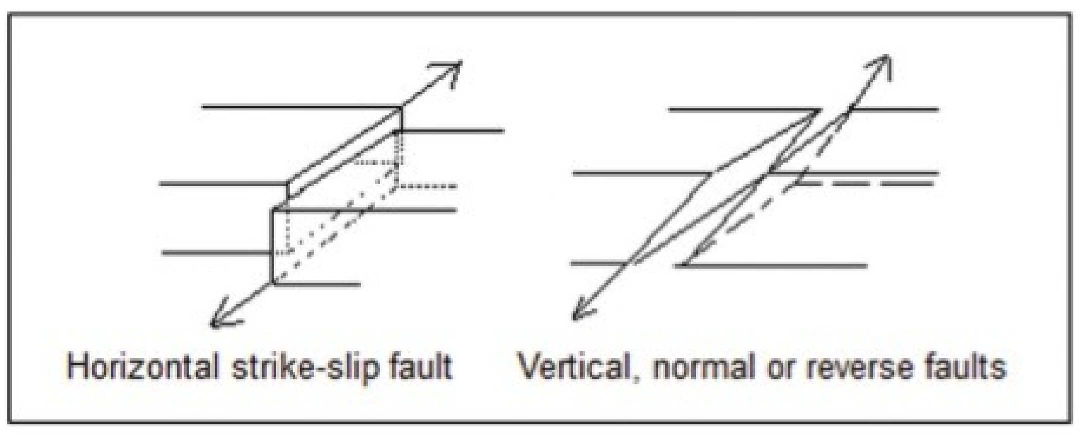
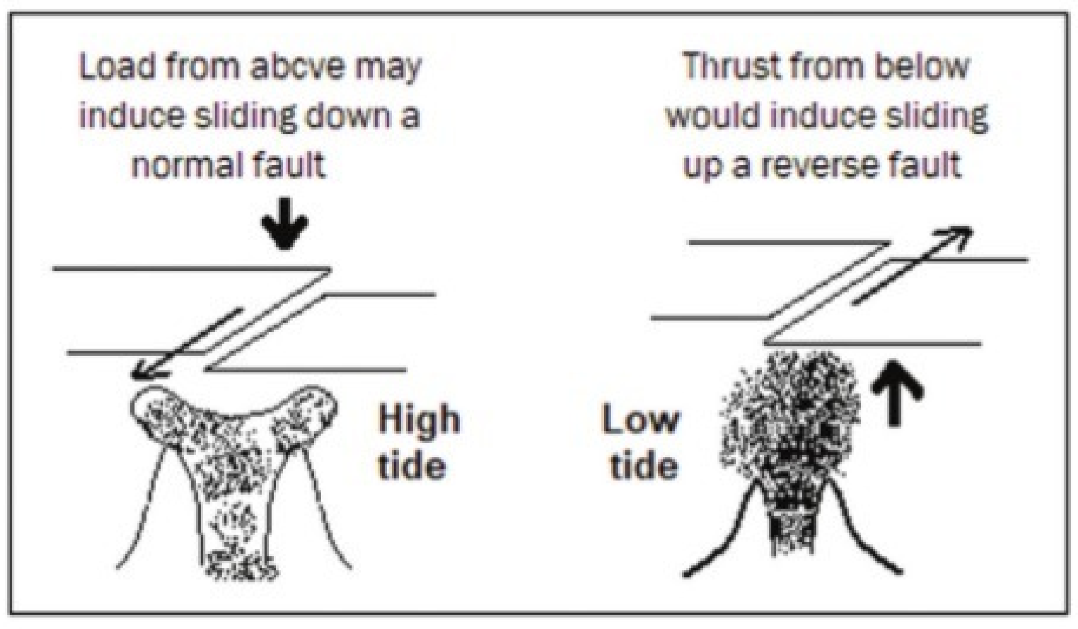
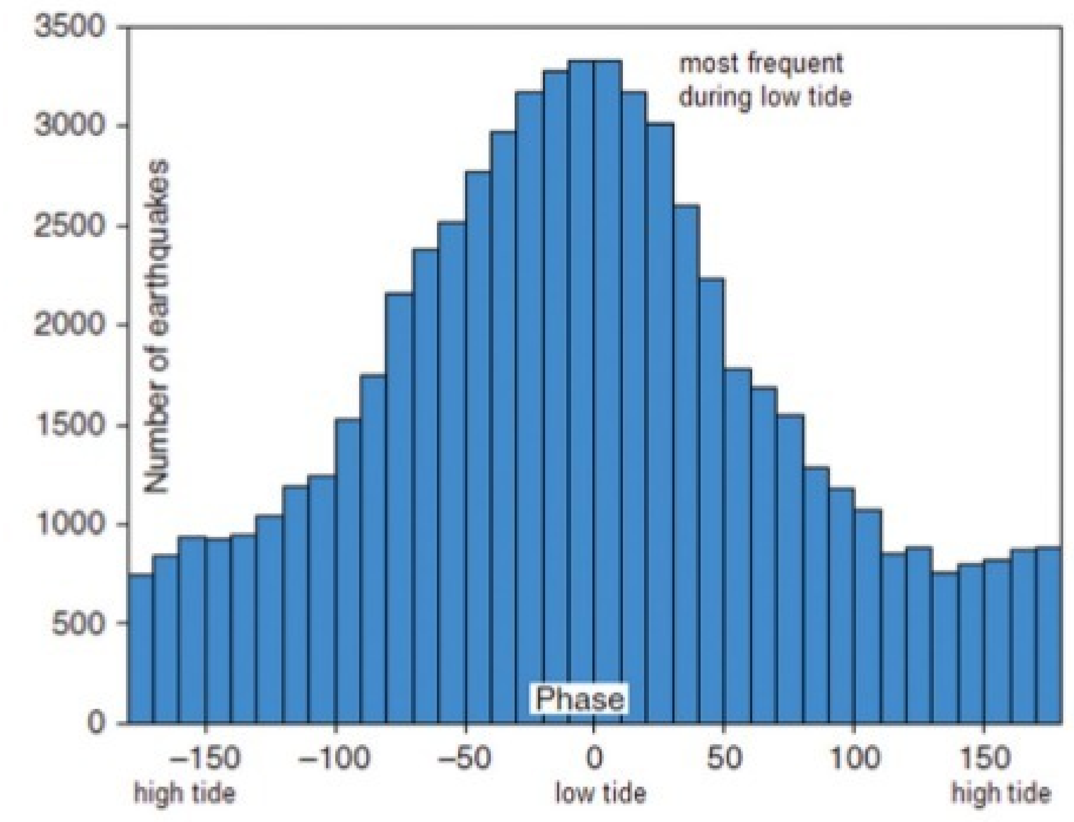
Tides that trigger earthquakes

At great depths in the Earth's seabed, reducing a load is sometimes the same as adding a large burden

S ANANTHANARAYANAN







The Earth's crust formed as its outer layers of molten rock cooled and solidified. The crust, however, did not form all once or in one piece, but in separate segments. These segments, called tectonic plates, were generally in relative motion and they shuffled about until they found orientations with greater stability. The crust is now largely firm, but imperfections remain and the plates of rock still need to shift and resettle. These events, where the plates slide over each other, are what we know as tremors or earthquakes.

Christopher H Scholz, Yen Joe Tan and Fabien Albino from Columbia University and the University of Bristol, in a paper in the journal, *Nature Communications*, examine a case where ocean tides promote or suppress such shifting of the Earth's crust, at great depths, on the seabed. And in the process, they find the answer to an old question about the mechanism by which ocean tides bring about earthquakes.

Adjacent faces of discontinuities, or weak sections of the crust, are known as faults. Uneven pressures along the faults could cause movement of the crust, horizontally, or along inclines, of the plates on the two sides of a fault. If there were friction, or adhesion between the two faces, the pressure would build up, until it overcomes resistance, with sudden and energetic movement of the two parts of the crust. The faults could extend to miles on end and earthquakes, as we well know, can be severe, indeed.

While tremors and upheavals of the earth, in the process of realignment of tectonic plates, happen from time to time, they could also be the result of forces or thrust. These could arise from a distant earthquake, erosion or buildup of landmass, or even manmade causes, like excavation or the use of explosives. And yet another source of pressure is the gravitational forces of the moon and the sun, which tug and pull on the material of the Earth.

They are powerful forces, which cause tidal deformation, as the Earth rotates and the Moon goes around the planet. The same force, caused by the Earth on the Moon, has affected its rotation, so that its speed of rotation is only once every lunar month. The Earth's gravity has hence effectively locked one face of the Moon to be always facing us.

The effect of the Moon on the Earth are the ocean tides, which rise and fall when the Moon is directly overhead or on the opposite side of the Earth, or just rising or setting. While ocean tides are clearly visible, the part of the land directly towards the Moon is also powerfully pulled towards it. This effect, of course, is not noticeable, as rock and earth are not fluid, like the sea. However, as ocean tides are large and energetic, the authors of the paper have studied the effect that ocean waves have on the realignment of the crustal faults that are found on the seabed.

Faults along the seabed are broadly of three kinds, the horizontal strike-slip fault or the vertical or slanting, "dip-slip", normal or reverse faults. In strike-slip faults, one plate slides to one side, along another, and in the other kind, one plate slides down another face, or slides up. While different kinds of thrusts can bring about such movements, it is of interest to see what effect the vertical pressure, arising out of the greater mass of water that collects during high tide would have.

As tides cause loading of the mass above the faults, it has been known and the extensive record available shows that the occurrence of seabed earthquakes is correlated with the tides. But the surprise is that the earthquakes occur more often during low tide than during high tide. As the main force acting on the matter of the crust is its own downward weight, it is reasonable to think that an increase of the load, in the form of thousands of tonnes of seawater during high tide, would make an earthquake caused by a vertical slip along a normal fault more likely. The time of low tide is one of lesser load and this should be an inhibitor of movement down a normal fault, rather than the promoter or a trigger to overcome resistance and set off a cascade of landmass.

The authors of the paper observe that the mid-ocean ridges, which are associated with underwater volcanic action, would be the most promising place to test theories of earthquake triggering. Accordingly, they study the records of the Juan de Fuca ridge, a mid-ocean mountain system in the Pacific Northwest region, formed by movement of crustal plates. The ridge is also home to Axial Seamount, an underwater volcano, 1,400 metres below sea level.

The authors cite the data collected during three months preceding an eruption of the Axial in 2015, and the frequency of earthquakes, as shown in the diagram, was the highest during low tide. The paper explains that the earthquakes were dominated by "normal faulting", with a mean fault dip of 67°. The reduction of the vertical load, during low tide, should hence have the effect of reducing the tendency to slip down such a steep slope, and it is the high tide, with a rise in the load, that should encourage slip, the paper says.

The factor that explains the paradox is found to be an additional, upward force, which has not been considered so far. This is from the volume of molten or nearly molten matter that lies beneath the fault. The Axial Volcano being an active volcano that erupts every decade, the collected molten material, the magma, is depleted after every eruption, followed by build-up until the next eruption. The crust above the volcano is thus sitting atop a cushion that could rise or fall, according to the pressure it is under.

During high tide, the weight of water tends to balance the upward thrust by magma, or could be considered to be balanced by the same thrust. During low tide, however, the balancing load is relieved, and the lower tectonic plates are pushed up the sloping separation at the faults.

It was the great sensitivity of seismic activity to tidal forces in the Juan de Fuca ridge that enabled the mechanism to be worked out, the paper says.

The writer can be contacted at response@simplescience.in

Flying with 'friends'

Tracking technology gives new insights into the behaviour of migrating birds

KIRAN DHANJAL-ADAMS

Though much is known about where and when birds travel, a lot less is known about the composition of flocks and how long they stay together. Do birds come together in flocks by chance? Do they actively choose flock members?

It's difficult to understand groups without being able to observe them directly. But advances in technology are changing this. Individual birds can now be fitted with small tracking devices called geolocators, which store data from one breeding season to the next. When the bird is recaptured, the data is then downloaded and used to reconstruct the bird's migratory pathway.

Geolocators are useful for tracking the location of individual birds. But they lack the spatial precision to investigate their behaviour. So researchers at the Swiss Ornithological Institute added pressure sensors to geolocators. That's because pressure is an indicator of altitude, and rapid changes in pressure can tell us when a bird is flying and how high.

In a study published in the journal *Current Biology*, we used these pressure loggers to track the behaviour of groups of migrating bee-eaters. We were able to monitor how these birds moved as flocks, something, which was impossible until the development of the new loggers.

The technology records how the individual birds are behaving. It allows researchers to see which ones are doing the same thing at the same time — in other words, which ones are making decisions together and coordinating their flight, and therefore belong to a flock.

Most surprisingly, we found that birds can spend long periods travelling together with the same individuals, even rejoining each other after separations.

What the data showed

We fitted 29 loggers on European bee-eaters (*Merops apiaster*) in 2015 and 2016. The species is very sociable and breeds in large colonies. They also sometimes raise young that are not their own, deciding which birds to help and how much assistance to offer. The species has also been shown to cooperate with other bee-eater species to mob predators and search for food.

So we hypothesised that they were also likely to socialise during migration.

The data confirmed this theory. We noticed that not only were some of the tracked birds flying and stopping at the same time, but they were also hitting the same altitude simultaneously.

This meant the birds were sharing the decision to fly or not; to go up, or down, to make slight shifts or to remain at the same altitude. And this wasn't happening occasionally over the course of a few hours; the behaviour was noted over months at 30-minute intervals.

Such patterns could only occur between birds interacting within the same flock.

Data also showed that 49 per cent of the tagged birds migrated 14,000 km together from Germany to the Congo Basin and back. The rest split while crossing the Sahara. But 89 per cent came back together again in Sub-Saharan Africa, locating each other despite a month spent travelling 5,000 km separately.

In Africa, all bird groups would repeatedly separate for one to five days, then come back together again before migrating back to Europe together. The birds that reunited were individuals that had previously spent time together.

Even in the breeding grounds, we found that European bee-eaters preferred the company of some individuals over others — and these tended to be the individuals with whom they would migrate.

Most surprisingly, none of these birds had previously been caught in the same burrow as chicks or adults (over 95 per cent of the population was monitored by researchers), and were not part of the same family unit.

Two pairs of birds also bred together after migrating to Africa in the same flock.

Beneficial behaviour

This is some of the first evidence we have of birds remaining in long-term flocks with non-family members of mixed age and sex.

Waterbirds such as cranes and geese can also migrate in stable multi-family flocks, but later separate into family or juvenile groups once they arrive at their destination. Bee-eaters, however, remain with the same non-family members throughout the year. In a manner of speaking, they form cliques.

Most likely, younger birds benefit from the knowledge and guidance of older birds, allowing them to share information on migratory conditions, to change their behaviour accordingly and to adapt to changes in conditions.

Furthermore, the species soar-glides during migration. Birds identify thermal updrafts, navigate within these to gain altitude, and leave at the right moment to make it to the next thermal. Young birds, however, often leave thermals at the wrong moment and lose momentum.

In fact, it is remarkably difficult for birds with different experience levels to remain together for longer than a few days, unless they compromise and wait for each other.

So staying together appears to be a deliberate strategy in bee-eaters, and it is likely that cooperation brings benefits beyond migration. Cooperating could also allow bee-eaters to search for food, defend territories and fend off predators.

A deeper understanding

Previously, most birds were thought to be guided by their genes during migration — birds taking "bad" migratory routes would die, while the ones taking "good" routes would survive to pass their genes onto their young. How else could a cuckoo find its way across Europe and Africa when it had never met its biological parents?

Our research, however, shows that the picture is a little more complex, and that there is a spectrum of migratory behaviours ranging from genetically-driven (as is the case of the cuckoo) to experience-driven (as is the case of cranes). Knowing that some bird species prefer to migrate with "friends" changes the way we think about the mechanisms that shape migratory behaviour. The ability of birds to survive changing conditions will be clearer when we understand what drives their movement from one environment to another.

The writer is a postdoctoral research associate, Swiss Ornithological Institute.
This article first appeared on www.theconversation.com

PLUS POINTS

Transparent teeth

With a large black grin and dark eel-like body, the deep-sea dragonfish is one of the ocean's most formidable predators. Part of this pencil-sized marauder's success is down to its fearsome set of fang-like teeth, which are covered in nanocrystals. This prevents light being reflected off them, meaning they are invisible to potential prey, according to the latest research.

"They spend most of their time sitting around with their jaws open, waiting for something to come by," said lead researcher Audrey Velasco-Hogan, a PhD student at the University of California San Diego, US. "Their teeth are always exposed, so it's important that they are transparent so they don't reflect or scatter any bioluminescent light from the environment."

Despite measuring just 15 centimetres in length, deep-sea dragonfish (*Aristostomias scintillans*) are apex predators and feed on fish that are up to half their size. They are so voracious that they even eat each other. If their teeth were visible, prey would immediately shy away, researchers say.

Scientists analysed the nanostructure of the teeth by using electron microscopy, which is a technique used to obtain high-resolution images of biological specimens. They discovered that like humans, dragonfish have an outer enamel-like layer and an inner dentin later. The outer layer was covered in grain-sized nanocrystals arranged to prevent light being scattered or reflected off the surface of the teeth, according to the paper published in the journal *Matter*.

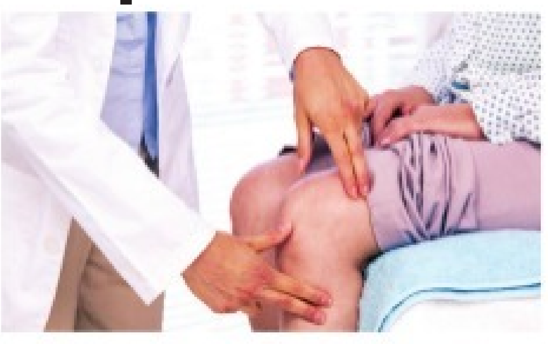
The inner layer is also structured in a different way, and does not have microscopic channels called dentin tubes which normally give teeth their ivory colour. The fact their teeth are very thin adds to the light-scattering effect.

"From a materials perspective, it's really interesting to see that dragonfish teeth have architectures that we do not see in others. By studying why these teeth are transparent, we can better understand deep-sea organisms like the dragonfish and the adaptations they evolved to live in their environments," Velasco-Hogan said.

The findings could provide inspiration for researchers looking to develop transparent ceramics.

The Independent

Unique info



An innovative online tool devised by researchers from the University of Sheffield in the UK will give patients unique personalised information about the risks and benefits of having a joint replacement for the first time.

The easy-to-use Patient Decision Aid for Joint Replacement generates an individualised set of results for patients based on a variety of factors including — how long the implant will last, predicted pain and function levels before and after surgery and the associated risks such as death rate. Professor Mark Wilkinson from the University of Sheffield's department of oncology and metabolism led the creation of the new tool, which can be used by patients in their own homes or by GPs during patient appointments. He said, "At the moment it is impossible for GPs and consultants to give each individual patient tailored information specific to them and their lifestyle. By using data from more than one million patients who have already undergone surgery, and information from individuals about their lifestyle and how joint pain currently impacts on their life, the tool is able to provide the risks and benefits in more detail than ever before.

"We hope the tool will help patients make better decisions about undergoing joint replacements based on their own personal circumstances. Patients also have the option to see how their results would change if, for instance, they lost weight or if they waited a couple of years before surgery."

The tool was built by the University of Sheffield in collaboration with the University of Bristol, with support from the National Joint Registry and Versus Arthritis. The data for the tool was provided by the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man which collects information on hip, knee, ankle, elbow and shoulder replacement surgery and monitors the performance of joint replacement implants.