Canyon. According to David Stuart, the Chaco civilization was a 'powerful' culture, while their descendants became an 'efficient' culture:

> ... a powerful society (or organism) captures more energy and expends (metabolizes) it more rapidly than an efficient one. Such societies tend to be structurally more complex, more wasteful of energy, more competitive, and faster paced than an efficient one. Think of modern urban America as powerful, and you will get the picture. In contrast, an efficient society "metabolizes" its energy more slowly, and so it is structurally less complex, less wasteful, less competitive, and slower. Think of Amish farmers in Pennsylvania or contemporary Pueblo farms in the American Southwest.
>
> In competitive terms, the powerful society has an enormous short-term advantage over the efficient one *if* enough energy is naturally available to "feed" it, or if its technology and trade can bring in energy rapidly enough to sustain it. But when energy (food, fuel and resources) becomes scarce, or when trade and technology fail, an efficient society is advantageous because it simpler, less wasteful structure is more easily sustained in times of scarcity.

The Pueblo III Era



By 1150 AD, some of the ancient Pueblo people began building cliff dwellings at higher elevations—like Mesa Verde in Colorado, shown above. This marks the start of the Pueblo III Era. But this era lasted a short time. By 1280, Mesa Verde was deserted!

Some of the ruins in Canyon de Chelly also date to the Pueblo III Era. For example, the White House Ruins were built around 1200. Here are some of my pictures of this marvelous place. Click to enlarge:

But again, they were deserted by the end of the Pueblo III Era.

Why did the ancient Pueblo people move to cliff dwellings? And why did they move out so soon?

Nobody is sure. Cliff dwellings are easy to defend against attack. Built into the south face of a cliff, they catch the sun in winter to stay warm—it gets cold here in winter!—but they stay cool when the sun is straight overhead in summer. These are good reasons to build cliff dwellings. But these reasons don't explain why cliff dwellings were so popular from 1150 to 1280, and then were abandoned!

One important factor might be this: there was a series of severe droughts starting around 1275. There were also raids from other tribes: speakers of Na-Dené languages, who eventually became the current-day Navajo inhabitants of this area.

Drought alone may be unable to explain what happened. Quoting Stephen Lekson's book:

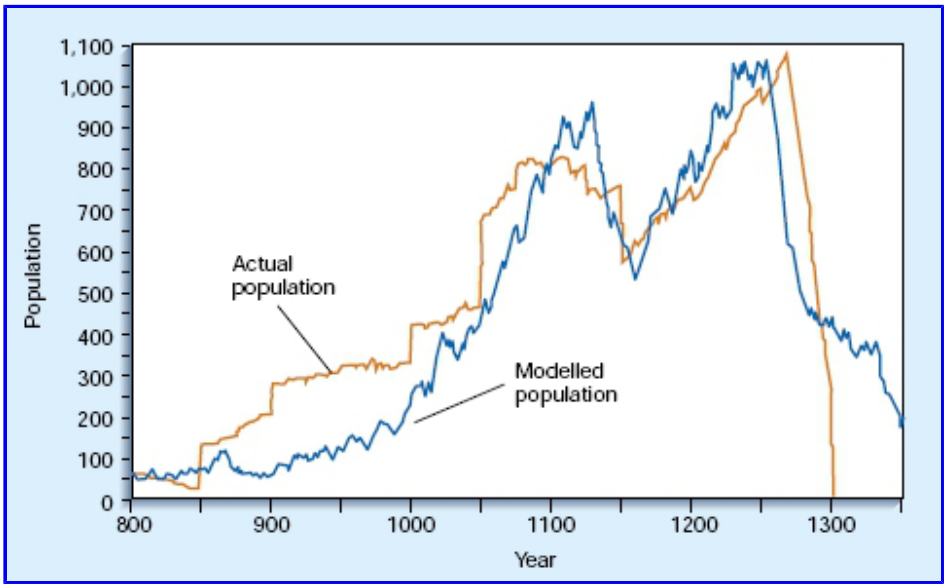
> Two current computationally high-powered projects—the Artificial Anasazi Project and the Villages Project—are modelling the lives and hard times of the ancient Plateau peoples. [....] The Artificial Anasazi Project is the heir apparent of SARG [the Southwest Archaeological Research Group] and *The Anasazi in a Changing Environment* agent-based modeling of the Long House Valley from 200 to 1300, undertaken by several SARG alumni and the Santa Fe Institute. The Villages Project, a collaboration of Washington State University and the Crow Canyon Archaeological Center, focuses on the northern San Juan or Mesa Verde region. A recent joint summary in *Scientific American* reviewed the successes and failures of high-resolution environmental modeling. Both projects mirrored actual settlement patterns from 800 to 1250 with admirable accuracy. Problems rose, however, with the abandonments of the regions, in both cases after 1250. There were unexplained exceptions, misfits between the models and reality.
>
> Those misfits were not minor. Neither model predicted complete abandonment. Yet it happened. That's

> perplexing. In the *Scientific American* summary of the Long House Valley model, Kohler, Gummerman, and Reynolds write, "We can only conclude that sociopolitical, ideological or environmental factors *not* included in our model must have contributed to the total depopulation of the valley." Similar conundrums best the Villages Project: "None of our simulations terminated with a population decline as dramatic as what actually happened in the Mesa Verde region in the late 1200."

These simulation projects look interesting! For more info, click on the links. Also try this short review by the author of a famous book on why civilizations collapse:

- Jared Diamond, Life with the artificial Anasazi, *Nature* **419** (2002), 567–569.

From this article, here are the simulated versus 'actual' populations of the ancient Pueblo people in Long House Valley, Arizona, from 800 to 1350 AD:



The so-called 'actual' population is estimated using the number of house sites that were active at a given time, assuming five people per house.

This graph gives a shocking and dramatic ending to our tale! Let's hope our current-day tale doesn't end so abruptly, because in abrupt transitions much gets lost. But of course the ancient Pueblo people didn't disappear. They didn't all die. They became an 'efficient' society: they learned to make do with diminished resources.

January 23, 2013

I'm afraid I have to debunk this article:

- From the 'X Files': "Advanced civilizations may live inside supermassive black holes", *Daily Galaxy*, January 18, 2013.

It starts with some perfectly sensible stuff about supermassive black holes that lurk at the centers of galaxies, but then it says:

> The inner workings of these supermassive black holes may be less hostile than we realize, possibly with stable regions where life and even planets could exist, according to Russian cosmologist Vyacheslav Dokuchaev at Moscow's Institute for Nuclear Research of the Russian Academy of Sciences.

Huh? I looked at his paper:

- Vyacheslav I. Dokuchaev, Is there life inside black holes?

The first warning sign comes right away:

> To clarify this possibility we suppose that BH interiors are described by the Kerr-Newman metric with a maximally extended global geometry. These BHs are named the eternal ones.

So he's talking about purely hypothetical rotating charged black holes that have always existed, not realistic ones formed from collapsing matter. These hypothetical 'eternal' black holes can be mathematically 'extended' to give worlds where the black hole is an entrance to a kind of corridor with infinitely many universes branching off it... like doors off a hallway. If we lived in a world like that, we might be able to jump into the black hole, go down the corridor and pop out into another universe!

But alas, this weird and wonderful scenario does not occur in the rotating charged black holes in our world, since ours are formed from collapsing matter!

The second warning sign comes here:

> The irresistible infall [...] will finish soon after traversing the inner Cauchy horizon [....] The internal space-time domain [...] between the central singularity and the inner BH horizon is the R-region, where stationary observers may exist just as anywhere on the planet Earth. This internal BH domain, hidden by the two horizons from the whole external universe, is indeed a suitable place for safe inhabitation. The only thing needed is to put your vehicle or your planet to a stable periodic orbit inside BH.

Sorry... no! According to simplified calculations, a rotating or charged black hole has an 'inner Cauchy horizon' inside the 'event horizon'. The event horizon is the point of no return: once you pass that, you can't get out of the black hole. The inner Cauchy horizon is the place where, according to simplified calculations, your future ceases to be determined by the past.

Sounds cool, eh? But unfortunately, more detailed calculations show that an infinitely bright sheet of light forms at the inner Cauchy horizon. When you hit this you'd be destroyed... just as in the abrupt end to the movie here!

This movie was made by Andrew Hamilton using a supercomputer simulation by John Hawley. It shows what it's like to fall into a Reissner-Nordstrom black hole, meaning one that's charged but not rotating. (A Kerr-Newman black hole is both charged and rotating.)

In this movie, you fall into a 4 million solar mass black hole like the one at the center of our galaxy. The clock shows the time in seconds as measured by your wristwatch. The tidal forces are weak enough that you aren't stretched to death. You safely pass through the event horizon — the point of no return. But you're vaporized when you hit the inner Cauchy horizon.

I should add that the 'more detailed calculations' that predict an infinitely bright sheet of light are still simplified. If there were an infinitely bright sheet of light, or even a very very very bright sheet of light, this would bend the geometry of spacetime in a drastic way. But in the calculation I'm talking about, this effect is neglected. A truly realistic calculation of what happens inside a charged or rotating black hole is very hard... and as far as I know, it's never been done!

But: nothing suggests there's a comfy region inside a supermassive black hole, where an advanced civilization could find peace and quiet, safe from childish civilizations like ours.

For an explanation of the movie and what's realistic and unrealistic about it, try this:

- Andrew Hamilton, Journey into a realistic black hole.

For more details, this paper is very good:

- Andrew J. S. Hamilton and Pedro P. Avelino, The physics of the relativistic counter-streaming instability that drives mass inflation inside black holes.

For my February 2013 diary, go here.

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baez@math.removethis.ucr.andthis.edu

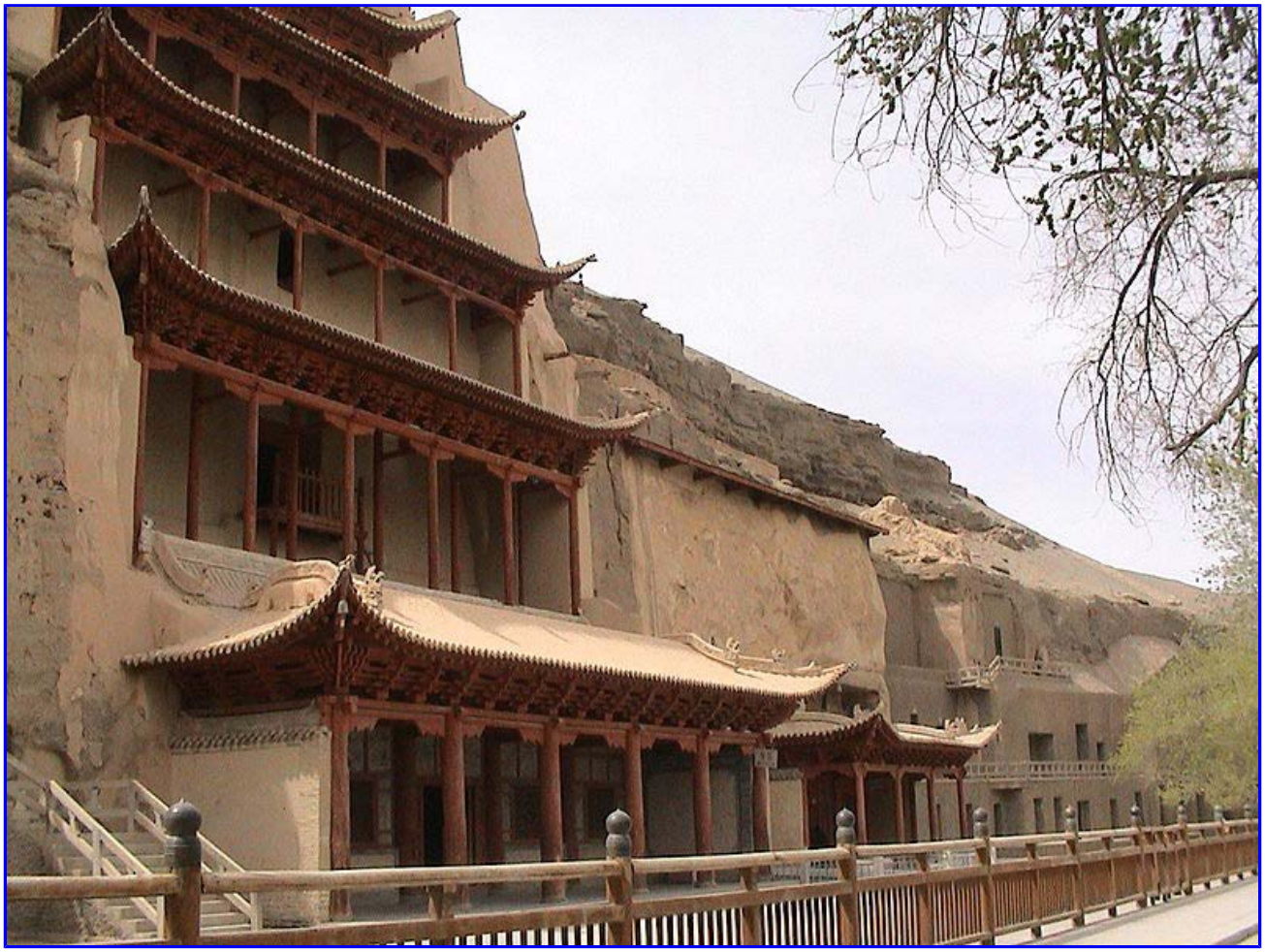
home

For my January 2013 diary, go here.

Diary - February 2013

John Baez

February 1, 2013



This summer I'm going to the Mogao Caves near the old Silk Road town of Dunhuang. I'm so excited!

> Locked away in the heart of the Gobi desert, four days' camel ride from the nearest town, lies one of the least-known of China's many wonders, the 'Caves of the Thousand Buddhas' at Tun-Huang. Here, carved in irregular rows into the cliff face and filled with magnificent wall-painting and sculptures, are more than four hundred ancient rock temples and chapels. Tun-Huang, which means 'Blazing Beacon', was the last caravan halt in China proper for travellers setting out along the old Silk Road. Piligrims, merchants and soldiers about to leave China for the spiritual darkness and physical dangers of the Taklamakan desert prayed at Tun-Huang's shrines for deliverance from the goblins and other perils ahead.

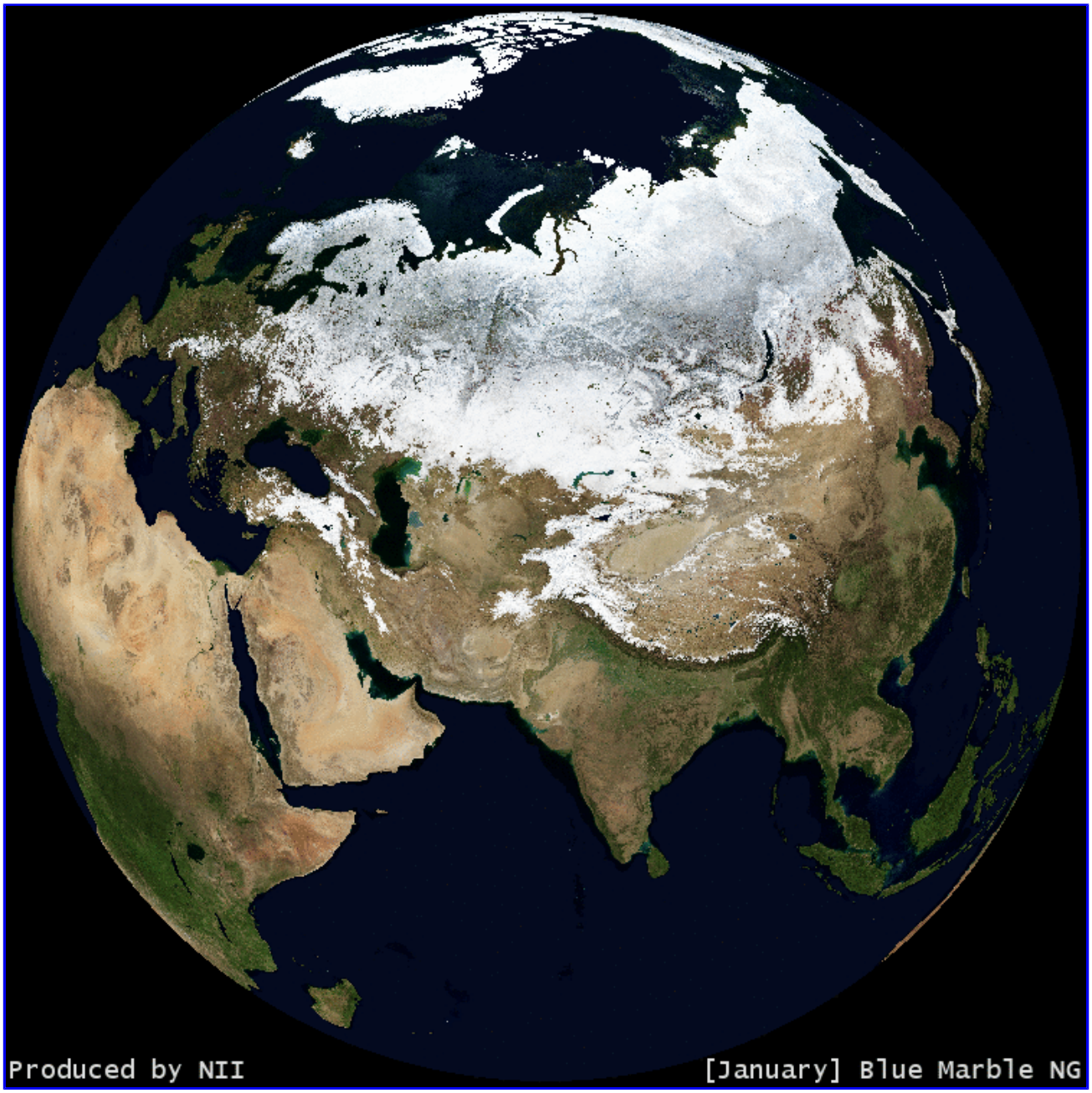
I've been wanting to explore this area, and the even more forbidding Taklamakan Desert, ever since I read Peter Hopkirk's *Foreign Devils on the Silk Road*, which I quote above. Aurel Stein's travel memoir *Ruins of Desert Cathay* made me even more intrigued. But I never had an excuse until now! I'll be in Singapore this summer, but Chenchang Zhu has invited me to a conference on higher algebraic structures in Lanzhou, and we will take an excursion to Dunhuang, 1100 kilometers to the west.

I'm afraid I'm going to keep posting about this subject until August, to relieve the twitchy excitement I'm feeling.

February 7, 2013

Just 6 kilometers south of Dunhuang you feel you're deep in the Gobi Desert. But then you see an oasis called Crescent Lake. You can get there on a camel or a four-wheel drive. I want to go there! The lake was about 5 meters deep in 1960. By the early 1990s it had shrunk to just 1 meter deep. In 2006, the local government started working to restore its depth.

February 8, 2013



Watch the seasons change! You can see the month at lower right. See the place north of India, north of Tibet, that never changes color? It's called the Taklamakan Desert. Sven Hedin, one of the first Europeans to explore it, called it the "worst and most dangerous desert in the world". It's a cold desert full of shifting sand dunes. Temperatures drop to -20 °C (-4 °F) in the winter, though it gets hot in the summer.

Dunhuang, the city I'm visiting in August, lies in the Gobi Desert, east of the Taklamakan. Travelers going west along the Silk Road would stop at Dunhuang before deciding to go north or south around the Taklamakan. Both these routes pass through ancient cities built on oases. I want to tell you more about this whole area. Not only is it the romantic Wild West of China, it's full of fascinating history, since the Silk Road was a meeting-ground of many ancient cultures.

This picture comes from a collection at the Digital Silk Road Project.

The Taklamakan Desert is almost surrounded by mountains: the Tien Shan range on the north, the Pamirs on the west, and the Kunlun mountains on the south. Water flows from these into the desert, into the Tarim River, and then to the mostly dried-up lake of Lop Nur. This let the explorer Sven Hedin travel by boat through the Taklamakan for eighty days back in 1899.

With a crew of five, he started on the Yarkand River and then took the Tarim almost to Lop Nur. Sometimes they would be carried by raging torrents; sometimes the river slowed and they would use a sail. For a while they got stuck in ice. At the end they discovered the ruins of Loulan, where they unearthed Chinese manuscripts from the Western Jin Dynasty (265-420)... and a wooden tablet with Kharosthi script on it!

Kharosthi was a language used in Afghanistan and Pakistan starting around the 3rd century BC, but later in Sogdiana, an empire centered around Samarkand. This language may have survived until the 7th century in some towns along the Silk Road.

Kharosthi is actually available as part of UNICODE, but my computer doesn't display it, and yours probably doesn't either — so if you're interested, go to the Wikipedia article.

February 9, 2013

Lanzhou is a big city, but if you drive south it quickly becomes mountainous, and in 4 hours you can reach the Labrang Temple. It's still in Gansu province, but it's one of the main monasteries of the Yellow Hat school of Tibetan Buddhism.

Labrang was founded in 1709, and it sits at the meeting-place of four Asian cultures: Tibetan, Mongolian, Han Chinese, and Hui, also called 'Muslim Chinese'. It was one of the largest Buddhist monastic universities, and a seat of Tibetan power until the early 1900s. It was repeatedly attacked by the Ma clique, a group of Hui warlords in Northwestern China who ruled the Chinese provinces of Qinghai, Gansu and Ningxia from the 1910s until 1949. It was closed by the communists from 1958 to 1970. But it's active again, with about a thousand monks, and some amazing annual festivals. I want to see this place!

February 9, 2013

Go 420 kilometers north of Lanzhou and you reach Badain Jaran, also called Badan Jilin, with the biggest sand dunes on Earth, near the edge of the otherwise rocky Gobi Desert. With immense optimism, a Chinese website calls this area a "resort":

> Badan Jilin Desert Tourism Resort, with an area of 47 thousand square kilometers and an altitude of 1200-1700 meters, has an extremely dry climate and hot sunshine. The highest temperature in the burning summer time can reach 38°C-43°C. The surface

> ground even has higher temperature. The highest temperature of the desert can be up to 70°C-80°C. During the winter and spring time, the wind is very strong. On the eastern and south-western edges of the desert, the Gobi is boundless and infinite.

Amazingly, there are lakes with fish here. Badan Jilin seems to be a Chinese form of the Mongolian name Badain Jaran, meaning Mysterious Lakes. And by one of these lakes there is a monastery, shown here.

No, it's not a resort! It cannot be reached except by camel or four-wheel drive, and in Nick Middleton's book *Extremes Along the Silk Road* his driver got stuck in dunes shortly before reaching it:

> The driver kept trying. On a couple of occasions, we all jumped out to dig when our wheels buried themselves in the sand, each time agonizingly close to the summit of the ridge. After the second time, Bruno and I stayed out and trudged up to the summit to watch the vehicle, now slightly lighter, descend, circle, and try again.
>
> It was late in the afternoon when we finally gave up, unloaded what we could carry and walked the rest of the way to the Alashan Miao monastery on the edge of the lake.

I don't think I'll be going here.

This photo was taken by kailas97. This guy has taken a lot of great pictures of this rugged area! You can see them on Panoramio.

February 10, 2013

Here's an ancient Chinese watchtower outside the western part of Dunhuang, the Silk Road oasis town famous for its caves. In the background are the Mingsha sand dunes, which lie between Dunhuang and more distant mountains.

Dunhuang means 'Blazing Beacon', so perhaps we should imagine this tower lit up with flames. Daniel Waugh writes:

> The physical geography of Dunhuang, its region, and the approaches to it help to explain why the town became so important militarily. The most logical route from the interior of China to the West moves through the "funnel" of the Gansu or Hexi Corridor, bounded on north and south by mountains. The mountains to the south are high enough to serve as barriers to invasion, and their glaciers fed the streams which made habitation in an otherwise dry region possible. To the north, the terrain is less well defended by nature; it was for this reason that, beginning in the last centuries BCE, the rulers of China began to create the "Great Wall," to defend against nomadic incursions. The Han emperors, especially beginning with Wu-Ti (141-87 BCE) extended the wall and its network of watchtowers along the Hexi corridor, through the "bottleneck" at Jiayu Guan (later to be the western boundary of China under the Ming) along both sides of the broadening valley past Anxi and well beyond Dunhuang. The British explorer Aurel Stein made the exciting discovery that the Han "limes" extended all the way to Lop Nor,

the salt lake at the edge of the Taklamakan Desert.

Here "limes" is an allusion to the walls marking the limit of the Roman empire.

> While it was possible for invaders to break through the defenses to the east of Dunhuang, the fortifications there in a real sense were the gateway to inner China. Even at the greatest extent of Chinese power in Inner Asia in the period up to the end of the first millenium CE, Chinese control beyond Dunhuang was exercised largely through vassal states. Written records indicate that Chinese travelers to the West clearly sensed they had stepped into another world at the moment they passed through the "Jade Gate." To go beyond was to leave behind the comforts of home and to enter culturally alien lands. Except for the garrisons manning the watch towers and small forts, Chinese armies almost inevitably retreated behind the defenses, often in disarray from their inability to provision themselves adequately on long stages through the desert.

I got this information from Daniel Waugh's Dunhuang website, and the photo from Wikipedia.

February 11, 2013

This thing at the eastern edge of the Taklamakan Desert is *big*. It's about 6 kilometers across and 20 long. You can see it on Google Maps here: Lop Nur. What is it? Could it be a

> ...training ground for human-fish hybrids, in preparation for colonization of the Pacific floor?

That's what one blogger jokingly suggests, but NASA's website gives the real answer:

> Located in China's resource-rich but moisture-poor Xinjiang autonomous region, Lop Nur is an uninviting location for any kind of agriculture. It sits at the eastern end of the Taklimakan Desert, where marching sand dunes can reach heights of 200 meters (650 feet), and dust storms rage across the landscape.
>
> Yet for all it lacks in agricultural appeal, Lop Nur offers something valuable to farmers the world over: potash. This potassium salt provides a major nutrient required for plant growth, making it a key ingredient in fertilizer.
>
> The discovery of potash at Lop Nur in the mid-1990s turned the area into a large-scale mining operation. The Advanced Land Imager (ALI) on NASA.s Earth Observing-1 (EO-1) satellite captured this natural-color image of Lop Nur on May 17, 2011. The rectangular shapes in this image show the bright colors characteristic of solar evaporation ponds. Around the evaporation ponds are the earth tones typical of sandy desert.

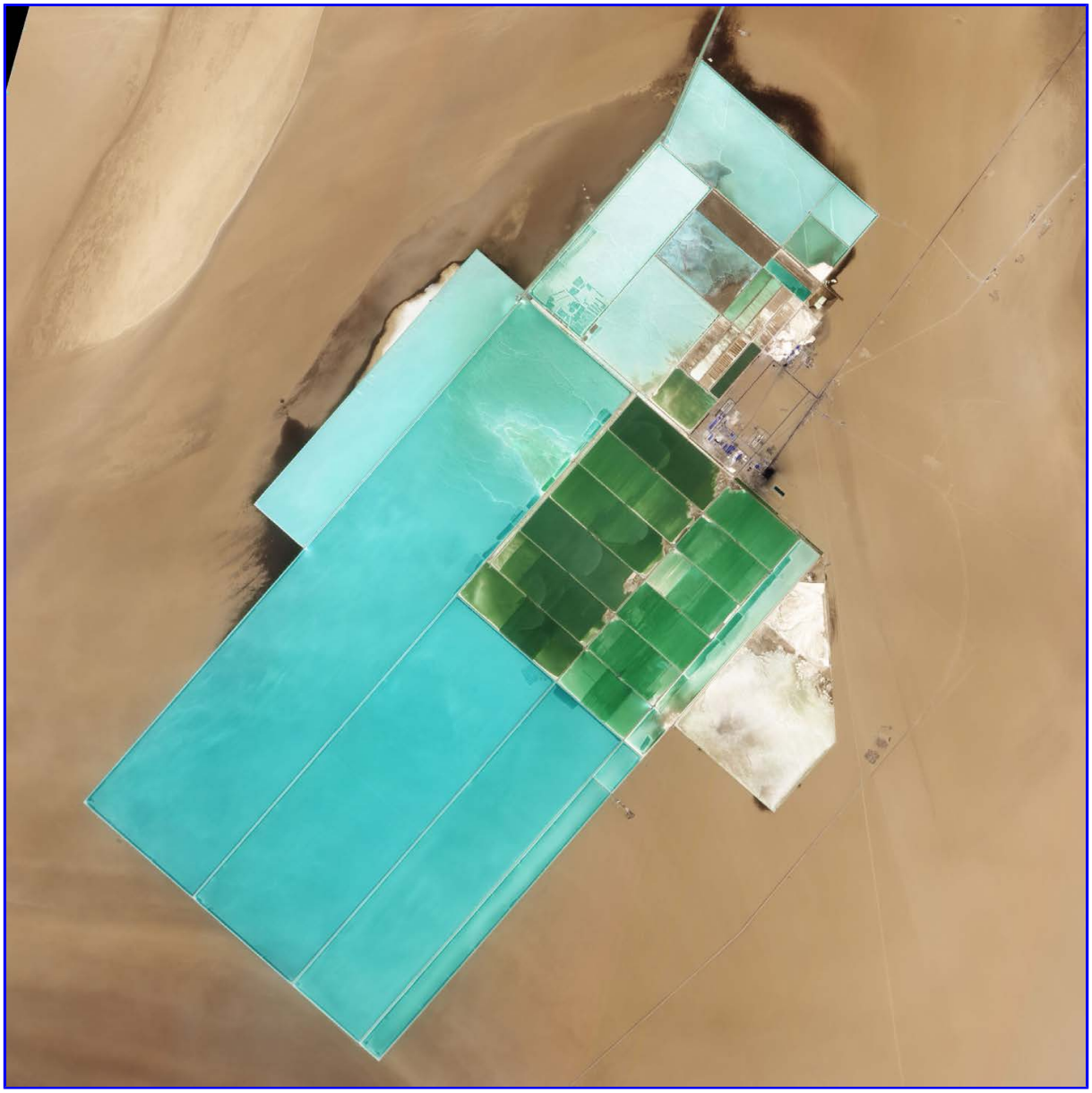
During the early and middle Pleistocene epoch, this area held a large brackish lake. Uplift of the northern part of the lake in the late Pleistocene created hollows that became receptacles for potash deposition. The main potash deposits found at Lop Nur today are brine potash, and this site is the second-largest source of potash in China.

Lop Nur slowly dried up in the Holocene. The area now receives average annual precipitation of just 31.2 millimeters (1.2 inches), and experiences annual evaporation of 2,901 millimeters (114 inches), according to a study published in 2008. The study found, however, that this area has experienced seven major climate changes since the end of the Pleistocene, including climatic conditions far more favorable to farming and settlement than today.

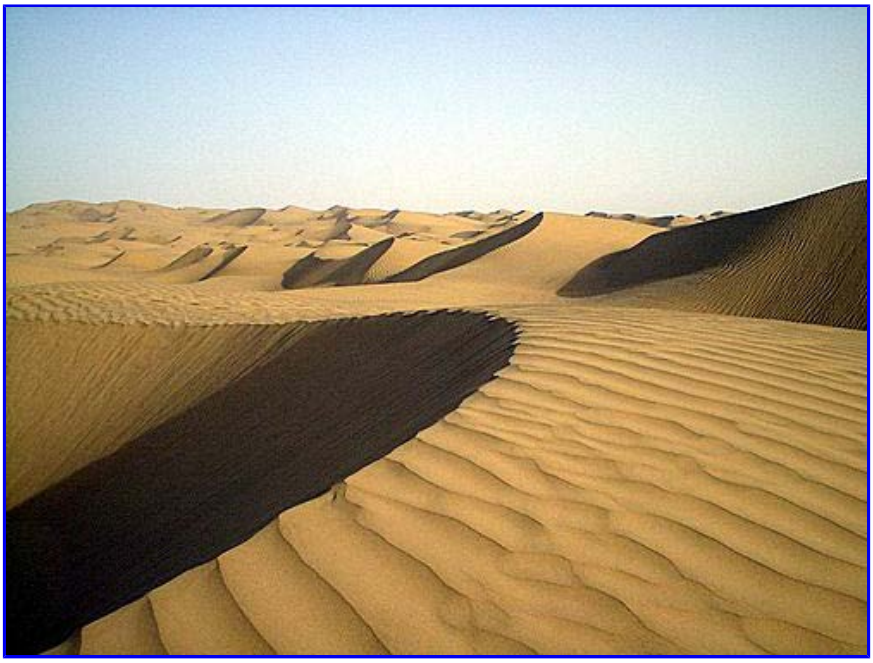
Examination of plant and mollusk remains at the lake, as well as studies of sediments, indicate that the Lop Nur region experienced a severe drought about 3,000 years ago, followed by wetter conditions. Between 1,250 and 400 years ago, Lop Nur likely experienced the conditions most favorable to farming and settlement, and red willow trees grew in the area. Pottery dating from the Tang and Song dynasties further testifies to welcoming conditions at the lake centuries ago.

Starting around 400 years ago, however, a more arid climate took hold, completely drying out Lop Nur. Today, by providing potash, the desiccated lake still supports agriculture, but it does so for farming efforts further afield.

The photo mentioned above is not the one you see here — it's on NASA's webpage and it looks like this:



February 15, 2013



While the edge of the Taklamakan Desert is a gravel desert with scattered oases, its heart consists of shifting sand dunes. In general, these dunes are between 20 and 100 meters high, and they are crescent-shaped. They're called barchan, and they slowly move along with the wind, with a steep downwind face and a less steep upwind face.

This photo was taken by zhou1 near the eastern end of the Taklamakan, and you can see it together with others on Panoramio.

The nearest town seems to be Qiemo, also known as Charchan or Qarqan. This town has a history dating back to the Bronze Age: some 2,400-year-old mummies were found less than five kilometers southwest of the city center. During the Former Han Dynasty (123 BC to AD 23) it was described as having "230 households, 1610 individuals with 320 persons able to bear arms..." with grapes and various types of fruit. The climate was wetter then!

February 16, 2013

Tian Shan means 'heavenly mountains', and here they seem to be floating in the clouds! This was taken north of Dabancheng, a small city at the northeast edge of the Taklamakan Desert. While this desert is fiercely dry, its fringes gather rain and runoff from the surrounding

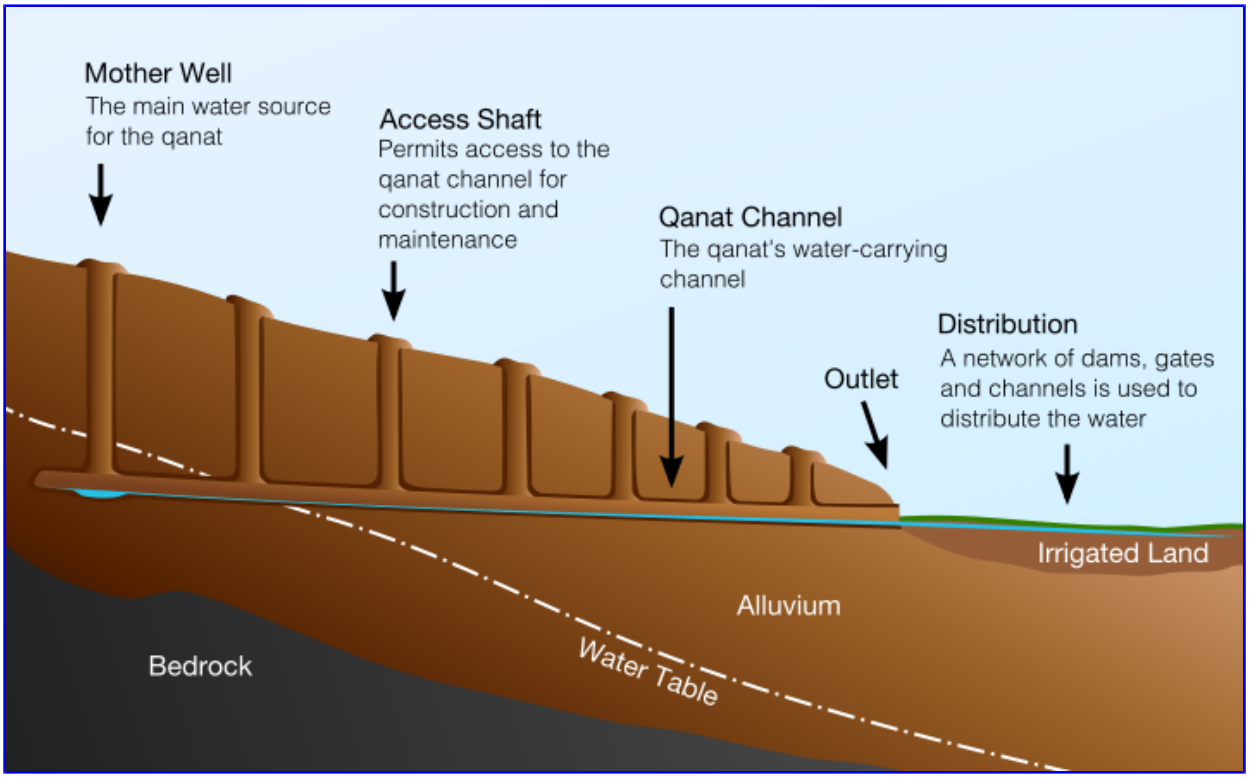
mountains, and here the land looks downright delightful.

The Tian Shan range forms the northern border of the Taklamakan Desert. This range was formed along with the Himalayas by the collision of the Indian and Eurasian plates, starting about 60 million years ago near the beginning of the Cenozoic. It's one of the longest mountain ranges in Central Asia - 2800 kilometers long, going east from Tashkent in Uzbekistan all the way to where this picture was taken!

Dabancheng is pretty obscure, but it's near a much bigger city, Urumqi. This was an important Silk Road stop in the Tang Dynasty. It's also farther from any ocean than any other city in the world: 2500 kilometers to salt water! This area is truly the 'Wild West' of China.

This photo was taken by ssSUH, and you can see it together with others on Panoramio.

February 17, 2013



The Silk Road town of Turpan is near the hottest, driest part of China — but it's famous for its grapes. How do they get water? Starting around 100 BC, people have dug wells and linked them with underground canals to collect runoff from the nearby Tian Shan mountains and carry it to their farms!

These canals take advantage of the steep land: while the mountains are quite high, the nearby Turpan Depression is the third lowest place on the Earth, 145 meters below sea level. Having canals underground helps reduce evaporation. They provide water year-round. They clearly work: there are over 1100 wells, and the canals have a total length of over 5000 kilometers!

Underground canal systems of this sort are common in the Middle East. Such a thing is often called a qanat — an Arabic word — but in Turpan they speak of the karez system, after a closely related Persian word, which has found its way into the local Uyghur language.

Sylvia Volk has a great page describing how qanats are built:

> First, you need a man with money to invest. Qanats are a good, sound investment: a well-made qanat can be used by many families for many, many years. Two or three good qanats will supply all the irrigation water for a small village. And the man who builds the qanat owns the water that runs through it; the family who owns a qanat will be collecting revenue for several generations to come.
>
> Next, you need a water-finding expert. The process by which they locate a water-source is apparently a jealously-guarded secret. But what is needed is a good well, about three hundred feet deep, with enough water that the bottom will accumulate a depth of two meters overnight. It has to be uphill of the area to be irrigated; that's very important. If it's not uphill, it's useless.
>
> Surveyors follow the water-finding expert, and dig their well. This well is called 'the mother well'. The surveyors measure its depth with a rope. They calculate where the qanat will come out . . . and this must be on lower ground (naturally!) feasible for

farming. (Most of the Asian desert is feasible for farming - just as long as you can get water to it.)

But this is how the surveyors find the spot where water will flow out: they set a pole upright, some distance downhill from the mother well. And stretch a string taut - from the well, to the pole. The string has to be leveled, and this they do by dripping water on it, and adjusting the tilt of the string until this water runs both ways (!!). Then they note the spot where this string meets the pole, and measure the height of the pole on the rope which measures the mother well's depth. They tie off a knot on the rope to mark it. Then they set out another pole downhill, mark the height, tie another knot, etc . . . and when the whole length of the string is knotted off, they have found the level at which the water must emerge. Theoretically. It seems like a hit-or-miss prospect to anyone raised with Western engineering; but this is stone-age technology, done with stone-age tools. And it does work: the proof is in the qanats.

The last task given to these surveyors is to dig shafts every three hundred yards along the course of the qanat, referring to the knotted string to dig to the correct depth.

Next, qanat experts called *muqannis* are called in. Wise men that they are, they start a little downhill from the emergence level indicated by the surveyors. The surveyors' shafts guide them, but they dig their own shafts every fifty feet or so, to remove material and for ventilation. Then they dig the qanat's channel, starting at the bottom and burrowing until they come to the top, and this is the channel down which the water will run. This is the business part of the qanat, and the muqannis dig the whole thing underground. It's a tunnel linking all these shafts together.

The channel is kept reasonably straight by placing two lamps in it, behind the diggers and several yards apart from each other. Then, the diggers can glance back over their shoulders as they work; if they see the two flames superimposed on each other, they know the way is straight. Nevertheless, there are usually sharp kinks in the channel just below each well, marking errors in the direction taken by the muqannis. Remember, these diggers start at the bottom and work uphill toward the mother well. When the muqannis reach water-bearing strata, the seepage runs away down the channel behind them. <> Just before the channel breaks through to it, someone has to empty the mother well; otherwise, the diggers won't be happy men. (You could lose a lot of muqannis that way.) However, once the channel breaks through, the muqannis are finished. If need be, they brace the qanat walls with oval bricks. They leave the original shafts open, so that they can climb down into the qanats and clean them if necessary; for muqannis also hire themselves out as qanat maintenance men.

And there you have it: a working qanat. A great boon to the community. It will be honored with a name of its own, for qanats are always given names. On the surface, it will be visible from an airplane: it will be a line of perfectly round green spots running across barren ground, and these green spots are lush grass growing around each ventilation shaft. The shafts themselves are usually capped with wooden covers, but obviously the moisture escapes. The channels of the qanat will be about four feet wide, and muqannis will walk them regularly, cleaning them as sewers are cleaned - and ducking, for bats with eight-inch wingspans live in the qanat tunnels and fly in and out at every exit. At the qanat's outlet, canals will run in every direction, carrying the water to fields and gardens and houses. A single qanat in Iran usually run two miles or more, and irrigates an area two miles square.

February 22, 2013

Here's an underground canal, or 'karez', in the old Silk Road town of Turpan. It looks spooky, but it must be great to see water in this town at the edge of the Taklamakan Desert! It only rains 1.6 centimeters per year on average. And the climate is harsh. The summers are long and very hot, the winters are short but very cold. The temperature easily drops to -12 °C (10 °F) in January, and shoots up to 40 °C (104 °F) in July. But thanks to the karez system, the hot dry summers let the farmers around Turpan grow a lot of high quality fruit. The town is famous for its very sweet grapes and melons.

This picture was taken by Vinh Binh.

For my March 2013 diary, go here.

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baez@math.removethis.ucr.andthis.edu

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For my February 2013 diary, go here.

Diary - March 2013

John Baez

March 3, 2013

This was once the capital of a kingdom! Beginning around 2 BC, the kingdom of Loulan on the eastern end of the Taklamakan Desert had a city of the same name as its capital. At the time, the nearby lake Lop Nur was big and full of water. Now it's mostly dry, and the city has been abandoned for centuries.

This photo is from the China Expat website. I'd like to go there, but I probably won't. Why not? On this site, Ernie Diaz writes:

> Korla, lying on the route between Urumqi and Kashgar, is the only city of substance in the vicinity of Loulan. From there, excursions can be arranged, involving camels as well as automobile. True, it takes considerable trouble to see this place that isn't there anymore. Such is the price of adventure.
>
> How to get there: A trip to the Ancient City of Loulan is not recommended to casual tourists because the journey is difficult and Loulan's remote location and harsh natural environment can prevent help reaching you in the event of an emergency. But if you are determined to go, please read the following tips carefully:
>
> 1. The Milan 36 Tuanchang, located 74 kilometers West of the county seat of Ruoqiang, is the best place from which to begin a Loulan exploration. You need to drive North-East for 222 kilometers and it will require constant use of GPS and a compass to stop yourself from getting lost. The condition of the ground makes driving very difficult, so your speed at points might be limited to about 3 kilometers per hour.
>
> 2. Vehicles can go no closer than 18 kilometers to the ruins of the ancient city, and you will have to finish the rest of the journey by foot or by camel.
>
> 3. The best time to visit Loulan is during mid-April and mid-October, when it is less windy in the desert.
>
> 4. You must have company and several off-road vehicles to go to Loulan. Other necessities include car-repair tools, GPS, satellite phone and medicine, as well as water and food that can last for at least 15 days.
>
> 5. The temperature gap between the daytime and night can be huge in the desert, so make sure you have appropriate clothing. And it is a good idea if your clothes and tents are in a striking color so rescuers can easily spot them in an emergency.

March 6, 2013

The Beauty of Loulan is a mummy found in 1980 in the long-abandoned city of Loulan near the east edge of the Taklamakan Desert. She is 3800 years old! She has high cheekbones, a high bridged nose and blonde hair. She is 162 centimeters tall — that's 5'2", for those upholding the old Imperial system of units. She died sometime in her 40s, and she's dressed in a red robe, her hair crisply braided. Over 200 mummies of this sort have been found in and near the Taklamakan Desert. DNA testing shows that they have haplogroup R1a Y-DNA, which is characteristic of East-Central Europe, Central Asia and the Indus Valley.

In China, where the central government is fighting Uyghur rebels, this discovery has stirred up controversy — since there's an argument about who really 'owns' the province of Xinjiang:

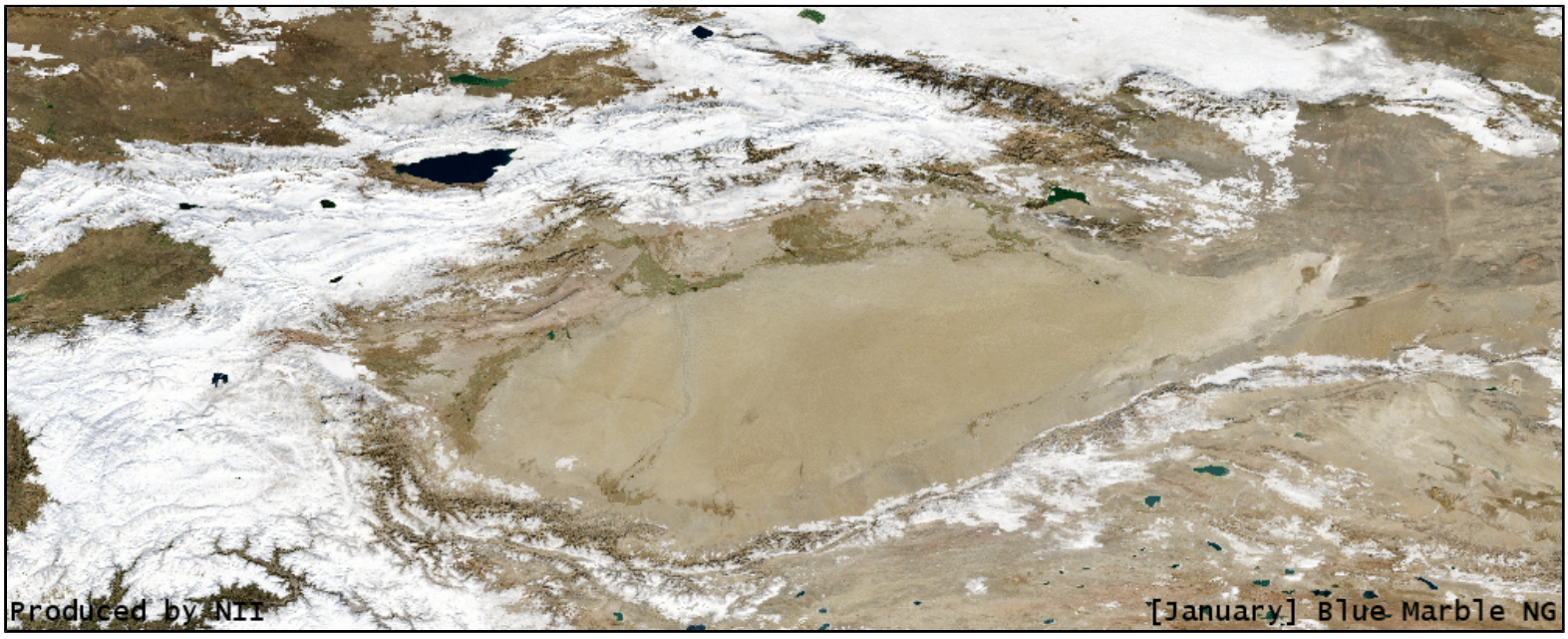
- Edward Wong, The dead tell a tale China doesn't care to listen to, *New York Times*, 18 November 2008.

Some Uyghurs claim the Beauty of Loulan as one of their own. But Victor Mair, an expert on this subject, says the Uyghurs came later:

> From the evidence available, we have found that during the first 1,000 years after the Loulan Beauty, the only settlers in the Tarim Basin were Caucasoid. East Asian peoples only began showing up in the eastern portions of the Tarim Basin about 3,000 years ago, Mair said, while the Uyghur peoples arrived after the collapse of the Orkon Uyghur Kingdom, largely based in modern day Mongolia, around the year 842.

Personally I don't think archaeology is a good way to settle political struggles, so don't think I'm taking a side here! I'm just trying to get to know this part of the world.

March 16, 2013



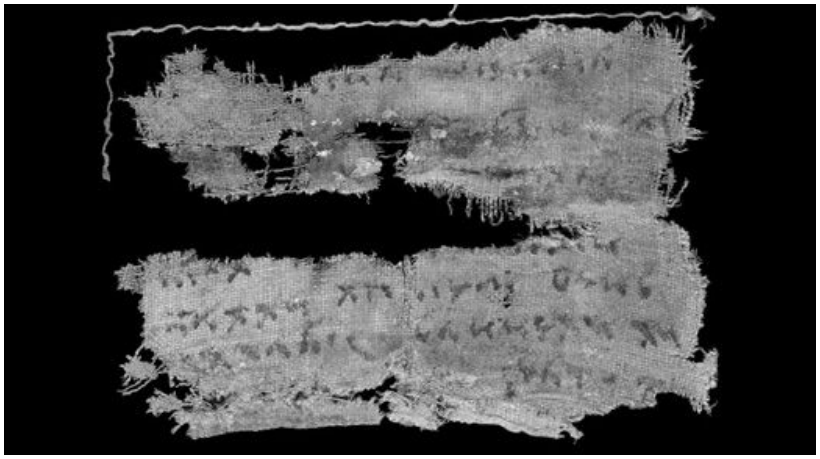
Surrounded by mountains whose snow cover changes with the seasons, the Taklamakan Desert in western China stays remarkably unchanged through the year. But if you look carefully, you can see two rivers that flow north across the desert - and the area around them turns green when the snow melts!

These are the White Jade and Black Jade Rivers — the Karakash and Yurungkash. When the snow melts, they flow north from the Kunlun Mountains into the Taklamakan Desert. The White Jade River actually carries chunks of white jade down from the mountains... I don't know what the deal is with the Black Jade River. Anyway, they merge in the middle of the desert and form the Khotan River about 145 kilometers north of the old Silk Road town of Khotan. The Khotan River then flows 290 kilometers further north across the desert, and finally empties itself into the Tarim River, which runs east across the desert's north edge.

For a long time, these rivers running north across the Taklamakan were the best way to get across that part of the desert.

The city of Khotan was the capital of the Kingdom of Khotan for a thousand years! I've got to tell you about this kingdom someday...

March 19, 2013



> Behold, I am living badly, not well, wretchedly, and I consider myself dead. Again and again I sent you letters, but I haven't received a single one from you, and I have lost hope in you. My misfortune is this: I have been stuck in Dunhuang for three years thanks to you.... I obeyed your command and came to Dunhuang and did not observe my mother's bidding, or that of my brothers. Surely the gods were angry with me on the day when I did your bidding! I would rather be a dog's or a pig's wife than yours!

This letter was discovered in 1907 by the famous British archaeologist Aurel Stein. It was in a mailbag in a Chinese watch tower near the Jade Gate, a fortified outpost 90 kilometers west of Dunhuang, a town at what was then the edge of China, on the Silk Road. It dates to around 314 AD. The mailbag contains some letters addressed to Samarkand, so that's probably where it was going.

This letter was written by a woman named Miwnay, whose husband had abandoned her. She didn't have enough money to take a caravan out of Dunhuang. We'll never know what happened to her.

She wrote her letter in Sogdian, a language in the Iranian family. Sogdiana was an ancient civilization centered in what's now Tajikistan and Uzbekistan, with Samarkand as one of its most famous cities. It's one of those mysteries that lures me to the Silk Road....

I cannot tell a lie: the letter I'm talking about is not the one in the picture here. The picture shows another letter in Sogdian found in the same mailbag, called Sogdian Ancient Letter No. 2. I'm talking about Sogdian Ancient Letter No. 3. For more see:

- Prof. Nicholas Sims-Williams, The Sogdian Ancient Letters 1, 2, 3 and 5.

For my April 2013 diary, go here.

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baez@math.removethis.ucr.andthis.edu

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For my March 2013 diary, go here.

Diary - April 2013

John Baez

April 1, 2013

Creepy... but beautiful! The Mar Sem Fim was a yacht owned by the Brazilian journalist Joco Lara Mesquita. Four researchers were using it to film a documentary off Antarctica when the weather turned bad. High waves and 40-knot winds made the boat toss back and forth .like a bucking bronco in a rodeo.. The Chilean Navy was sent to the rescue, since the closest ships were at the Chilean Antarctic base Presidente Eduardo Frei Montalva. They had to wait for the weather to calm down to save the four crew.

They did it just in time: icy water had filled the yacht. Later this water froze, expanded and split the hull! Surrounded by ice, the boat sank to the bottom of a shallow bay: Maxwell Bay of Ardley Cove, Antarctica.

Lots of people who see this photo feel uncomfortable, and that fascinates me. I think it's a metaphor of death. But in early 2013, ten months later, the yacht's owner returned to the site and rescued the Mar Sem Fim! Divers wrapped strong lines under the hull and attached them to inflated buoys. Once it reached the surface, they towed it back to shore. You can see photos of the whole story here:

- Chilling remains of the Mar Sem Fim, *Sometimes Interesting*, 6 March 2013.

April 24, 2013

This is the Beauty of Xiaohe, one of the mummies found in the Small River Cemetery near the eastern end of the Tarim River in the Taklamakan Desert.

This cemetery dates back to 1970 BC. It was rediscovered in 1934 AD by the Swedish archaeologist Folke Bergman... and then forgotten until a Chinese expedition found it again with the help of a GPS system. Archaeologists began excavating it in 2003.

When they dug into it, they found five layers of burials. They found almost 200 poles, each standing 4 meters tall. Many had flat blades, painted black and red, like oars. At the foot of each pole there was a boat, laid upside down and covered with cowhide. Inside the boats were bodies. Mummies!

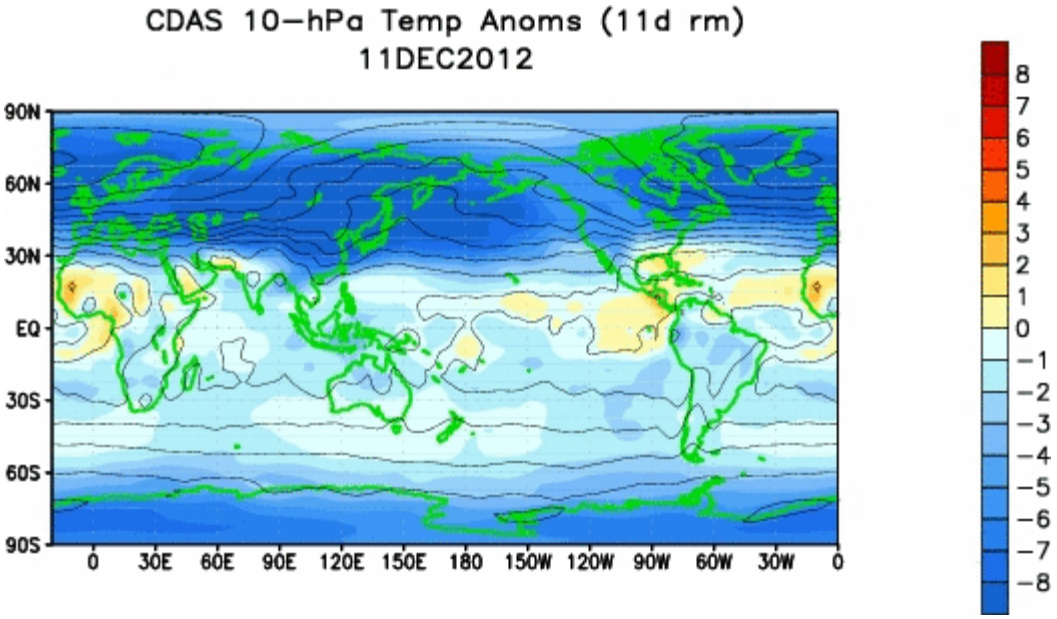
The mummies were wearing large woolen capes with tassels and leather boots. They had felt caps with feathers tucked in the brim. And next to them were grave goods, including beautifully woven grass baskets, skillfully carved masks and bundles of ephedra, a widely used medicinal herb.

I'm summarizing a nice New York Times article; you can read the whole thing here:

- Nicholas Wade, A host of mummies, a forest of secrets, *New York Times*, March 15, 2010.

For a map showing the location of the Small River Cemetery, go here.

April 25, 2013

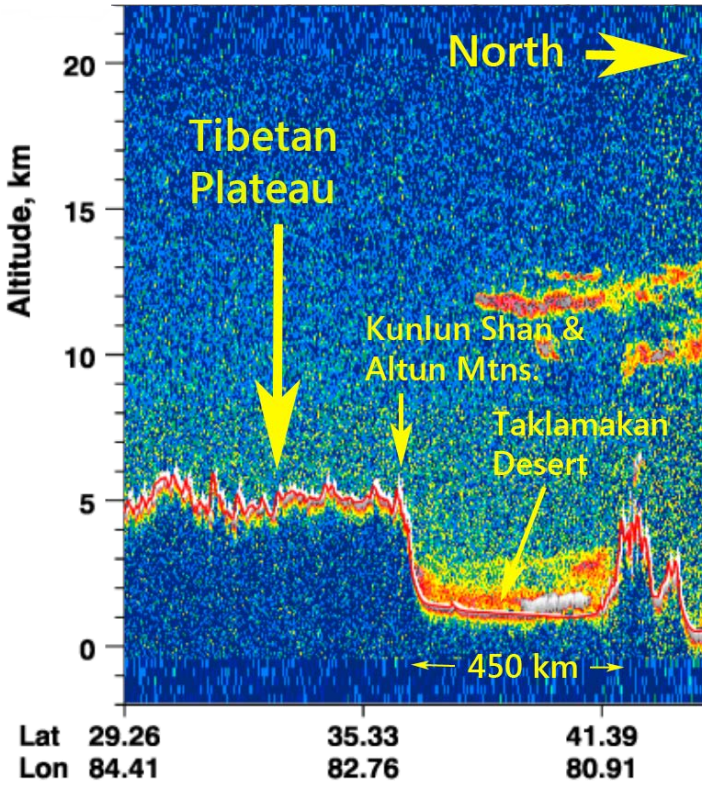


I've been talking a lot about Silk Road towns in the Taklamakan Desert, their history and architecture. But this desert might also play an important role in the world's weather! Check out this amazing Sudden Stratospheric Warming event. See where it starts? For more, read this:

- Randall Gates Simpson, Sudden stratospheric warming: causes & effects, *Arctic Sea Ice*, 22 April 2013.

These events are not rare. They're so dramatic that at first scientists thought they were caused by volcanic eruptions! They're still mysterious.

April 27, 2013



The Taklamakan Desert, surrounded by mountains to the north and south, is really quite amazingly deep. You can see it nicely in this image made by the CALIPSO satellite. There's almost a 4-kilometer drop when you descend from the

Kunlun Shan mountains into this desert... and quite a rise to the north, too, when you hit the Tian Shan mountains.

CALIPSO stands for Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations. It's a French/American project to study clouds, dust and the like by shining a laser beam down to the Earth and measuring the amount that gets scattered back.

This technique is called lidar. The word 'lidar' was originally created by combining the words 'light' and 'radar'. However, everyone tends to assume this word is an acronym. So, people often spell it LIDAR - and then they had to come up with some words that this could be the acronym of! Since RADAR is an acronym for 'RAdio Detection And Ranging', some people say LIDAR is an acronym for 'LIght Detection And Ranging'... or 'Laser Imaging, Detection And Ranging'.

Hey, but nobody writes 'RADAR' in all capitals anymore: like 'laser', it's become an ordinary word! People are so confusing.

I got the above picture from this article about how the Taklamakan Desert may affect the world's weather:

- Randall Gates Simpson, Sudden stratospheric warming: causes & effects, *Arctic Sea Ice*, 22 April 2013.

For my May 2013 diary, go here.

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For my April 2013 diary, go here.

Diary - May 2013

John Baez

May 1, 2013

Did you know that in 1532 the Sultan of Yarkand — an important city in Central Asia, back then — tried to march all the way to Tibet and take the city of Lhasa, because he believed it was the *qibla*, the direction of prayer, for all Buddhists? His horses all died of altitude sickness before he got there. This is just one of many things I learned from *Buddhism and Islam on the Silk Road*, by Johan Elverskog. Having grown up learning lots of European history, it's great to see the world from a different perspective, in which Central Asia is the center. It's so cool! For example, here's a bit about the Qara Khitai Khanate, or Western Liao — an important empire from 1120 to 1350:

> On account of their Sino-nomadic legitimization the Qara Khitai state therefore functioned as a perfect buffer between the Muslim world and the Tantric Bloc. In large measure the Muslim and Buddhist worlds would therefore remain separate during the Western Liao. The coming of the Mongols, however, was to change this dynamic completely. Yet before turning to the impact of the Mongol conquest it is important to leave the Muslim world and outline the developments in the Buddhist world. Indeed, to avoid the common mistake of ignoring the interconnectedness of Eurasian history we need to keep in mind that developments in the Buddhist world were intimately related to events unfolding in Muslim Central Asia. In fact, the very creation of the Tantric Bloc, with Tibet as its spiritual core, was very much related to the course of events described above.
>
> The most important element in this regard was clearly the revival of Buddhism in Tibet. After the Tibetan Empire collapsed in the ninth century so too had Buddhism on the Tibetan plateau. Yet on account of the Muslim advance into the Buddhist frontier zone Buddhist masters from places like Kashmir and Khotan started to seek refuge in the Guge kingdom of western Tibet. And as news spread of this Buddhist revival in Tibet ever more Buddhist masters from South Asia made their way across the Himalayas.
>
> [...]

> One one level the diaspora of these Khotanese, Kashmiri and Indian Buddhists into Tibet could have ended as with the Nestorian Christians in Central Asia: as an historical oddity of little concern to anyone. Yet that was not to be the case. As we all know Tibet and its Tantric Buddhism continues to exert a powerful influence on the world stage. Why and how this happened is far beyond the scope of this study; nonetheless, one thing is clear: the Indian masters and their Tibetan disciples turned the obtuse antinomianism of Tantric Buddhism into gold.
>
> [...]
>
> The reasons for this are many, though one important factor in this development was, oddly enough, the Muslim invasion of India. It was this event that set in motion the brain drain of tantric masters that ushered in both the withering of Buddhism in India and the simultaneous growth of the Dharma in Tibet.

The 'Tantric Bloc' is Elverskog's name for a loose collection of states influenced by Tantric Buddhism, eventually running from Tibet through Mongolia all the way to Japan.

This photo of the Potala Palace in Lhasa is from Around the World in 80 Clicks, a travel photo website.

May 7, 2013

I saw this picture by George Steinmetz here:

- Kaushik, The green belt along the world's longest desert highway, *Amusing Planet*, 5 May 2013.

Let me quote a bit:

The Tarim Desert Highway across the Taklamakan desert, in China, links the cities of Luntai and Minfeng on the northern and southern edges of the Tarim basin. The total length of the highway is 552 km, of which approximately 446 km is built across uninhabited areas covered by shifting sand dunes, 20 metes tall, that frequently bury the highway.

To prevent the highway from getting buried by the encroaching sand dunes, rows of vegetation were planted on both sides of the road to anchor the sand with their roots. A massive irrigation system was constructed that pump water from underground reservoirs to sustain the artificial ecosystem. Hundreds of workers were employed, housed every four kilometers along the road who tend to the short, small-leaved rose willows, sacsaoul and buckthorn and make sure they do not die. The water comes from wells, bored 100 meters deep into an aquifer which sits under the desert, which in turn is fed by the rivers that flow down from the surrounding mountains. Despite the high saline content in the water, the green belt continues to thrive.

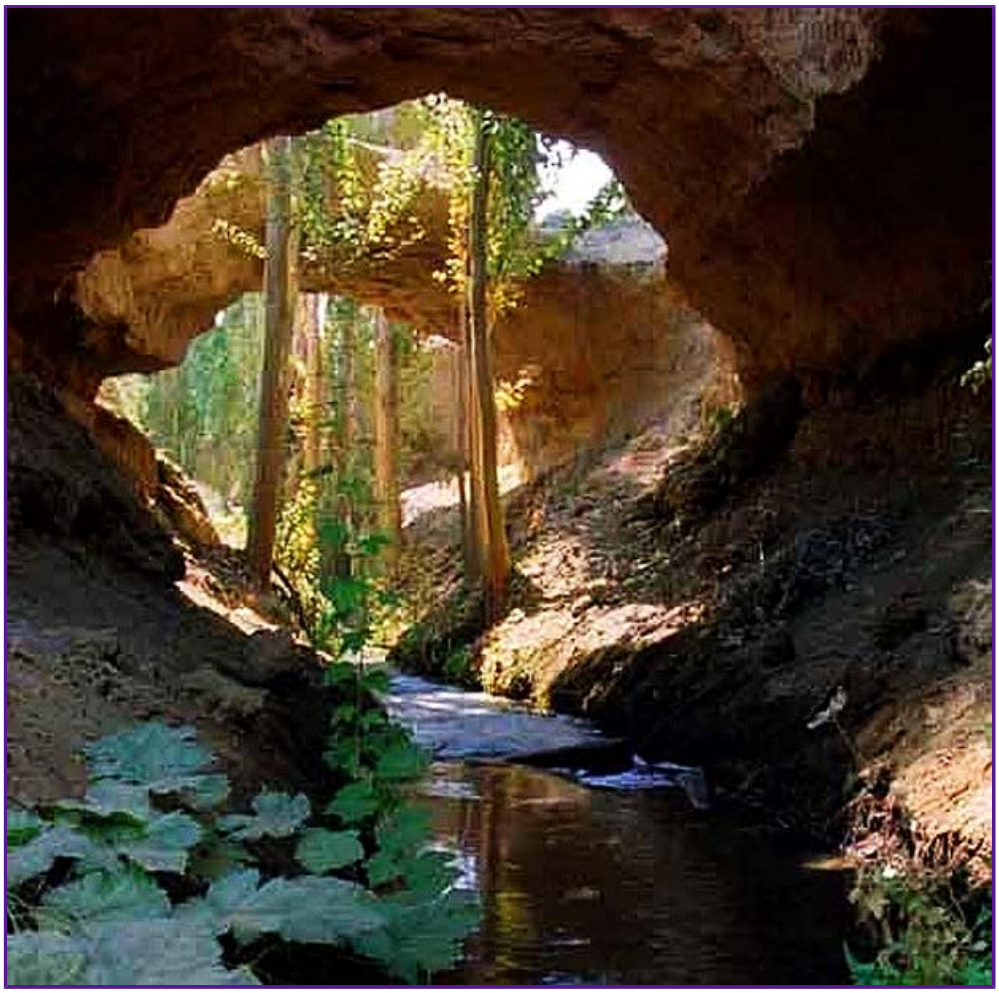
For five years the government experimented with various plants that could survive desert conditions. In 1999, a pilot project of sand protection afforestation belt along a 6.3-kilometer section of the highway was completed. In 2001, the project was expanded until a 30.8-km stretch along the highway was afforested. The project was finally approved by the state in 2003. Today, nearly four-fifth of the highway is flanked by 72 to 78 meter-wide tree belt, covering a total area of more than 3,000 hectares.

The Tarim Desert Highway has great economic significance, which is why such expensive and elaborate measures had to be adopted just to keep the highway usable. The highway was built in 1995 to service an essential north-south oil pipeline, that lies underneath the Taklamakan desert. Beneath the shifting sands contains the largest oil-gas field in China. The highway not only allows direct access to resources that lie underneath the Tarim Basin, but also allows transport of goods and resources from the Lunnan Oilfield to the south of the country rather than take a detour around the desert that would encompass hundreds of kilometers. Because the region is entirely uninhabited, a gas station and a few restaurants were built at the halfway point along the desert highway to service travellers.

May 8, 2013

Even a camel can get tired crossing the Taklamakan Desert! This photo was taken by Richard Desomme in a flat barren area east of the Yurungkax River and west of the Keriya River. There's a story to be told here, but I don't know it. The precise location is 37° 51' 27.03" N, 81° 13' 58.48" E.

May 27, 2013



This is the entrance of a man-made underground canal in the city of Turpan, China, northeast of the Taklamakan Desert.

Turpan lies in the second deepest geographical depression in the world, with over 4,000 square kilometers of land below sea level! It has short cold winters but it gets really hot in the summer, with average high temperatures over 32 0C (96 0F) from May to September, and sand storms. Luckily, melt water flows down from nearby mountains. This makes their karez system of wells and underground canals really helpful! They have over 1100 wells, and over 5000 kilometers of underground channels.

The inhabitants of Turpan started building this irrigation system during the Han dynasty (206 BCE-24 AD), when this city was part of China. When that dynasty collapsed, Turpan became part of an independent kingdom whose capital was the nearby city of Jiaohe (now abandoned). Turpan became important as a stop on the Silk Road, frequented by Chinese and Sogdian traders... and after various twists and turns it was recaptured by the Chinese during the Tang dynasty, in 640 AD.

All this is on my mind because I'm planning a trip in August. Lisa and I might fly out to this area on August 8, meet the mathematician Weiwei Pan, and make our way to Dunhuang by August 11. It seems easier to fly to Urumqi than Turpan, but Turpan looks more interesting — though hotter, and a 2-hour train ride away. I have a limited amount of time — should I go there? I actually prefer staying places and getting to know them, so we may just go to Dunhuang and look around there. Then Lisa has to leave, and Weiwei and I will go to a math conference in Lanzhou. It looks close on a world map, but it's 1000 kilometers to the east! After the conference we may poke around Qinghai, a mountainous province just a bit west of Lanzhou.

For my June 2013 diary, go here.

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For my May 2013 diary, go here.

Diary - June 2013

John Baez

June 1, 2013

Qinghai Lake is the biggest lake in China. I may see it after my conference in Lanzhou. It's just a 3-hour drive west of the big city of Lanzhou, but that drive takes you out of Gansu Province up to Qinghai Province, which according to Wikitravel is...

> China's most scarcely populated province. There are only 5.2 million people in an area bigger than France. Labor camps, prisons and nuclear testing sites are scattered among the ice-capped mountains. The extreme eastern part of the province is less harsh, with two major Tibetan monasteries and the charming capital of Xining. The southern regions of Qinghai sit at an average elevation of over 4000 m (13,120 ft) while the northern regions sit between 2500 m and 3500 m (8200 to 11,500 ft). Qinghai has some of the largest pasture lands in China. Many yaks and sheep are herded by Tibetan and Mongolian nomads.

The cool mountain air should make a nice change from the roasting deserts of western China, which I plan to explore before the conference. But I guess that means I'll need to bring warm clothes!

An interesting thing about this lake is that it has *salty water*, despite being up in the mountains. The reason is that *no water flows out*. It's in what showoffs call an endorheic basin, meaning simply that no water can flow out. The basin in which the Taklamakan Desert resides, the Tarim Basin, is another much larger endorheic basin in this area. With the Himalayas, the Tibetan plateau, the Kunlun Shan and Tian Shan ranges, not to mention many others, this is one of the most landlocked parts of the world. And Urumqi is famous for being the big city that's the farthest from the ocean of any in the world!

June 5, 2013

Near the old Silk Road town of Dunhuang, you can do some camel trekking. Sara Naumann writes:

> Just in case you think riding a camel is like riding a horse, I'll school you in Dunhuang-style camel riding. First, you board your camel while the camel is on the ground with its legs tucked under it having a nice rest. The camel is not necessarily thrilled with having to work so may do nasty things like grunt at you. But also a nice word and a pat on the head might get you some nuzzling for which you're unprepared so think about how much intimacy you want with your ride. After you get on the saddle, hold on. The camel will pitch forward as it stands up first on its back legs. If you're not steady, you will tumble over the saddle and onto the camel's head which it will not like. Nor will you.

With tremendous help from Weiwei Pan, my travel plans are solidifying and now they tentatively look like this:

- Aug 6th: Lisa and I fly from Singapore to Dunhuang.
- Aug 8th: Weiwei shows up and we visit the night market.
- Aug 9th: Crescent Lake and Echoing Sand Mountain in the morning. Camel trek in the afternoon; overnight in desert.
- Aug 10th: Drive to see rock formations in Yadan (on the way: Han Great Wall, Yumen Pass, Western Caves).
- Aug 11th: Visit Mogao Caves (Yangguan pass if we have time).
- Aug 12th: Museums? Fly to Lanzhou at 7 pm.
- Aug 13th: Lisa leaves for Singapore.
- Aug 14th-16th: Math conference in Lanzhou.
- Aug 17th: Drive south to Labrang Monastery.
- Aug 18th-19th: West to Qinghai Lake, then back to Lanzhou.
- Aug 20th: Return to Singapore.

For Sara's complete camel story, with pictures, go here:

- Sara Naumann, Camel trekking in the Mingsha sand dunes, About.com.

This photo comes from here:

- Dunhuang: sand, camels, and grottoes, *China Vacation*, 12 August 2012.

It was taken in Mingshan, an area of sand dunes near the amazing Crescent Lake south of Dunhuang. I reflected it because for some strange reason I wanted the camels to head ot the right... maybe they remind me of script on a page?

June 10, 2013

This is the Library Cave in Dunhuang, walled off sometime before 1100 AD — nobody knows why. The guy here is Paul Pelliot.

Pelliot was a French expert on classical Chinese who worked at the École Française d'Extrême Orient in Hanoi. Vietnam was a French colony then — and you can still buy baguettes on the street in Hanoi.

In 1900 he was sent to Beijing to search for Chinese books for the Icole's library. While there, he was caught up in the Boxer Rebellion and trapped in the siege of foreign embassies. He made two forays into enemy territory during this siege.one to capture an enemy standard, and another to obtain fresh fruit! For his bravery, he received the Legion of Honor. He was just 22.

He returned to Hanoi and was made Professor of Chinese at the École. In 1906 he led a mission to explore Central Asia, starting in Paris. His expedition traveled through Russia by rail to Uzbekistan, where they switched to horses and carts and went over the Alai Mountains to China — the west end of the Taklamakan Desert, and the great city of Kashgar.

He then went east, with too many adventures and discoveries to tell here, until he reached Urumqi, near the east end of the desert.

There he met Duke Lan, whose brother had been a leader of the Boxer Rebellion. The two had a bittersweet reunion. Pelliot had been in Beijing while Duke Lan and his soldiers were besieging the foreigners during this rebellion! They reminisced about old times and drank champagne. But then Duke Lan showed Pelliot a manuscript from Dunhuang.

This was just the kind of thing Pelliot was seeking! Recognizing its value, he quickly set off for Dunhuang.

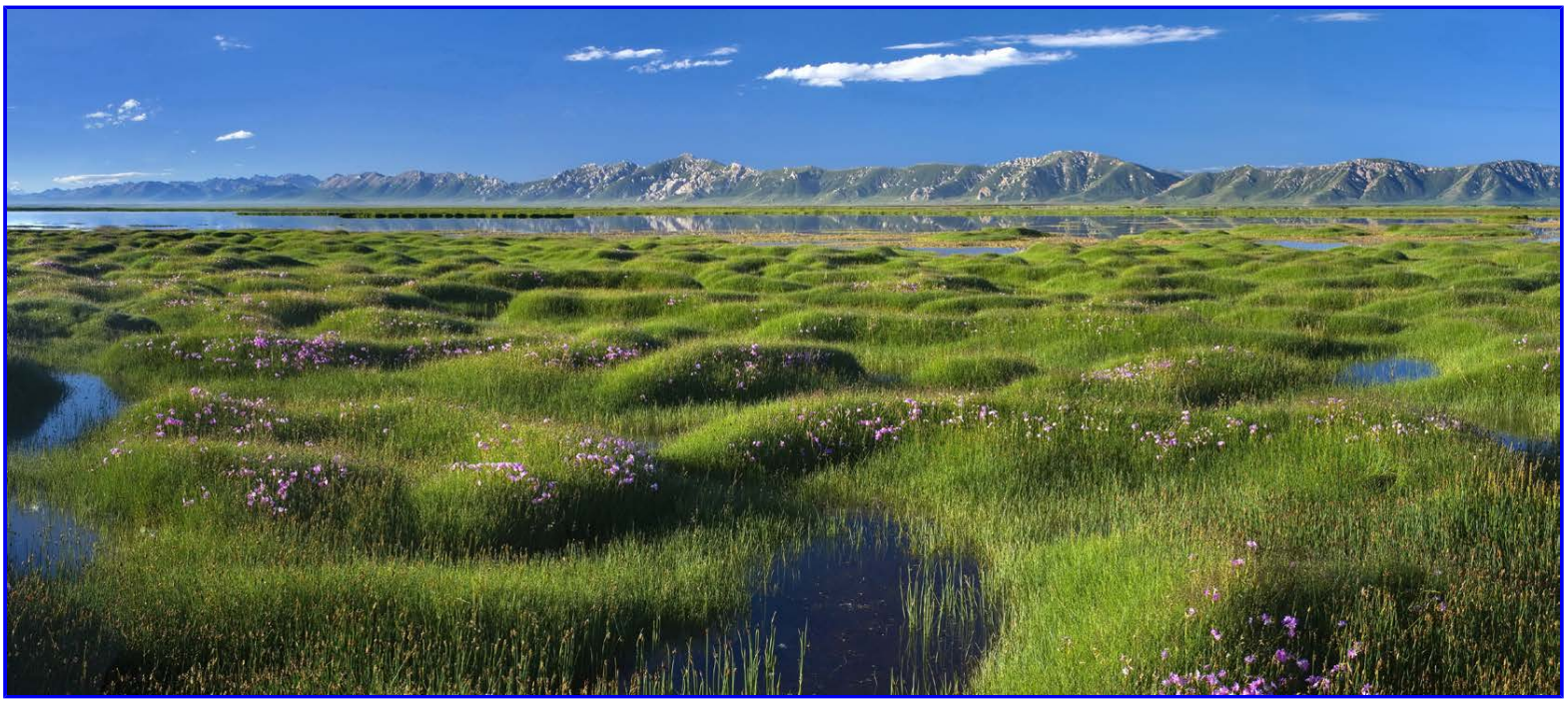
The Library Cave is one of almost a thousand caves in Dunhuang: the Mogao Caves. It was guarded by a Taoist monk named Abbot Wang. Pelliot persuaded Wang to let him look at it, and it turned out to contain a massive hoard of ancient manuscripts: almost 50,000. After three weeks of studying them, Pelliot convinced Wang to sell him a selection of the most important ones. Wang, who was interested in continuing the refurbishment of his monastery, agreed to the price of 500 taels (£90).

My tale is paraphrased from these articles:

- Paul Pelliot, Wikipedia.
- Dunhuang manuscripts, Wikipedia.

The manuscripts are now spread around the world: many are in the British Library, the Bibliothèque Nationale in France, and the National Library of China in Beijing. But luckily, they are being digitised by the International Dunhuang Project, and can be freely accessed online.

June 1, 2013



Qinghai is a province of China southeast of the Taklamakan Desert. It's much higher — and as you go further south, you reach the Kunlun Mountains and then Tibet. It holds China's largest lake. But this picture shows a smaller one, Donggi Conag Lake, which is 'only' 220 square kilometers in size.

Not very many people live here — but the people who do are a fascinating mix of Han, Tibetans, Hui, Tu, Mongols, and Salars. The Han, I hope you know, are the 'ordinary' Chinese. You've probably heard of Tibetans and Mongols. But what about the rest?

The Hui are Chinese-speaking Muslims, not primarily of Han ancestry, but related. The Tu or Monguor speak a Mongolic language that's been heavily influenced by Chinese and Tibetan; most of them are farmers, and they live mainly in Qinghai and Gansu, the province directly to the north. The Salar speak a Turkic language of their own; their ancestors were

migrating Turks who intermarried with Han, Tibetans and Hui.

I'm just trying to get a little sense of this area before I visit it! I won't be seeing Donggi Conag Lake, but I plan to visit Qinghai Lake, which is almost 4500 square kilometers in size.

I found this photo by someone nicknamed Huanghe Jingren ('Yellow River Scenery Person') on Panoramio. They've got a lot of amazing photos there!

June 9, 2013

At the northern edge of the Taklamakan the dunes give way to grasslands, with rivers and oases surrounded by trees! This beautiful photo was taken near the town of Yuli in the Bayin'gholin Mongol Autonomous Prefecture — or Bayingol for short.

A 'prefecture' is a subdivision smaller than a province. Bayingol is in Xinjiang Province, and it's the largest prefecture in China, in the largest province. It's sparsely populated, though! The people here are mainly a mix of Mongols, Uyghurs and Han Chinese.

The word 'Bayingol' means 'rich river', and I'm sure that's how you feel if you travel through the Taklamakan Desert and then reach this place.

The person who took this photo has lots more great shots of Xinjiang and other parts of China on Panoramio. This particular one was taken near the town of Yuli at 410 2' 37.92" N, 860 4' 57.61" E.

June 12, 2013

My sister just passed a test to get a license in pest control. She wrote:

> So I am now your go-to person for information on the bionomics of all major species of mosquitoes, lice, ticks, fleas, mites, bedbugs, flies, biting members of the ant and bee families, birds, snakes, and vermin indigenous to Virginia. Indeed, I was disappointed not to have the opportunity to regurgitate more of this knowledge (just as mosquitoes regurgitate St. Louis encephalitis into human hosts once part of their gut becomes blocked by the virus pathogens).

I replied:

> Lisa and I agreed that now, when she thinks I'm being a pest, she can consult you for advice on how to control me.

She replied:

> In general, in cases such as this, the best first-choice option is physical exclusion. Removal of food sources and harborage locations are other tactics that can be successful in addition to or instead of exclusion. If such approaches failed, I would probably advise trap and release. Poison baiting or biocontrol via fungal agents would be last resorts.

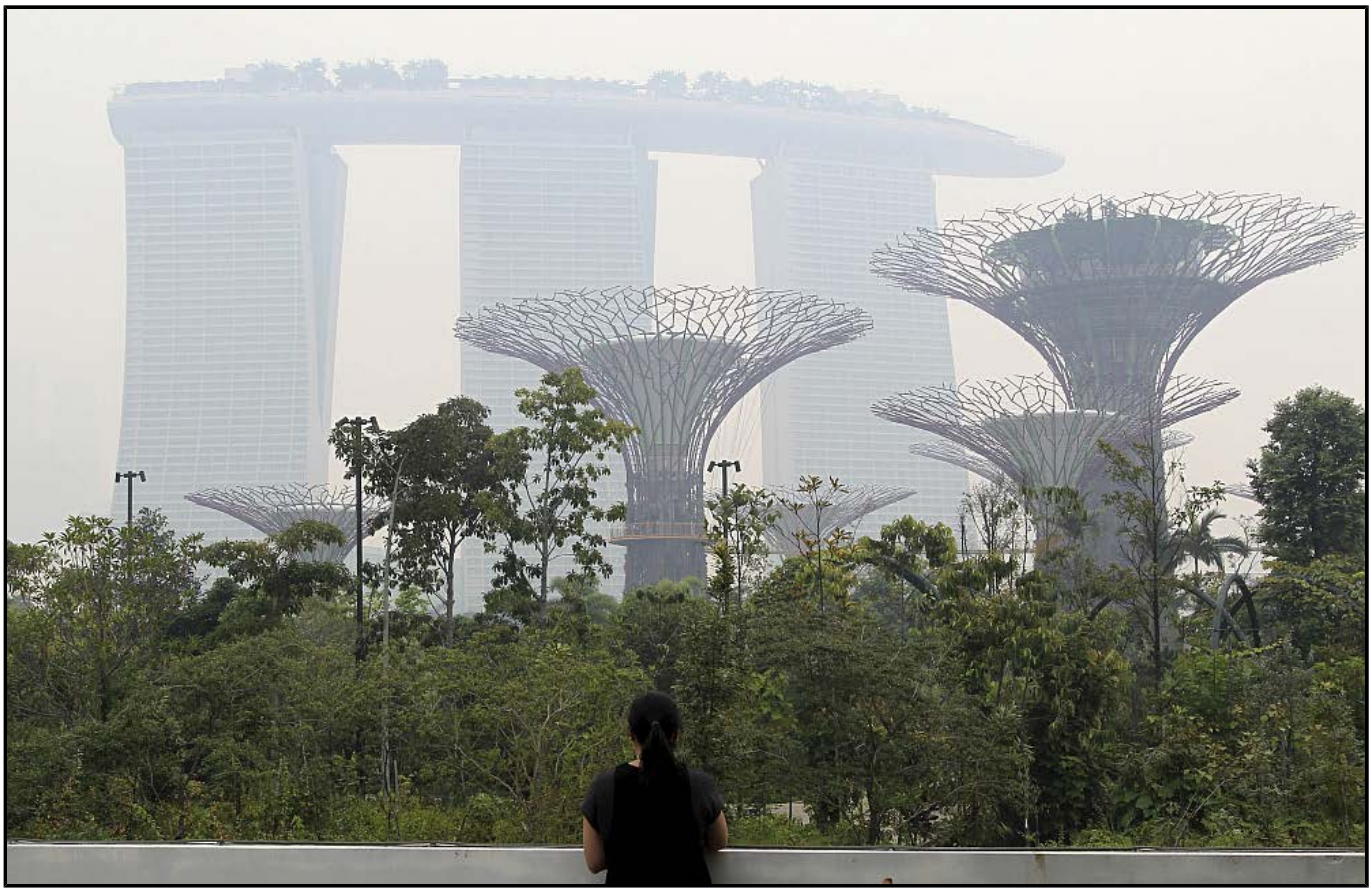
June 20, 2013

The old Silk Road town of Dunhuang is full of trees, but surrounded by tall dunes. The view from the rooftop restaurant at the Silk Road Hotel is spectacular!

Unfortunately this hotel is sold out... so I'll console myself by saying that it was probably too expensive, and too fancy: the rooms are done up in a charming 'caravanserai' style.

This photo was taken by Joanie Preston in November 2011, and it appears on Tripadvisor.

June 28, 2013



Downtown Singapore always looks futuristic — but last week, in the smoke of burning jungles, it looked downright post-apocalyptic!

See that thing like a ship on top of 3 skyscrapers? That's the Marina Bay Sands hotel and gambling casino. It cost $8 billion to build and it has an 'infinity pool' on top, a swimming pool with no edge that looks like you can just swim off the edge and fall off... it scares me. And see those things like weird 16-storey-tall artificial supertrees? Those are weird 16-storey-tall artificial Supertrees. They operate as temperature moderators, absorbing and dispersing heat. They also collect rainwater and act as ventilation ducts for conservatories nearby. Several are outfitted with photovoltaic cells to generate solar power. At night, they glow in strange colors.

This photo was taken by Wong Maye-E.

June 30, 2013

In China, the zoo in the city of Luoyang has three new tiger cubs! They're all female, they're 3 months old, and they're the offspring of a pair of tigers at this zoo.

They're South China tigers. This is a tiger subspecies, *Panthera tigris amoyensis*, that was native to the provinces of Fujian, Guangdong, Hunan, and Jiangxi in southern China. In the early 1950s there were more than 4,000 in the wild — but then tigers were targeted by an 'anti-pest' campaign in Mao's Great Leap Forward. By 1982 there were at most 200, and by 1987 at most forty.

The South China tiger has been considered 'critically endangered' since 1996 — and it may be extinct in the wild, since scientific missions to find one have failed, though there are still occasional reports of sightings, and a reported attack on a cow in 2007. There are about 72 in captivity, though few seem to be 'pure' South China tigers, as there's genetic evidence of cross-breeding with other species.

The South China tiger seems to be a relic population of the original 'stem' tiger, living close to the area where tigers first appeared. Morphologically, it's the most distinctive of all tiger subspecies.

Tigers living in zoos can't easily adapt to life in the wild. But the organization Save China's Tigers is trying to rewild the South China tiger. They took a few from zoos to South Africa and trained them to regain their hunting instincts. 14 cubs have been born, of which 11 survived. These cubs should learn their survival skills from their rewilded mothers directly. When they get old enough they'll be taken back to a nature reserve in China. This may have already happened... in any case, it should be soon!

For more cute pictures, see the *China Daily* article.

For my July 2013 diary, go here.

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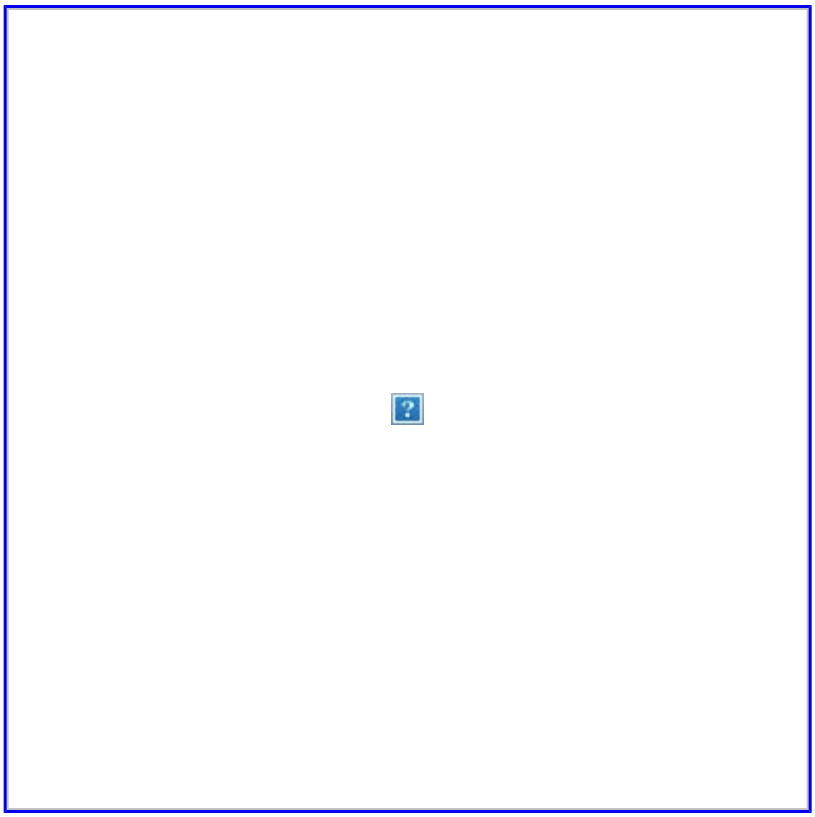
[For my June 2013 diary, go here.]

Diary - July 2013

John Baez

July 13, 2013



Yay! My sabbatical request went through, so I'm free to be with Lisa while she's in Europe from January to June next summer!

So here is my schedule from now until next summer:

- August 6-20, 2013 - I'm going to Lanzhou and nearby parts of China, and giving three 50-minute talks on "Spans and the Categorified Heisenberg Algebra".

- September 20 - I'm coming back to California.

- October 1-4 - I'll speak at the inaugural conference for the new Center for Quantum Mathematics and Computation at Oxford University. To reduce my stress level and please people who like fundamental physics and categories, I'll give a short version of the same talk on "Spans and the Categorified Heisenberg Algebra".

- October 5 - I'll speak at TEDx Torino, about environmental issues.

- October 22 or 23 - I've been invited by Erik Winfree to speak about stochastic Petri nets at the Computer Science department at Caltech.

- October 25-26 - I'm speaking at a workshop on "What is Climate Change and What Should We Do About It?" at the Balsillie School of International Affairs at the University of Waterloo.

- November 6 - I'm going to talk to 5th through 8th graders at the Riverside STEM Academy about career opportunities in mathematics, at the absurdly early hour of 8 am.

- December 4-7 - I'm giving a 2-hour tutorial on information geometry at NIPS, a Neural Information Processing Systems conference at Lake Tahoe, Nevada. Then I'll attend part of the conference.

- December 14-20 - I'll go to Berkeley and participate in a Machine Intelligence Research Institute workshop with Eliezer Yudkowsky and some other people. There will be a one-day break because...

- December 17 - I'll give a talk about "Life's Struggle to Survive in Changing Climates" at the SETI Institute in Mountain View.

- January 1 - June 1, 2014 - My wife Lisa will be working in Erlangen. I will join her and poke around Europe a bit. I've been invited to the computer science department in Oxford for up to a month by Bob Coecke, and I've also been invited to spend a month at University Paris 7 by Paul-Andri Melliès, who is helping run a Institut Henri Poincaré session on "Semantics of Proofs and Certified Mathematics" from April 22 to July 11.

- April 7 - May 2, 2014. I'll help run a Dagstuhl Perspectives Workshop on "Categorical Methods at the Crossroads". This is being held in a German castle, shown above, which has become a center for computer science. The idea is to get people who apply category theory to lots of different subjects to talk to each other. I'm running this with Samson Abramsky and Fabio Gadducci (in computer science) and Viktor Winschel (in economics).

Whew! Sounds like fun, but also lots of work! But I'll have plenty of time to rest after I'm dead...

July 18, 2013

Some forgotten history: Edison made the first commercially viable incandescent light bulb in 1879... but street lights were introduced in Paris in 1878. They didn't use incandescent lights. They used 'carbon arc lamps', generating light with a continuous electric spark!

The arc lamp was invented by the chemist Humphrey Davy back in 1809: he connected two wires to a battery, and used charcoal strips as electrodes, making a spark that could light up the room. But the arc lamp only became practical after the generator was invented. Arc lighting came to Paris in June 1878 as part of an exposition, and soon it found its way to London and the US as well.

But there was a problem. The arc made a constant humming noise. It was really annoying! So in 1899, in London, a young engineer named William Duddell was asked to find a solution.

He discovered that by changing the voltage he could vary the pitch of the sound. This didn't solve the problem... but at this point Duddell got distracted and had a cool idea. By attaching a keyboard, he was able to play music on an arc lamp.

Watch the video above to see the idea in action... not with a keyboard, alas, but using an arc as a speaker.

In fact a German engineer named Simon had a similar idea a year before, and called it the 'singing arc'. But I think Duddell was the first to play music with it. It was one of the first electronic instruments! Not the first — but that's another story, for another day.

For a while, Duddell toured England demonstrating the singing arc. Scientists even speculated about the possibility of playing music over London's street lights!

Sadly, the idea sputtered out and died. But the great mathematical physicist Henri Poincaré wrote several papers on this problem. Forgotten until recently, they appeared in the now-obscure journal La Lumihre ilectrique, and weren't included in his collected works. He also gave five lectures on this topic in 1908, where he showed that the oscillation of the arc is an example of a limit cycle: a solution of a differential equation that settles down to a periodic orbit.

I found out about this story from a nice new book:

• Jeremy Gray, *Henri Poincaré: A Scientific Biography*, Princeton U. Press, Princeton, 2013.

I got extra details from here:

• This Month in Physics History - December 20, 1900: Nature reports on William Duddell's 'musical arcs'.

Some serious steampunk fans should build a singing arc controlled by a keyboard. It would be perfect for the right sort of rock group.

For my August 2013 diary, go here.

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baez@math.removethis.ucr.andthis.edu

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[For my July 2013 diary, go here.]

Diary - August 2013

John Baez

August 6, 2013

Lisa and I flew from Singapore to Dunhuang.

August 8, 2013

Weiwei and her boyfriend Anthony showed up and we visited the night market in Dunhuang.

August 9, 2013

This morning we went to the Mingsha Dunes and Crescent Lake, which are right next to each other, a little bit southeast of Dunhuang.

We paid to ride a camel through the dunes. It looks romantic from a distance — but when you do it with a bunch of other tourists, like here, you have to wait a long time to get a camel. And once you get going, you can actually get stuck in a camel traffic jam! Still, it was good preparation for the more serious camel trek we did later.

The photo above was taken by Weiwei Pan, who is much better at photography than me. Since she's Chinese, she wasn't shy of laughing about the foibles of Chinese tourists. For example, the concept of 'roughing it' isn't popular among Chinese. They tend to dislike dirt. So, when exploring the Mingsha Dunes, they all get special bright orange boots to keep the sand off.

I'm not shy of making fun of American tourists, but there were almost no Western tourists near Dunhuang! A few go to the

Mogao Caves, but they don't stay around long.

Anyway, Americans who want a camel trek can do it in the Big Bend region of Texas, home of the old U. S. Camel Corps, which has recently been revived, in a nostalgic sort of way, by Doug Baum:

> ... in the 1850s, the first American settlers took root as the nation moved west. The soldiers who came to guard them discovered that their horses and mules didn't cut it out here. They couldn't traverse the distances between water supplies. So Gen. Jefferson Davis brought in camels before turning his attention to other things, like secession.
>
> "The U.S. actually sent a sailing ship, the USS Supply, twice. And they bought camels in the modern countries of Algeria, Tunisia, Egypt and what's now Turkey," Baum says.
>
> Eventually, hundreds of camels would be in use in the Big Bend by the Army and private owners. What happened to them all? After the Civil War, everything that the Confederate traitor Davis had touched was scrubbed away — and that included the Army's camels. The railroads finished them off. By the 1870s, they were mostly gone. That is, until Baum and his Texas Camel Corps brought them back.

This is from:

- Wade Goodwyn, Camels trek in the Texas deserts, just like old times, *All Things Considered*, December 21, 2013.

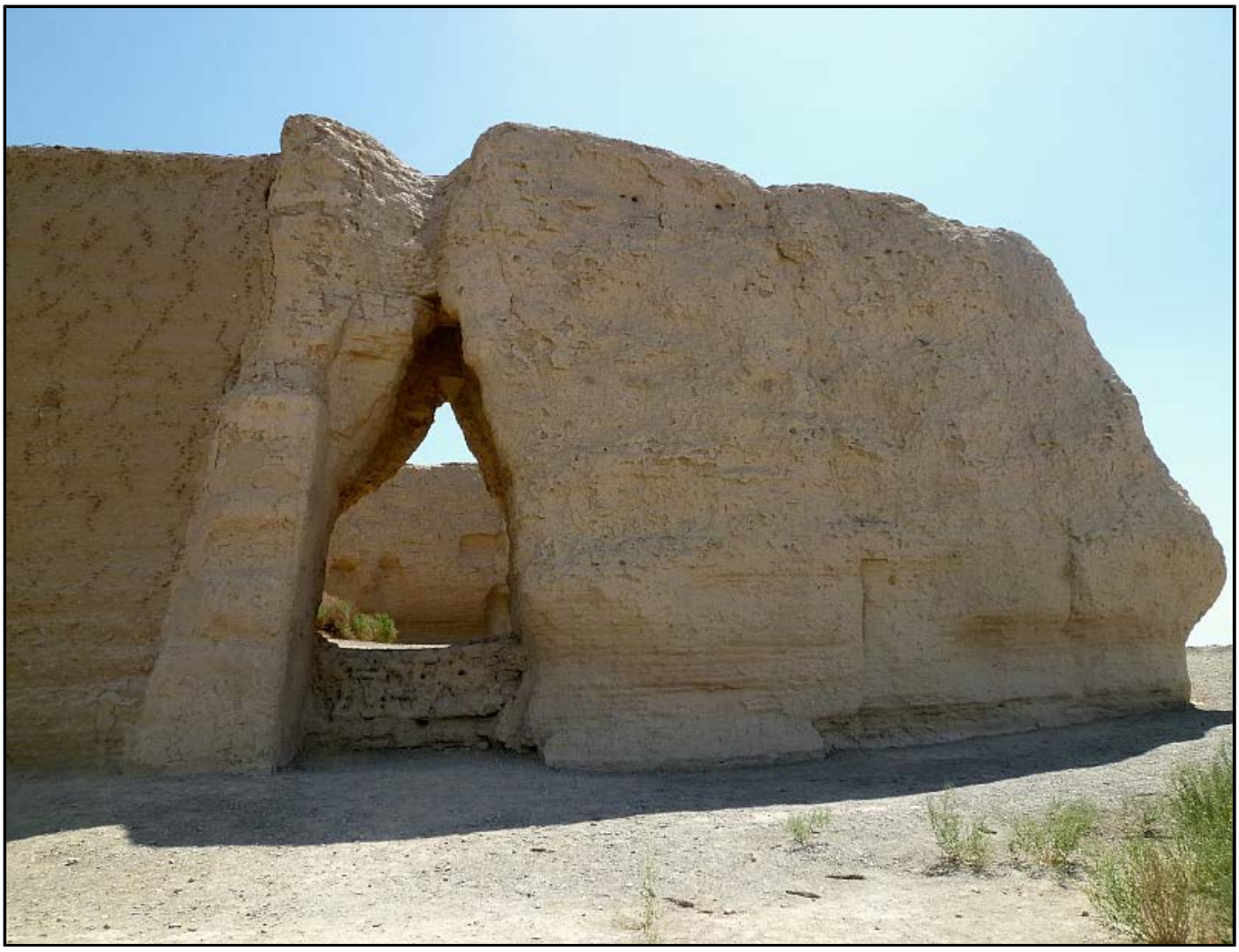
Camel trek in the afternoon; overnight in desert.

Dunes at sunset, viewed from above our campsite:

August 10, 2013

We drove to see rock formations in Yadan. On the way we saw ruins of the Han Great Wall:

We also saw Yumen Pass:



Here are the rock formations of Yadan:

August 10, 2013

We revisited the Mogao caves with Weiwei and Anthony.

August 12, 2013

Lisa and I flew to Lanzhou at 7 pm.

August 13, 2013

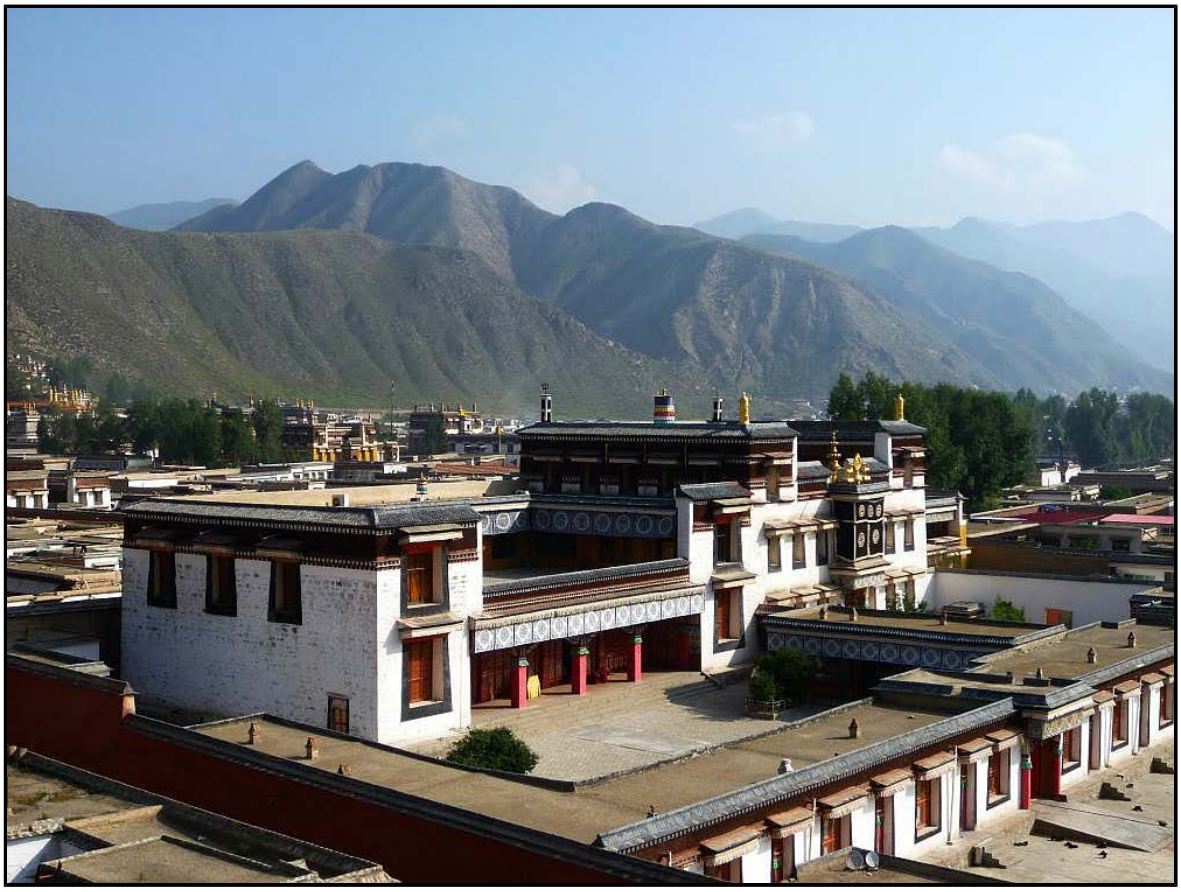
Lisa left for Singapore.

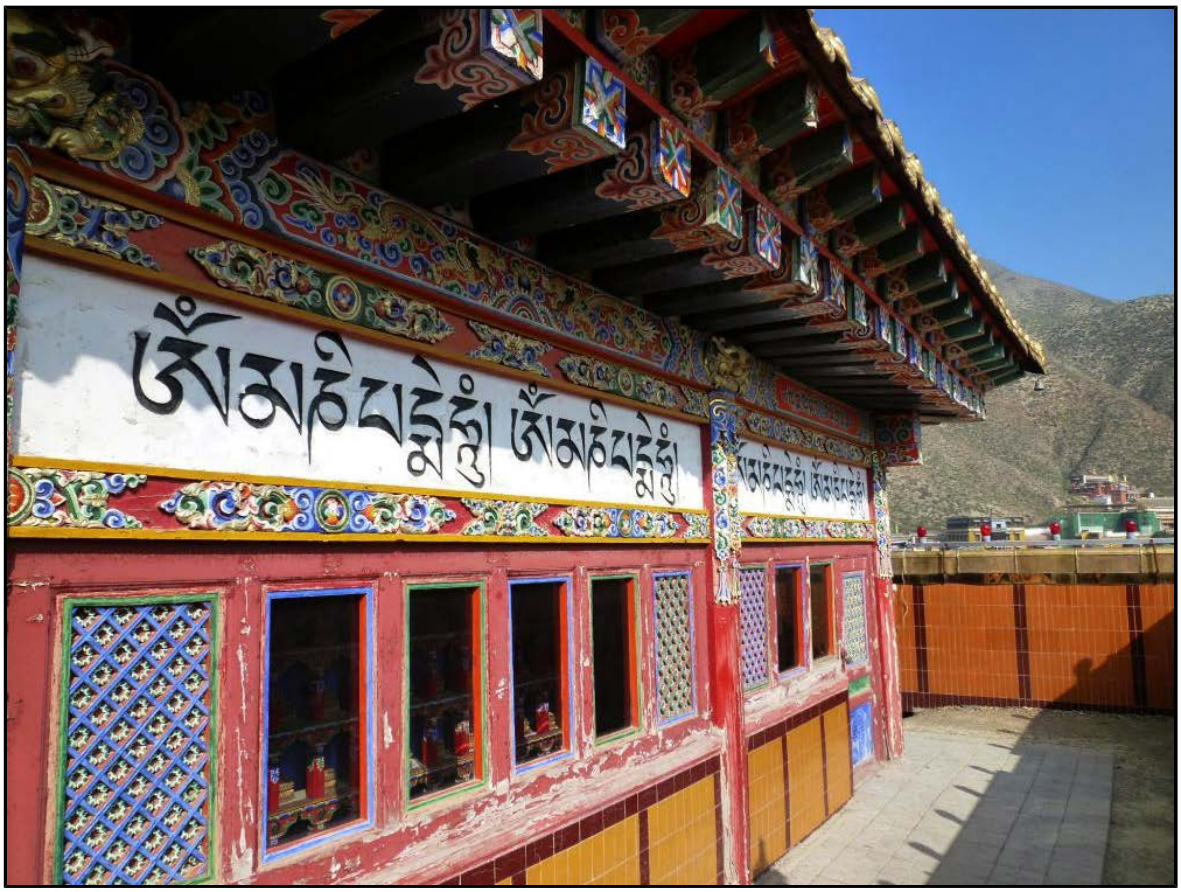
August 14, 2013

The math conference in Lanzhou started.

August 17, 2013

The math conference ended, and a bunch of us took a bus south to Labrang Monastery.

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August 18, 2013

We went further south, to Langmusi, a town at the southern end of Gansu Province, right next to Sichuan Province. This was a great place for a hike into the Namo Gorge.

August 19, 2013

We took a long bus ride back to Lanzhou.

August 20, 2013

I flew back to Singapore.

For my September 2013 diary, go here.

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For my August 2013 diary, go here.

Diary - September 2013

John Baez

September 1, 2013

Do you see something strange about this lion?

A woman named Liu Wen went the zoo in Luohe, a town in the Chinese province of Henan. She noticed that the 'lion' was not a lion — it was a Tibetan mastiff, the kind of dog shown here!

She said: "I had my young son with me so I tried to play along and told him it was a special kind of lion. But then the dog barked and he knew straight away what it was and that I'd lied to him."

A spokesman for the zoo later said: "We're doing our best in tough economic times. If anyone is unhappy with our displays we will give back their money."

Tibetan mastiffs are not true mastiffs. They're impressively large dogs widely used in Tibet to protect people's houses. They're a primitive breed, which goes into heat just once per year instead of two, like a wolf. They're aloof with strangers, intelligent, and very stubborn.

My friend Weiwei Pan says the Chinese attribute wonderful powers to these dogs. They command high prices — one was recently sold for $1.5 million. When we were in the Tibetan part of Gansu province, our Chinese guide repeatedly warned us not to stray too far, lest we encounter a ferocious Tibetan mastiff. But we never saw one, except in the distance. The guide was probably just trying to keep us under control. He also said it was dangerous to drink beer at high altitudes.

Since it's so big, China is full of strange and outrageous news stories — and luckily, you can now read a lot of them translated into English:

- The Shanghaiist.

For more on Tibetan mastiffs, see:

- Kate Andries, What's a Tibetan Mastiff? Explaining Dog Posed as Lion, *National Geographic News*, August 16, 2013.

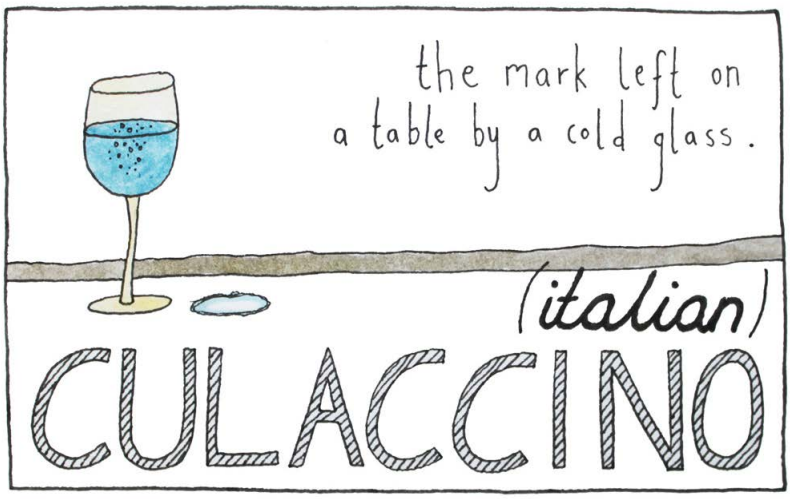
For photos of the zoo see:

- Becky Evans, Is this the world's worst zoo? Visitors' fury after staff in China try to pass off Tibetan mastiff as a lion and a mongrel as a leopard, *Daily News*, August 15, 2013.

The 'wolf' and 'leopard' in this zoo were also dogs. The silliest-looking fake is the 'leopard'.

September 1, 2013

Next time you want to be a smart-aleck, go into a crowded fancy café and starting talking to someone at the bar. When the barista asks what you want, say "I'll just have a culaccino".



September 21, 2013

Here's a great story. Steve Volk is a reporter who suffered from a recurring nightmare. He had it whenever he was going through a stressful time, and it always went the same way.

Alone at home at night, he feels something bad is about to happen. He looks out the window and sees the face of a man, just hovering there. It goes away... but then it reappears, looking very threatening. Then there's a knock at the door. Quivering with fear and rage, he yells at the man outside, cussing, daring him to come in. The man knocks down the door, bursts in, and they start to fight... then he wakes up.

Then he learned about lucid dreaming, where you know you're dreaming while it happens. He researched it,, learned how people do it, and then prepared for months, getting ready for this dream again

And then one night it happens:

> I'm walking through my apartment, nobody there but me. And I feel that familiar buzz of anticipation, something bad is going to happen. I look into the window, and there's that guy. But this time I'm there. My

perspective shifts and I am in this body, in this place. Not observing something, but in it. So I could feel my fingers tickling my palms, I could feel my feet on the floor. And I'm locked into these feelings, because they make the dream more stable. And I wanted the dream to be stable, because this face has been showing up in this window for twenty years.

And it does its thing: it recedes, it comes back. And I go to the door, and I reach for the door, and the handle is a door-handle: it feels that real. And I turn it.

A moment or two later, the guy appears in the doorway. And there's this moment when we look at each other, face to face, and he's this total nondescript guy, like any old beer-drinking dude. And he looks at me, and he's clearly perplexed, because we're not going through our usual dance. You know, I'd backed up to give him room. And the guy walks in, and we're looking at each other. And I hadn't thought about what I'd say — I just thought I'd let him in.

And what does the guy do? He pulls out a gun...

For the rest of the story — which is really interesting! — go to this website and click the little thing that says 'Stream':

- Wake up and dream, *Radiolab*, January 23, 2012.

For my October 2013 diary, go here.

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[For my September 2013 diary, go here.]

Diary - October 2013

John Baez

October 1, 2013

For almost five months a year, Lake Baikal is covered with ice. Perhaps because it's so deep, it starts freezing only in January, long after the Siberian frosts become intense. It usually thaws in May. At its peak, the ice is between 1 and 2 meters thick. Big cracks can be 10 to 30 kilometers long!

Lake Baikal is the world's largest freshwater lake. It contains roughly 20% of the world's unfrozen surface fresh water! It's 1600 meters deep — that's almost a mile! — and it's 640 kilometers long. It's over 30,000 square kilometers in area. It holds over 24,000 cubic kilometers of water.

Lake Baikal is also the *oldest* freshwater lake — about 25 million years old. Most lakes don't last very long. For example, the Great Lakes between Canada and the US started forming only 10,000 years ago, with the retreat of ice at the end of the last glacial period. I bet they've come and gone many times! But 25 million years goes back into the Oligocene, before the glacial cycles we're used to. Lake Baikal is in a rift valley, created by the Baikal Rift Zone. So, the whole lake is itself a kind of crack, that even now is expanding at 2 centimeters per year.

These are two of many beautiful images of Lake Baikal, which I found on a Russian website that no longer exists.

For my November 2013 diary, go here.

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For my October 2013 diary, go here.

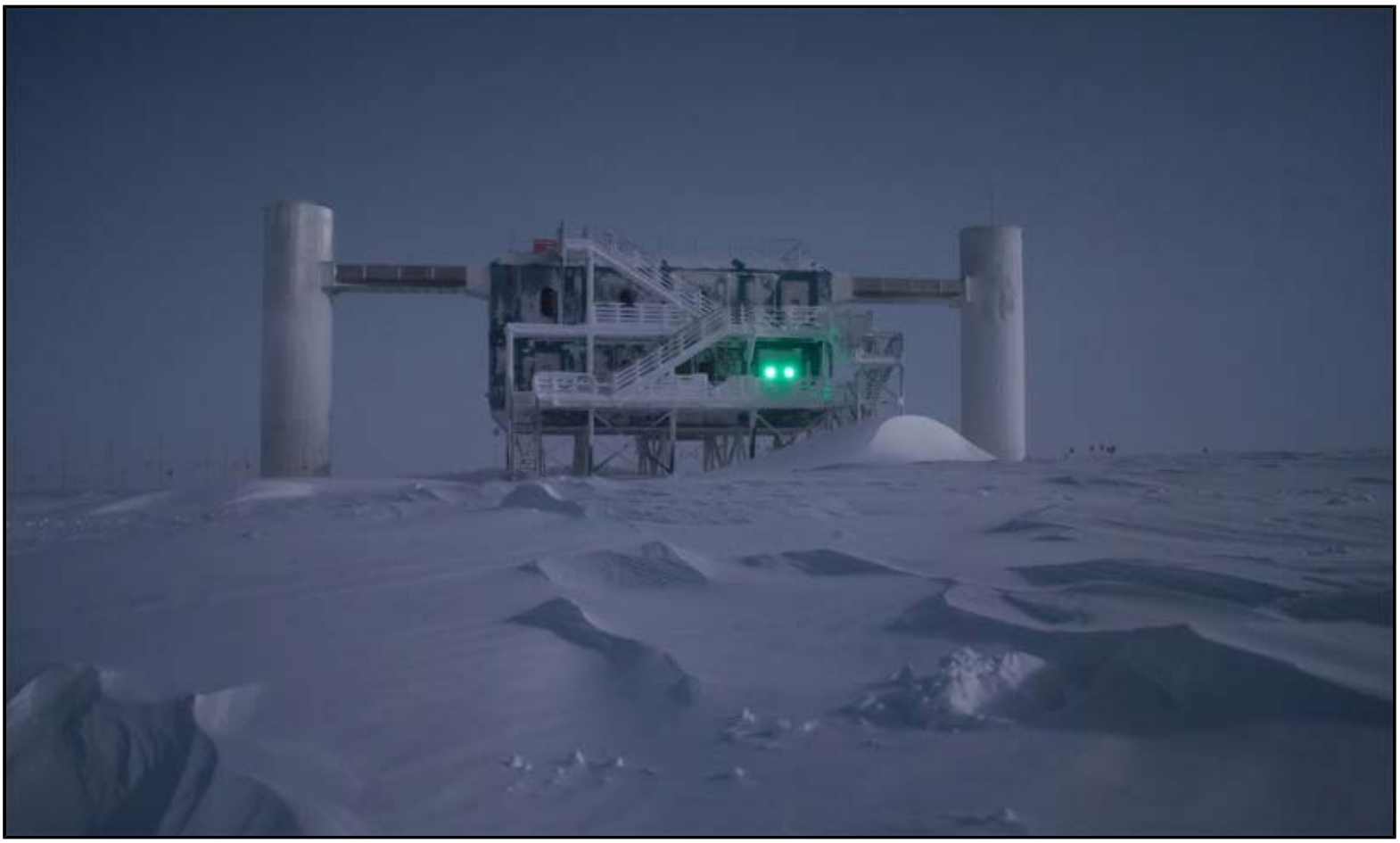
Diary — November 2013

John Baez

November 1, 2013

Moscow-based photographer Alexander Khokhlov and makeup artist Valeriya Kutsan are making portraits that use model's faces to create optical illusions. One series of these portraits is called "2D or Not 2D". This one isn't from that series, but it still could deserve that title!

November 20, 2013



This is the IceCube Neutrino Observatory in Antarctica. Actually most of it is deep under the ice. Almost 90 wires, each with 60 detectors attached, were lowered into holes melted in the ice using a hot water drill. And recently they've found some neutrinos with astoundingly high energies — up to 1 PeV!

I should explain that. An electron volt is how much energy an electron gets when it moves through a wire where the electric potential changes by one volt. A PeV is a peta-electron volt, or 1,000,000,000,000,000 electron volts... that's a 1 with 15 zeros after it.

But you still may not get how impressive it is for a neutrino to have that much energy. So let's go through some examples... and then I'll explain how a neutrino gets this much energy!

If you look at something orange, a bunch of orange photons are hitting your eye. Each one has an energy about about 2 electron volts. To pull the electron off a cold hydrogen atom takes 13.6 electron volts. These are the kind of energies we see in chemistry.

When they use X-rays to scan your luggage at the airport, it gets hit with lots of photons having over 100,000 electron volts of energy each.

When an electron hits its antiparticle and they annihilate, they turn into photons having a total of two times 511,000 electron volts of energy. In other words: mass can turn into energy, and the mass of an electron equals 511,000 electron volts of energy!

A proton is a lot heavier than an electron. When a proton hits its antiparticle and they annihilate, we get two times 938,000,000 electron volts of energy. A MeV is a million electron volts. So, that's 938 MeV.

The recently discovered Higgs boson is a lot heavier than a proton! To make a Higgs boson, you need about 125,000,000,000 electron volts of energy. A GeV is a billion electron volts. So, that's 125 GeV.

The particle accelerator used to make the Higgs boson can collide protons that have an energy of roughly 3 trillion electron volts: that's 3 TeV. People often say a flying mosquito has an energy of roughly one TeV. If so, this accelerator makes protons with the energy of three flying mosquitos! It doesn't sound like much until you realize it's all packed into a single particle.

A neutrino is an extremely light particle, much lighter than an electron. But Ice Cube has found neutrinos coming from space with energies up to 1,000,000,000,000,000 electron volts. That's a quadrillion electron volts, or a PeV. In other words: the energy of about a thousand flying mosquitos, packed into a single neutrino!

How do neutrinos get so energetic? The best guess is that even more energetic protons shooting through space hit photons from the cosmic background radiation, causing a reaction that makes neutrinos. These high-energy protons are called cosmic rays.

When I last checked, the most energetic cosmic ray ever seen was detected in 1994, when folks at the Fly's Eye cosmic ray detector in Utah observed one whose energy was about 320,000,000,000,000,000,000 electron volts. That's 320 quintillion electron volts, or 320 EeV. That's about the energy of a one-kilogram mass moving at 10 meters/second, all packed into one proton!

So, the next question is: why there are protons shooting through space at such high energies? But that's a question for another day.

Here's the new discovery:

- IceCube Collaboration: M. G. Aartsen, R. Abbasi, Y. Abdou, M. Ackermann, J. Adams, J. A. Aguilar, M. Ahlers, D. Altmann, J. Auffenberg, X. Bai, M. Baker, S. W. Barwick, V. Baum, R. Bay, J. J. Beatty, S. Bechet, J. Becker Tjus, K.-H. Becker, M. L. Benabderrahmane, S. BenZvi, P. Berghaus, D. Berley, E. Bernardini, A. Bernhard, D. Bertrand, D. Z. Besson, G. Binder, D. Bindig, M. Bissok, E. Blaufuss, J. Blumenthal, D. J. Boersma, S. Bohaichuk, C. Bohm, D. Bose, S. Böser, O. Botner, L. Brayeur, H.-P. Bretz, A. M. Brown, R. Bruijn, J. Brunner, M. Carson, J. Casey, M. Casier, D. Chirkin, A. Christov, B. Christy, K. Clark, F. Clevermann, S. Coenders, S. Cohen, D. F. Cowen, A. H. Cruz Silva, M. Danninger, J. Daughhetee, J. C. Davis, M. Day, C. De Clercq, S. De Ridder, P. Desiati, K. D. de Vries and 215 more authors, Evidence for high-energy extraterrestrial neutrinos at the IceCube detector.

Let me check the claim that a flying mosquito has a kinetic energy of 1 TeX — I got it from Wikipedia, but that doesn't mean it's true! According to the American Mosquito Control Association, the smaller mosquitos found around the house weigh about 2.5 milligrams. And according to a paper online, a fast mosquito flies 10 centimeters per second — this was hard to estimate because they fly in an irregular pattern, but that's another story. This paper also talks about mosquitos weighing 1 milligram, so I'm going to use that figure for a round number.

Kinetic energy is one half mass times velocity squared. So, the kinetic energy of such a mosquito is half of a millionth of a kilogram times (0.1 meters/second)^2, or 5×10^{-9} joules.

But a TeV is 1.6×10^{-7} joules! So in fact this estimate is fairly bad.

Even if we use heavier mosquitos, weighing 2.5 milligrams, we only get 1.2×10^{-8} joules. They'd have to also fly 6 times as fast to get an energy of a TeV.

The paper I used sounds like a famous martial arts movie:

- Bernard D. Roitberg, Edward B. Mondor and Jabus G. A. Tyerman, Pouncing spider, flying mosquito, *Behavioral Ecology* **14** (2003), 736–740.

For my December 2013 diary, go here.

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Diary - December 2013

John Baez

December 1, 2013

Look, dad! The world is ending!

No — it's just a halo combined with a full parhelic circle, two sun dogs and a 120° parhelion. They were photographed on a cold foggy day in Finland by Pauli Hänninen.

A parhelic circle is a horizontal white line at the same height from the horizon as the Sun, or occasionally the Moon. If it's 'full', it stretches all around the sky. More commonly it only appears in sections. It happens when beams of sunlight are reflected by vertical or almost vertical hexagonal ice crystals in the atmosphere.

A 120° parhelion appears as a bright blue-white spot on the parhelic circle, 1200 away from the Sun. It's caused by light that bounces inside the hexagonal ice crystals at least twice.

A sun dog or 'parhelion' is a bright spot 22° to the left or right of the sun, again caused by ice crystals in the upper atmosphere. Why 22°? I don't really know: all I know is that "these crystals act as prisms, bending the light rays passing through them with a minimum deflection of 22°."

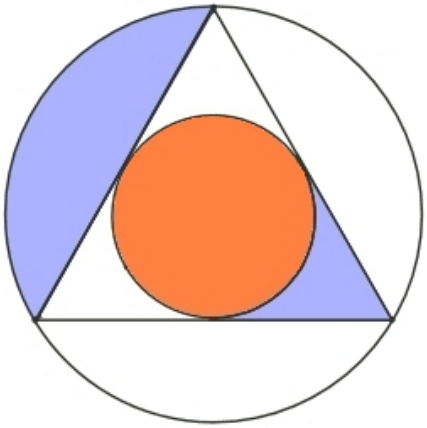
In the above photo you can see a halo around the Sun, which seems to be 22° away... and two sundogs at left and right. Then there's the long parhelic circle. It doesn't show the 120° parhelion, but here's a photo showing that:

For a diagram of how all these events fit together, and more photos, see:

- Jesus Diaz, These incredible sky lights look like alien spaceships coming to Earth, *Gizmodo*, November 1, 2013.

Some famous philosophers have written about sun dogs! In his *Meteorology*, Aristotle recorded an event where "two mock suns rose with the sun and followed it all through the day until sunset." And some sun dogs seen in Rome in the summer of 1629 made René Descartes interrupt his metaphysical studies and write a work on natural philosophy, called *The World*.

December 9, 2013



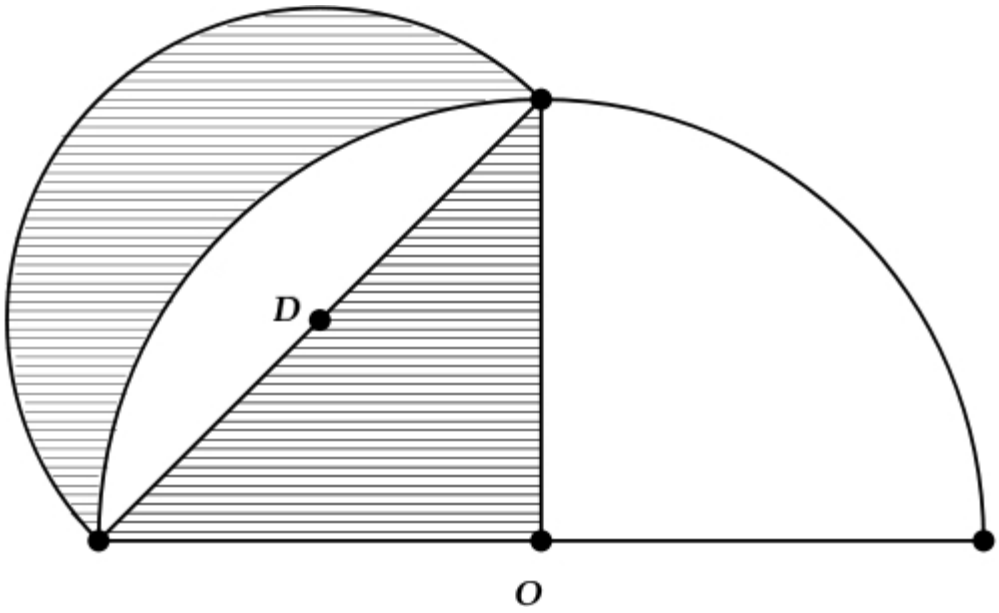
Puzzle: show the area of the orange circle equals the total area of the two blue regions!

It's not complicated if you think about it the right way. I never knew this cool fact until last night, when I read this:

- Brian McCartin, *Mysteries of the Equilateral Triangle*.

In case you're wondering, this is an equilateral triangle with a small circle inscribed in it and a big circle circumscribed around it.

December 10, 2013



Puzzle: show the crescent has the same area as the triangle.

Greek mathematicians really wanted to 'square the circle': the goal being to use straightedge and compass to first draw a circle and then construct a square with the same area.

In 440 BC, Hippocrates of Chios figured out how to square this crescent-shaped region, which lies between the circle centered at O and the smaller circle centered at D. So, this region is called the lune of Hippocrates.

This gave some people hope that the circle could be squared... but it was a false hope. Much later, around 1885, Lindemann and Weierstrass proved that squaring the circle was impossible.

Any crescent-shaped region formed by two circular arcs is called a lune. It's widely believed that only 5 kinds of lune can be squared. Three were discovered by Hippocrates. Two more were discovered by Martin Johan Wallenius in 1766. A proof that these are the only squarable lunes was given by Tchebatorew and Dorodnow. However, they made some assumptions which require further proof.

For more, try these:

- Brian J. Shelburne, The five quadrable (squarable) lunes.
- Erik Postma, Which lenses can be squared?, *Mathoverflow*.
- Wil Jagy, Hermite Lindemann and transcendental reals, *Mathoverflow*.

You have to be a loon to think you can square the circle, but you can square the lune to the tune of Claire de Lune.

December 13, 2013

Here's a true story from a spacewalk on July 16 this year:

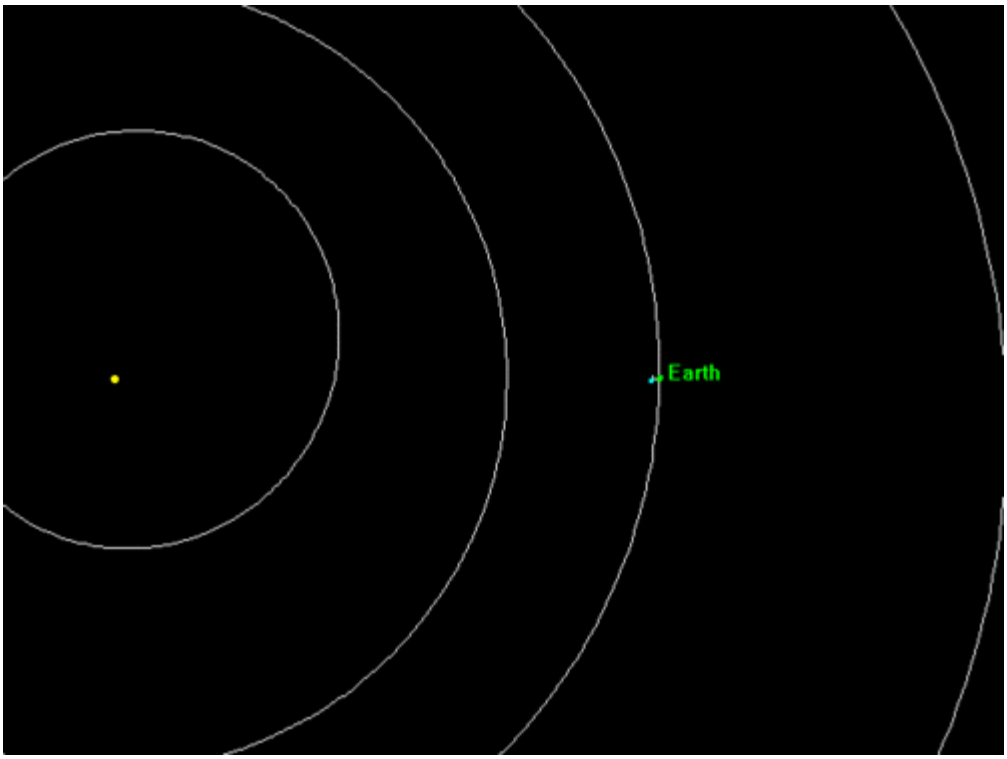
> ... As I move back along my route towards the airlock, I become more and more certain that the water is increasing. I feel it covering the sponge on my earphones and I wonder whether I'll lose audio contact. The water has also almost completely covered the front of my visor, sticking to it and obscuring my vision. I realise that to get over one of the antennae on my route I will have to move my body into a vertical position, also in order for my safety cable to rewind normally.
>
> At that moment, as I turn 'upside-down', two things happen: the Sun sets, and my ability to see — already compromised by the water — completely vanishes, making my eyes useless; but worse than that, the water covers my nose — a really awful sensation that I make worse by my vain attempts to move the water by shaking my head.
>
> By now, the upper part of the helmet is full of water and I can't even be sure that the next time I breathe I will fill my lungs with air and not liquid. To make matters worse, I realise that I can't even understand which direction I should head in to get back to the airlock. I can't see more than a few centimetres in front of me, not even enough to make out the handles we use to move around the Station.
>
> I try to contact Chris and Shane: I listen as they talk to each other, but their voices are very faint now: I can hardly hear them and they can't hear me. I.m alone. I frantically think of a plan. It.s vital that I get inside as quickly as possible. I know that if I stay where I am, Chris will come and get me, but how much time do I have? It's impossible to know.

Blind, unable to hear, and alone, Luca Parmitano still managed to figure out a solution to get himself back to the airlock. You can watch a movie of it here!

Later, NASA blandly reported:

> The water was not an immediate health hazard for Parmitano, but Mission Control decided to end the spacewalk early....

December 14, 2013



On September 3, 2002, an amateur astronomer named Bill Yeung looked into his telescope and discovered a strange object near Earth. Experts were surprised to discover that it was orbiting Earth! The orbit was unstable, which meant this object hadn't been here long. But there was no recently launched spacecraft that matched the orbit of this thing!

It got the name **J002E3**. It's fun to watch this animated gif and see how J002E3 came in from the Lagrange point L_1 between the Earth and Sun, went around the Earth a few times, and then got kicked out.

But what was it?

University of Arizona astronomers found that its electromagnetic spectrum was consistent with white titanium dioxide paint - the same paint used by NASA for the Saturn V rockets. Tracing back its orbit, they found that it had probably been orbiting the Sun for 31 years. The last time it was near Earth was1971.

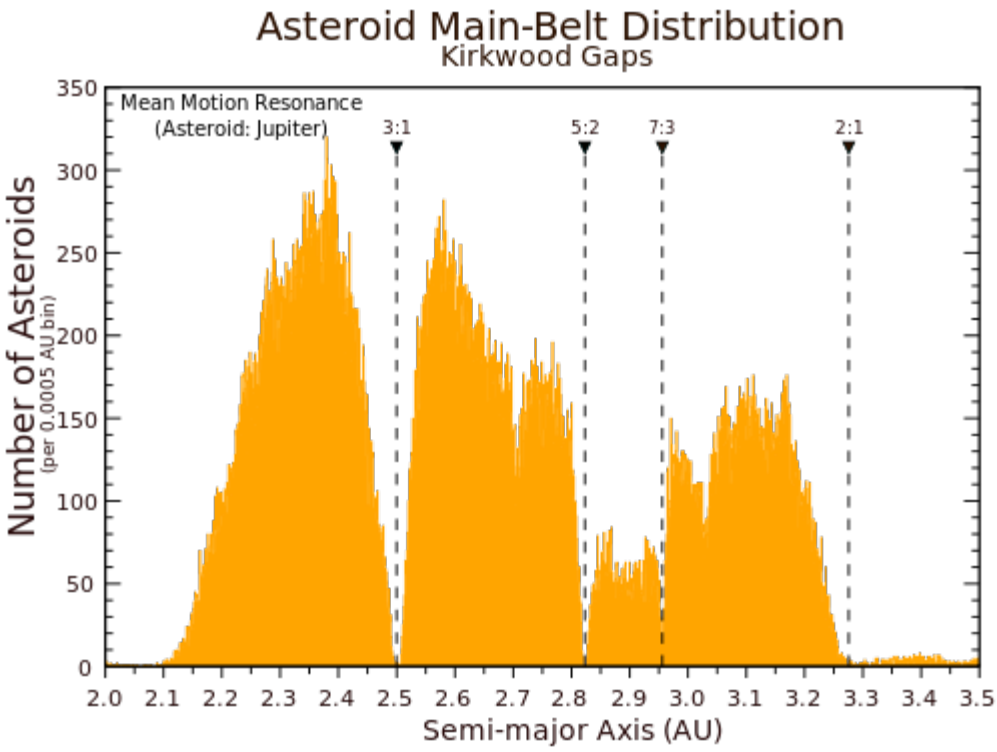
This seemed to suggest that it was a part of the Apollo 14 mission. But NASA knew the whereabouts of all hardware used for this mission! The third stage of that rocket, for example, was deliberately crashed into the Moon for seismic studies.

So, the most likely explanation seems to be that J002E3 is the third stage of the rocket for Apollo 12. NASA originally planned to shoot this into an orbit around the Sun. But they used more of the propellant than planned, and it seems that venting the rest didn't give this rocket stage enough energy to escape the Earth.Moon system. So, it ended up in a complicated orbit around the Earth after passing by the Moon on November 18, 1969.

It may hit earth someday! It weighs 10 tonnes. But don't worry: a 10-tonne meteor hits the Earth every few years, and most of them don't cause much trouble.

The explanation here is adapted from Wikipedia, and the animated gif was made by Paul Chodas aand Ron Baalke of NASA.

December 15, 2013

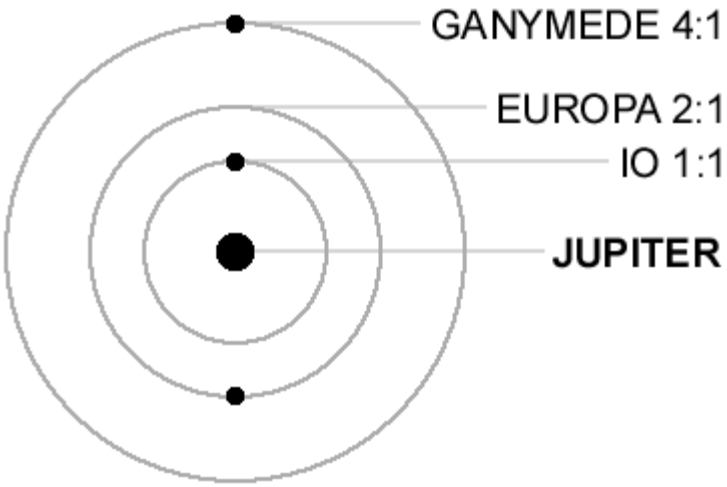


Most asteroids lie between Mars and Jupiter, but they avoid certain places — the Kirkwood gaps, discovered in 1857 by Daniel Kirkwood, a professor at a small college in Pennsylvania. He noticed that not many asteroids go 3 times around the Sun each time Jupiter goes once around the Sun: this is called a 3:1 resonance, and you can see that gap on the chart.

Other gaps show up at other simple ratios. Why does this happen? I don't fully understand it. The usual story is that it's like pushing on a swing: if you push on a swing each time it swings back, it picks up energy and swings higher. Similarly, if you have a big heavy planet orbiting a star, asteroids that go around N times each time the planet goes around M times pick up energy and their orbits change... leaving a gap at this location.

This effect, called an unstable N:M resonance, happens a lot. You can also see it in Saturn's rings, which have gaps where the dust particles would be in resonance with its big moons.

So far, so good. But there are also stable resonances, where one planet or moon likes to go around N times when the other goes around M times! For example Jupiter's moon Io is in a 2:1 resonance with Europa, and Europa is in a 2:1 resonance with Ganymede.



Also, Neptune is in a 3:2 resonance with Pluto.

So sometimes resonance makes orbits unstable, but sometimes it makes them stable. Why? Wikipedia tries to explain it, but I'd need to see some more detail — probably some math — to really understand what makes the difference between the two cases:

Here are the main Kirkwood gaps. It helps to know that the Earth is 1 astronomical unit or AU from the Sun, Mars is 1.52 AU away from the Sun, and Jupiter is 5.2 away. The biggest Kirkwood gaps are these:

- 2.06 AU (4:1 resonance)
- 2.5 AU (3:1 resonance), home to the Alinda family of asteroids
- 2.82 AU (5:2 resonance)
- 2.95 AU (7:3 resonance)
- 3.27 AU (2:1 resonance), home to the Griqua family of asteroids.

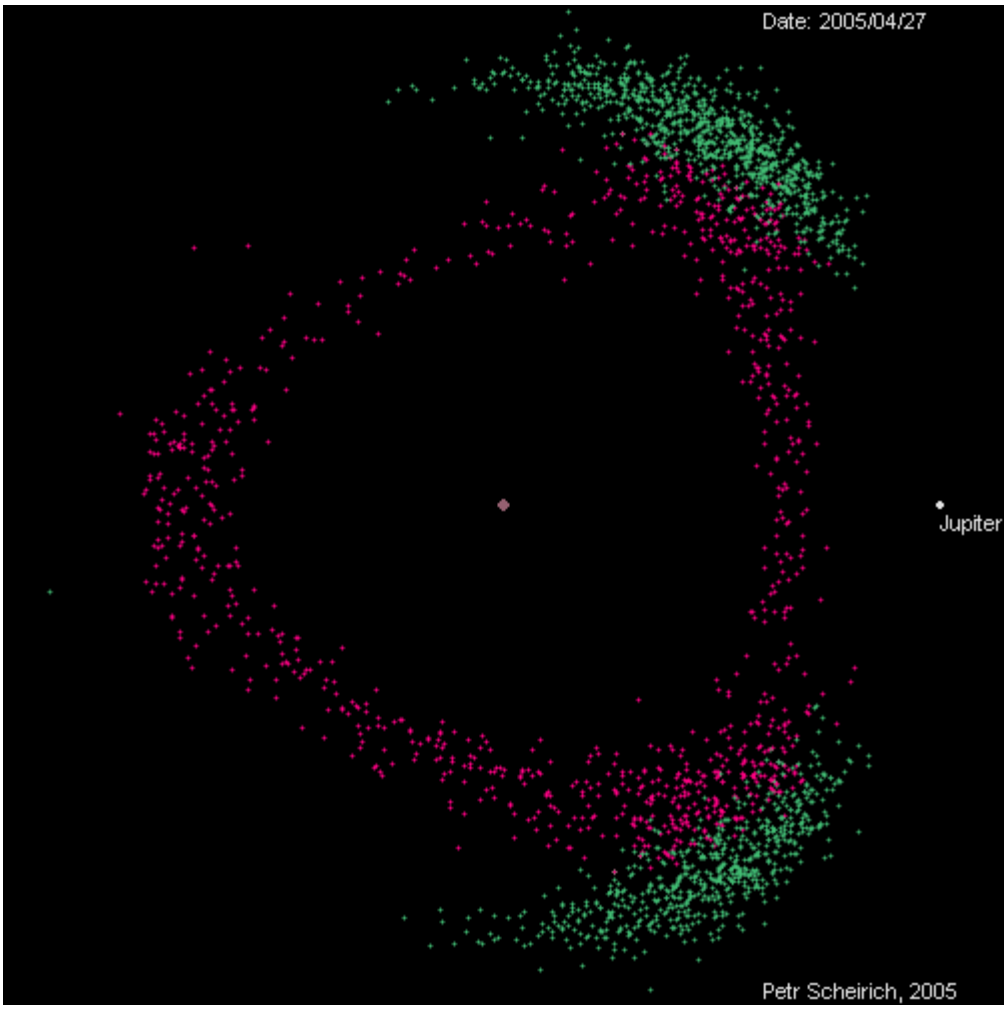
Hey! Why are there families of asteroids located in the gaps? Apparently they're in the process of moving out, but I'd like to know more.

There are also lots of weaker or narrower gaps:

- 1.9 AU (9:2 resonance)
- 2.25 AU (7:2 resonance)
- 2.33 AU (10:3 resonance)
- 2.71 AU (8:3 resonance)
- 3.03 AU (9:4 resonance)
- 3.075 AU (11:5 resonance)
- 3.47 AU (11:6 resonance)
- 3.7 AU (5:3 resonance).

If you played sounds at these frequency ratios, you'd get different chords. 2:1 is an octave. 5:3 is a major sixth. 3:1 is an octave and a fifth. So the Kirkwood gaps are a nice example of the 'music of the spheres' that astronomers of old used to dream about. But the music is not played by the asteroids — *it's in the gaps!*

December 16, 2013



Here are some asteroids viewed in a rotating frame of reference where Jupiter almost stands still. The Trojans, in green, are asteroids that stay near the Lagrange points 600 ahead or behind Jupiter. They go around the Sun once each time Jupiter orbits the Sun. But the Hildas, in purple, go around the Sun 3 times while Jupiter goes around twice. We say they're in a 3:2 resonance with Jupiter.

The Hildas seem to be moving in a triangular pattern. But actually each one takes an elliptical orbit around the Sun. There are three kinds of ellipses. Two go farthest from the Sun near the Lagrange points, while one goes farthest from the Sun opposite Jupiter. Although the whole triangle of Hildas is nearly equilateral, it's not quite. The side between the two Lagrange points is a bit different from the two other sides. You can also see the whole triangle pulsing as Jupiter moves in and out!

This animated gif is one of many made by Petr Scheirich, and you can have hours of fun looking at his website:

- Petr Scheirich, Asteroid (and comet) groups.

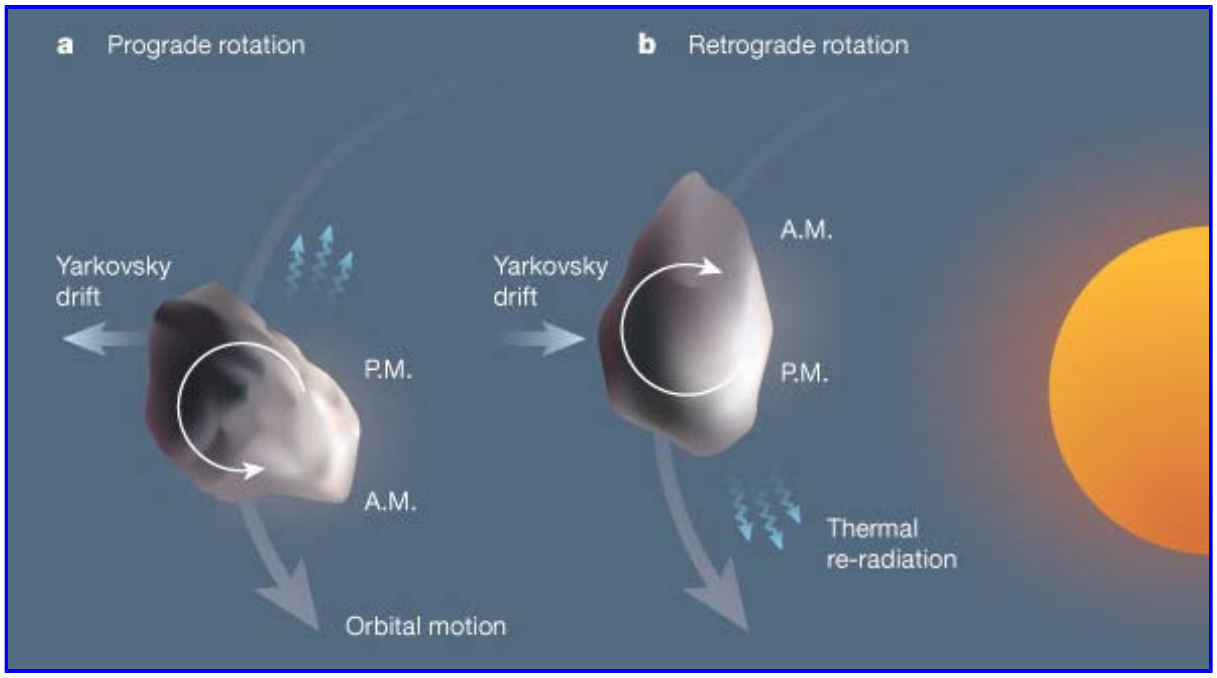
There's a lot to say about Trojans and Lagrange points, but let me talk about Hildas. Over 1,100 Hildas have been found, the first being Hilda, named after the discoverer's daughter. It's big — 175 kilometers in diameter — but not very bright, because it's made of ancient stuff containing lots of carbon, similar to the nucleus of a comet.

The Hildas don't form a 'true' asteroid family, because they aren't fragments of a single parent object. Instead, they're a 'dynamical' family: they're defined by having similar orbits. Any Hilda's orbit has an eccentricity less than 0.3, an inclination less than 200, and a semi-major axis between 3.7 AU and 4.2 AU. Remember, the semi-major axis of an ellipse is half the distance between the farthest points.

So, the Hildas are outside the main asteroid belt, which lies between the 4:1 resonance with Jupiter at 2.1 AU and the 2:1 resonance at 3.0 AU.

The density of Hildas near the triangle's corners is more than twice the density on the sides. The reason is that the Hildas move more slowly when they're farther from the Sun! So, they stay near the corners for an average of 5.0-5.5 years, but move along the sides of the triangle more quickly, for 2.5 to 3.0 years. The overall period of the Hildas is about 7.9 years, which is 2/3 the period of Jupiter.

December 17, 2013



The Yarkovsky drift makes small asteroids move away from the Sun or get closer to it, depending on which way they turn.

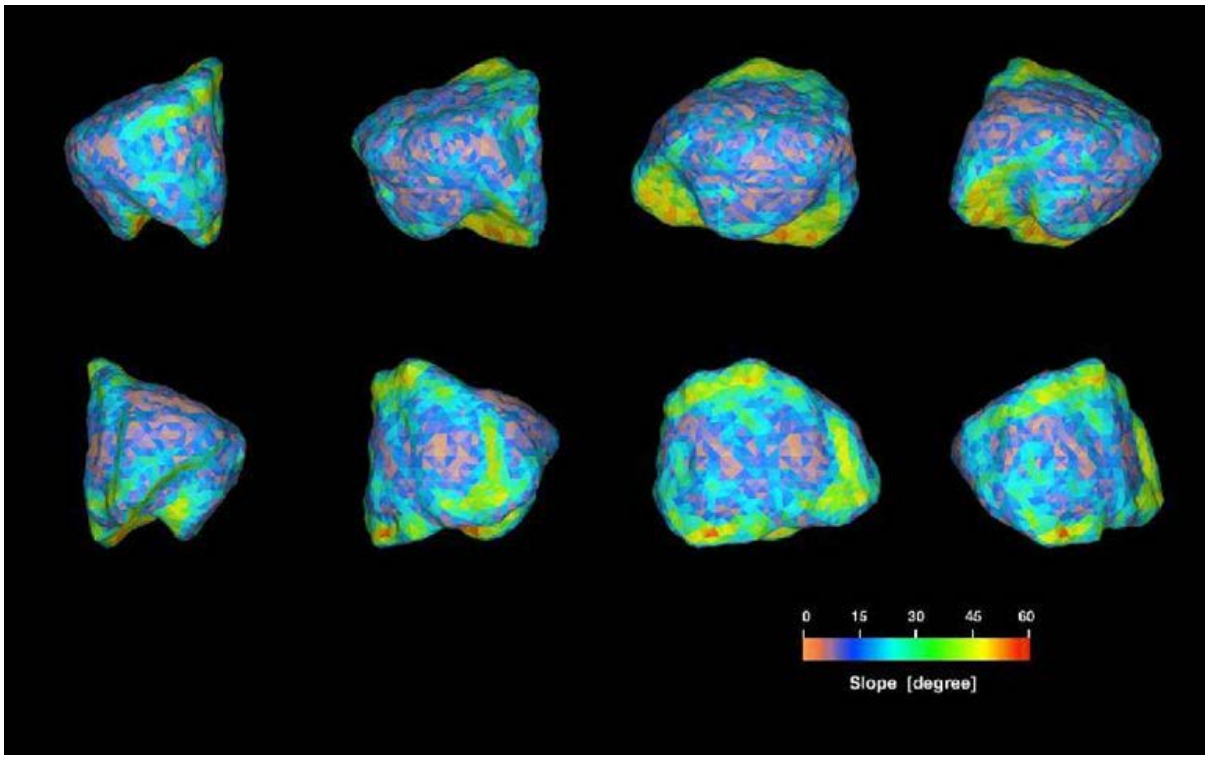
The asteroid at left is turning the same way it's revolving around the Sun. So the hottest part of the asteroid, which has been in the sunshine warming up all day, is in back — the part marked "P.M." When it radiates heat, this pushes the asteroid in the direction it's already going, so the asteroid gains energy! This gradually makes the asteroid move farther from the Sun: that's the 'Yarkovsky drift'.

The asteroid at right is turning in the opposite way from how it's revolving around the Sun. So, radiating heat makes this asteroid lose energy and move closer to the Sun.

This effect was discovered theoretically in 1900 by a Russian civil engineer named Ivan Osipovich Yarkovsky, who worked on scientific problems in his spare time. It's a small effect, which is strongest for small asteroids, so it was only seen in the 1990s. For twelve years, astronomers carefully used radar to measure the position of a small asteroid called 6489 Golevka. It drifted 15 kilometers due to this effect!

To understand how small this effect is, think about this. The force it created on 6489 Golenka was about 0.25 newton. This is the force that pushes down on your hand when you're holding a quarter of an apple. It created an acceleration of just a tenth of a nanometer per second per second. But this acceleration adds up over time!

December 18, 2013



The YORP effect is a way for asteroids to spin faster and faster... even until they explode!

It's powered by sunlight. Sunlight heats the asteroid, which then radiates heat in the form of infrared light. If an asteroid has an irregular shape, like 6489 Golevka here, this infrared light can push on the asteroid in a way that makes it spin!

This is impossible if the asteroid is a sphere or ellipsoid made of some uniform material. It's easiest to understand for an asteroid shaped like a windmill.

Indeed, the YORP effect may remind you of a light mill, or Crookes radiometer — a toy like a windmill in a glass bulb with vanes black on one side, white on the other, powered by light. But it's a bit different, since these light mills only turn the way they do because there's a little gas in the bulb. If the bulb contained a perfect vacuum, the light mill would feel a torque pushing it the opposite way. Light mills are very tricky! Both Maxwell and Einstein wrote papers on them... and they came up with different explanations of how they work! I wrote about this on the *n*-Category Café once.

The full name of the YORP effect is the Yarkovsky–O'Keefe–Radzievskii–Paddack effect. It's a relative of the Yarkovsky effect, which makes a rotating asteroid move towards or away from the Sun.

In 2007, astronomers detected the YORP effect in a small asteroid named 2000 PH5. To celebrate, they renamed this asteroid 54509 YORP. The rotation rate of this asteroid is increasing by 0.0002 degrees per day each day.

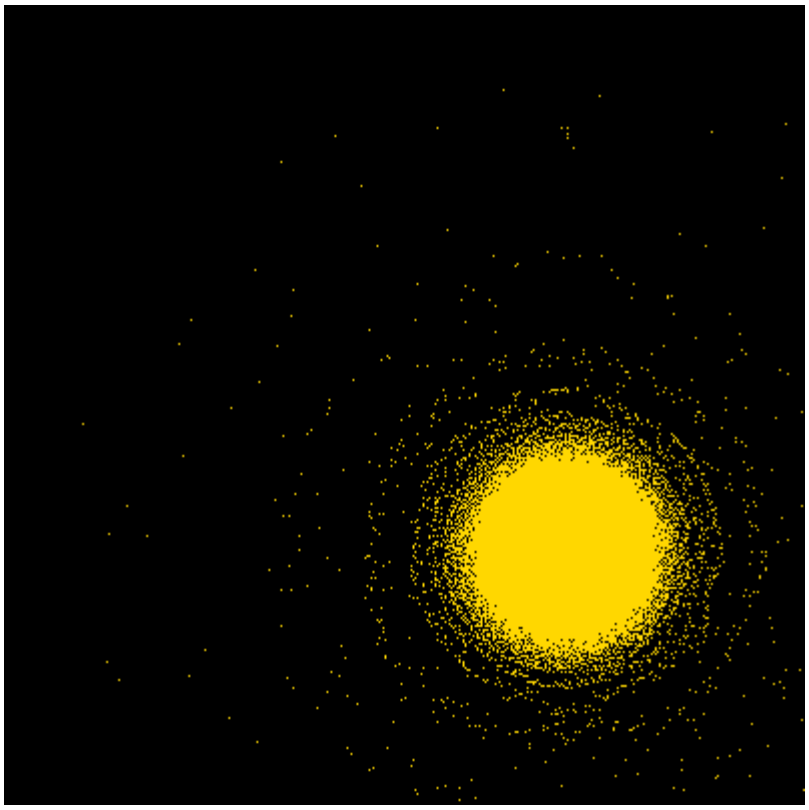
That doesn't sound like much... but in astronomy, things take a long time. The rotation rate of this asteroid will double in 600,000 years. Simulations show that it will keep spinning faster until it turns around once every 20 seconds... and then it will burst! Asteroids are often loosely held together clumps of rock. If they spin fast, they can split into a binary asteroid. So, the YORP effect may explain the existence of some binary asteroids.

According to Wikipedia:

> Observations show that asteroids larger than 125 km in diameter have rotation rates that follow a Maxwellian frequency distribution, while smaller asteroids (in the 50 to 125 km size range) show a small excess of fast rotators. The smallest asteroids (size less than 50 km) show a clear excess of very fast and slow rotators, and this becomes even more pronounced as smaller populations are measured. These results suggest that one or more size-dependent mechanisms are depopulating the centre of the spin rate distribution in favour of the extremes. The YORP effect is a prime candidate. It is not capable of

significantly modifying the spin rates of large asteroids by itself, however, so a different explanation must be sought for objects such as 253 Mathilde.

December 19, 2013



(If this images doesn't play as an animated gif, download it and look at it that way.)

About 2 billion years ago, an asteroid about 100 kilometers across was completely pulverized when a smaller one hit it! This created the Koronis family in the outer part of the main asteroid belt. There are hundreds of asteroids in this family. The biggest are Lacrimosa and Urda, with diameters of 48 and 44 kilometers.

In the simulation here, a 119-kilometer asteroid is hit by a smaller one moving at 5 kilometers per second - or roughly 10,000 miles per hour. The shock wave created by the impact shatters the bigger asteroid, which had a lot of cracks to begin with. Hundreds of thousands of fragments shoot in all directions. Then gravity pulls them together over several days. The largest new asteroid, shown here, contains 4% of the mass of its parent.

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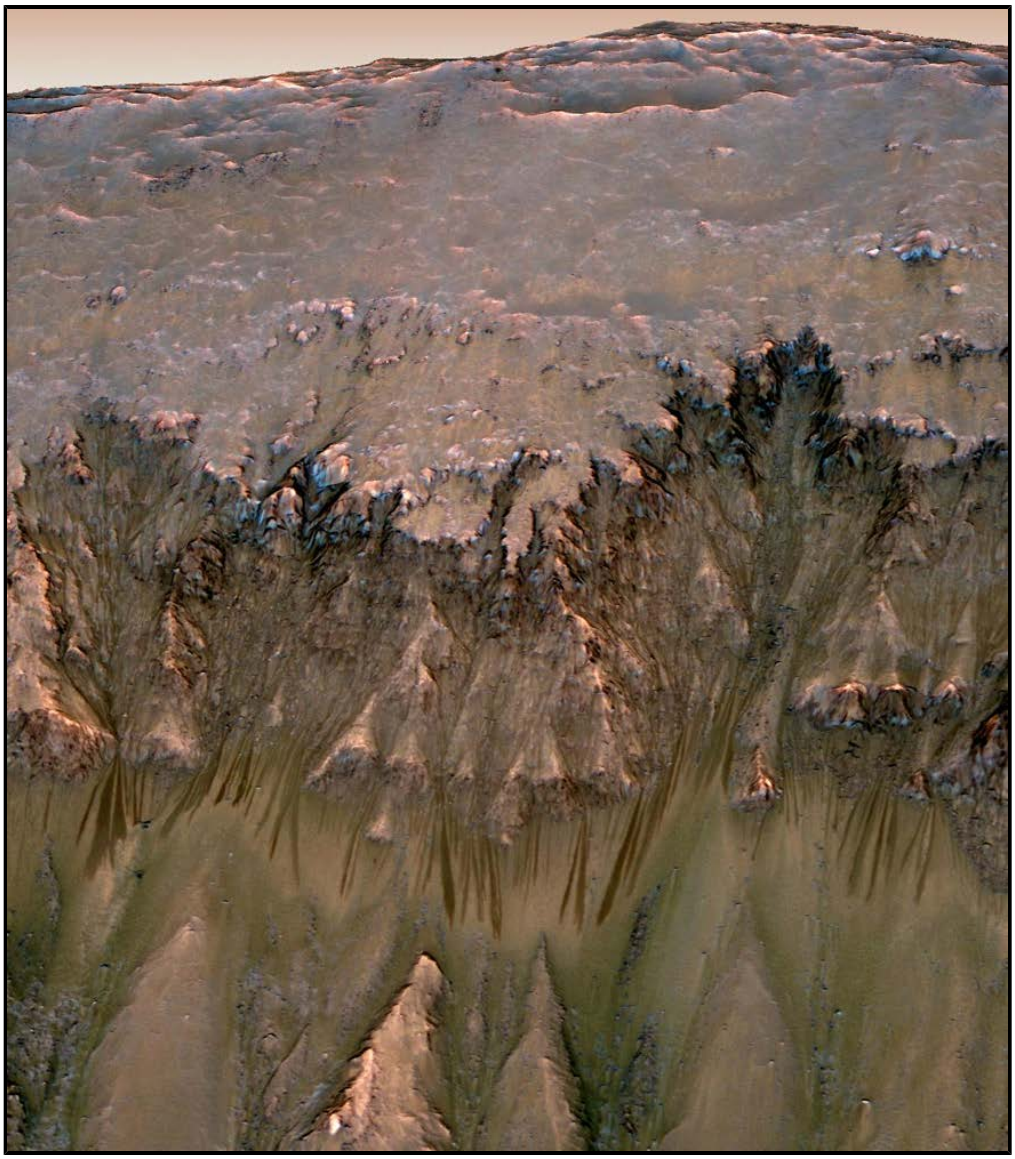
This simulation was one of many done by Patrick Michel around 2000. He used a Compaq Dec Alpha and a Beowulf cluster. To compute the gravitational interaction of many chunks of rock using parallel processing, he used the "hierarchical tree method".

December 23, 2013



You are in a helicopter exploring the southern part of Mars. When you enter Newton Crater, you see dark streaks that look like signs of dripping water, or moisture. What are they?

Here's what we know. They are 0.5 to 5 meters wide. They appear in the early spring. They grow larger in the summer. They go away in the winter. Similar things appear in a number of places in the southern hemisphere, but so far none have been seen in the north.

A paper in *Science* argues that they could be caused by brine — very salty water. Salts absorb water very eagerly, and brine has a lower melting point than ordinary water.

This image was created using a photo made on 30 May 2011 by the High Resolution Imaging Science Experiment (HiRISE) camera on NASA's Mars Reconnaissance Orbiter. It has been reprojected to show what this view would look like from a helicopter inside the crater. A synthetic Mars-like sky has been added, and the color has been enhanced. The season was summer at the location of the crater: 41.60 south latitude, 202.30 east longitude.

Puzzle: could we design a helicopter that works on Mars? The gravity is weaker, but the atmosphere is thinner.

For more, see this:

- Alfred S. McEwen *et al*, Seasonal flows on warm Martian slopes, *Science* **333** (2011) 740–743.

December 27, 2013

WOW! Maria Leijerstam is now the first person to cycle to the South Pole! She arrived on December 27th.

She was racing against two men, and she arrived at the pole with a lead of hundreds of miles! It took her just 9 days to go 640 kilometers. She rode a custom-made recumbent tricycle whose great design let her cut through the gale-force winds and *scale the Transantarctic Mountains* — a route similar to Scott and Amundsen's famous South Pole expeditions. Her competitors had to go around, and that's a big part of why she won.

With the mountains behind her, Maria then faced a 480-kilometer journey over the polar plateau. Snow drifts, crevasses, whiteouts, rough grooved terrain and temperatures as low as -35° made it hard — but she cycled in 12-hour stints, and did up to 60 kilometers per day... for the win!

She's now back home in Wales. I love what people can do with the right technology together with intelligence and huge amounts of determination. She practiced for 4 years - watch this video:

For more see:

- Maria Leijerstam, Maria claims two world titles, 27 December 2013.

Word of the day: rough grooves in snow are called 'zastrugi'.

December 31, 2013

My mother sent me a box of old stuff including this photograph of my dad, Peter Baez... and the poncho he was wearing here! This would have been taken around 1958 or so.

For my January 2014 diary, go here.

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baez@math.removethis.ucr.andthis.edu

home