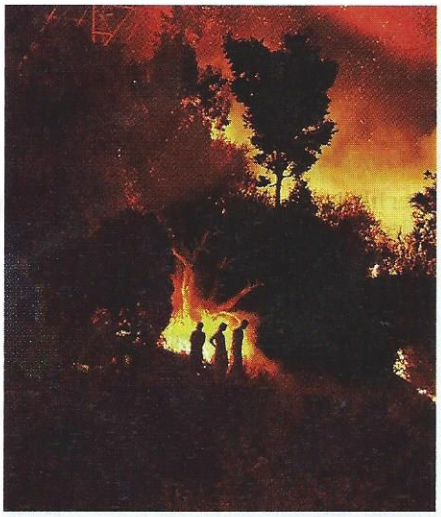


Too many needles in the wrong place

work, that pine-wood biochar is an effective agent for stripping lead from water. But pine wood is a valuable commodity, so he wondered if he could pull off a similar trick using another forest product—one that currently has no value, namely pine needles. To test this idea he and his colleagues went foraging for needles in the forests of Uttarakhand state, north-east of Delhi. They returned their spoils to the laboratory, divided the needles into batches, and charred the batches in an electric furnace at temperatures ranging from 350-750°C.

Experiments suggested that material charred at 550°C extracted lead most efficiently, and examination showed that this material had the largest internal surface area per gram (determined by a technique that measures a substance's ability to adsorb gases), and the optimal level of carbonisation needed to preserve the metal-capturing organic compounds. The best temperature for the process, they discovered, was 35°C—just under body heat, and also ambient, at least in the summer, in the wide plain south of the Himalaya through which the Ganges, one of the most polluted rivers on the planet, flows.

Whether these laboratory observations can be turned into a practical process is hard to say. Special filtration-beds would have to be built in water-treatment plants—facilities of which India is in any case woefully short. But it is not short of material to make the biochar.

An average hectare of Himalayan conifer forest produces over six tonnes of needles a year. The process of charring would reduce this to two tonnes, but that is still a fair yield. How much of this fallen foliage would need to be removed to reduce the fire risk and gain the other potential benefits, and what further effects this might have on the local ecology, remain to be determined. But Dr Mohan's work does show how the cost of this removal might be turned into a benefit enjoyed by all. ■

Navigation

Crystal clear

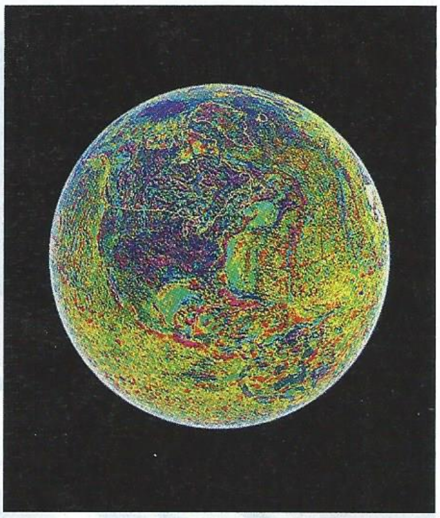
Magnetometers based on diamonds will make precise navigation easier

MAGNETIC COMPASSES have guided sailors for centuries, but a compass tells you only in which direction you are pointing, not whereabouts you are. A new form of magnetic navigation being developed by the United States Air Force Research Laboratory (AFRL) can do better. It employs magnetometers made from tiny diamonds to indicate an aircraft's precise location over Earth's surface. It is so accurate that it might supersede GPS for aerial navigation.

A conventional compass aligns with the magnetic field generated by convection currents within Earth's liquid-iron core. This field is, itself, approximately aligned with the planet's axis of spin, and thus with the geographical poles. But there are fainter terrestrial magnetic fields around as well. These are embedded in the rocks of Earth's crust and have a pattern sufficiently elaborate and distinctive as to be unique from place to place. In principle, therefore, they can tell you where you are. The trick is to reduce that principle to practice.

Until recently, the only magnetometers sensitive enough to be useful for this task have been costly and bulky. Some also require cooling with either liquid helium or liquid nitrogen. None of these things is true of a diamond magnetometer.

The diamond in question has an atomic lattice containing anomalous places called nitrogen-vacancy defects. Diamonds are crystals of carbon and these vacancies are places where a carbon atom in the crystal lattice has been replaced by a nitrogen atom, and an adjacent carbon is missing.



Where in the world?

When exposed to green laser light such vacancies fluoresce. The pattern of fluorescence changes in a magnetic field in a way which allows that field's strength and alignment to be determined.

Diamond magnetometers are not, in truth, as sensitive as the alternatives. But in addition to their cheapness, lack of bulk and ability to function at room temperature they also have one further advantage. As Michael Slocum, a researcher at AFRL who is working on the project, observes, other sorts of magnetometers need careful calibration—and any system that depends on calibration is likely to suffer from measurement drift over the course of time. Since the nitrogen defects in a diamond do not move around, no calibration is needed.

Magnetometer-based navigation does require accurate maps of Earth's surface magnetic fields. The best such are made by flying an aircraft over the area in question, but if that is not possible then (as the picture shows) a satellite can do a reasonable job. Tests suggest that navigation of this sort can locate an aircraft's position to within 13 metres. And, crucially for military applications (and unlike GPS-based systems), it is unjammable by the enemy. ■

The socioeconomics of sewage

Class acts

Analysing waste water may assist census takers

YOU ARE what you eat, the saying goes. It therefore follows that what you excrete gives away a lot about you. Writ large, that information might yield useful demographic clues about particular neighbourhoods. This, at least, is the thinking behind a study by Saer Samanipour of the University of Amsterdam, in the Netherlands. Dr Samanipour has been analysing sewage, and has shown that it gives a pretty good profile of an area's population.

To make sure that his analysis reflected the most up to date demographic information Dr Samanipour timed it to coincide with a census. The one he chose was that conducted in Australia, in 2016, so he called on the assistance of a group of colleagues from the University of Queensland.

As they describe in a paper in *Environmental Science and Technology Letters*, team members collected samples from more than 100 sewage-treatment plants for five to seven consecutive days around the time of the census. They analysed these for 40 chemicals that past research has suggested have socioeconomic significance. Nicotine, for example, is associated more with