elementary cognitive tasks (for instance, the reaction time needed to press the correct button when one or other of two lights comes on; or the time needed to decide whether two words are synonyms or antonyms, or whether a simple sentence is true or false) (I. Deary, Univ. Edinburgh). Here the message seems rather clear: performance on one of these tasks does not correlate with performance on others, but each independently correlates with *g*, usually at about 0.30. Together, however, they account for a sizeable portion of the total variance in *g* (D. K. Detterman, Case Western Reserve Univ.). The implication is that *g* depends on a whole series of relatively independent cognitive processes or operations.

This conclusion may well reconcile the apparent conflict between psychometricians, who study *g*, and evolutionary psychologists, who argue that the mind is modular. One way of understanding such modular theories is to define modules functionally: we, and our ancestors, have always had to solve a variety of problems, such as finding food, shelter or a mate, or recognizing other people, understanding their intentions and detecting whether they are lying. But rather than thinking of each of these tasks as being solved by an independent, encapsulated piece of neural machinery, hard-wired for this purpose, we should accept that we use multiple, overlapping sets of processes for each (R. M. Nesse, Univ. Michigan).

Is intelligence adaptive? And if it is, why does it still vary so much in the population when, according to Fisher's fundamental theorem, at equilibrium the additive genetic variance for any adaptive trait should be zero? At least in modern Western societies there has for some time been, if anything, a negative correlation between IQ and number of offspring. But there are many reasons why that is beside the point: among others, IQ may not measure the relevant aspects of adaptive intelligence, and to say that a trait has evolved because it is adaptive is to make an assertion about past adaptive significance, not current function. If we allow that modern hunter–gatherers provide the best contemporary evidence for earlier stages of human evolution, two lines of argument suggest that intelligence may have possessed adaptive significance (A. Whiten, Univ. St Andrews): first, it is clear that hunting depends on a variety of cognitive skills, not just on speed, strength or visual acuity; second, skilful hunters have more offspring than the less skilful — often with the less skilful hunters' partners.

This last observation has suggested the possibility that the evolution of intelligence has been subject to sexual selection (G. F. Miller, University College London), and that this might explain its persisting variation. Like the peacock's tail, intelligence, or its overt manifestations, may be more a way of attracting the opposite sex rather than being of intrinsic adaptive value. Certainly, there is assortative mating for IQ (that is to say, a moderately high connection between husbands' and wives' IQ scores) and intelligence is rated as one of the most desirable characteristics in a mate in many cultures. But it remains to be shown that assortative mating for IQ is not largely a by-product of social stratification by IQ, and there are more mundane explanations (deleterious mutations, say) for the persisting variations in IQ. According to Bailey's law (J. M. Bailey, Northwestern Univ.), the heritability of virtually all human traits is 0.50 ± 0.20, and *g* is no exception. But the heritability of some other traits, such as schizophrenia, seems a great deal more problematic. ■

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Earth science

Volcanic action at Axial Seamount

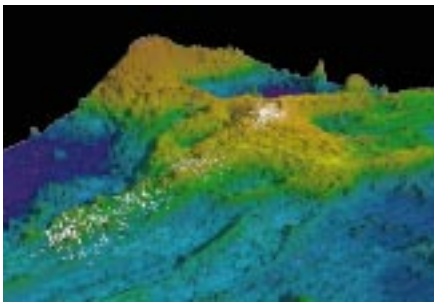
Earl Davis

Seafloor spreading is an intermittent process in which roughly 3 km^3 of oceanic crustal rock is added to the Earth's surface each year along the global chain of mid-ocean ridges. But its intermittent nature, along with the remoteness and great depth of most spreading centres, makes the process difficult to study in 'real time'. An innovative approach is being taken by a group studying a submarine volcano called Axial Seamount, and they report their latest findings in a series of papers in *Geophysical Research Letters*[1–8].

Axial Seamount lies on the Juan de Fuca Ridge, a seafloor-spreading centre located about 300 km off the coast of Oregon, Washington and British Columbia. The investigators are using two approaches that are well suited to the study of active geological processes. The first is long-term continuous monitoring, with instruments deployed on the ocean floor and in the water column close to the site, as well as with several US Navy SOSUS coastal hydrophone arrays. These arrays were not designed for seismic monitoring, but are sufficiently broad-band and sensitive to locate offshore earthquakes that are too small to be detected by seismographs on land. The second approach involves 'event response', in which observations and experiments are carried out at the site as soon as possible after activity is indicated by the acoustic monitoring.

The name Axial Seamount is well chosen. The volcano lies at the intersection of the Juan de Fuca Ridge axis and a 'hotspot', a site of concentrated upwelling magma from the Earth's mantle. Although less intense, this hotspot is in many respects similar to those beneath Hawaii and Iceland, and it adds considerable fuel to the normal geothermal fire that feeds the rest of the Juan de Fuca Ridge. The seamount itself rises 1,000 m above the 'normal' ridge axis to the north and south (Fig. 1).

Since the beginning of real-time monitoring in 1991, two major episodes of seismic and volcanic activity have been detected by the SOSUS monitoring arrays. The latest began on 25 January 1998, and events associated with this eruption are described in the eight papers[1–8].



NOAA VENTS PROGRAM

Figure 1 **Bathymetry of Axial Seamount, the site of the January 1998 volcanic eruption along the Juan de Fuca Ridge described in the papers[1–8] discussed here. The view looks across a 100-km-long portion of the ridge, along a chain of seamounts striking northwest from Axial Seamount. Seismic activity associated with the eruption (epicentres shown as white dots[1]) began with a cluster of earthquakes at the seamount's summit, then propagated down its southern rift zone (towards the left of the image). Water depths range from about 1,500 m (light brown) to 2,700 m (dark blue).**

Action began with an earthquake 'swarm' beneath the floor of the summit crater, or caldera[1], with over 100 small-magnitude tremors occurring each hour (Fig. 2, overleaf). Only three were large enough to be evaluated using data from seismic monitoring stations on land. Within about three hours of the onset of seismic activity, an instrument bearing a pressure gauge identified the beginning of subsidence of the caldera floor[2] (Fig. 2). At the same time, an array of acoustic detectors set up across the rift zone running down the north flank of the volcano revealed lateral contraction of the seamount[3], and sensors at the sea floor

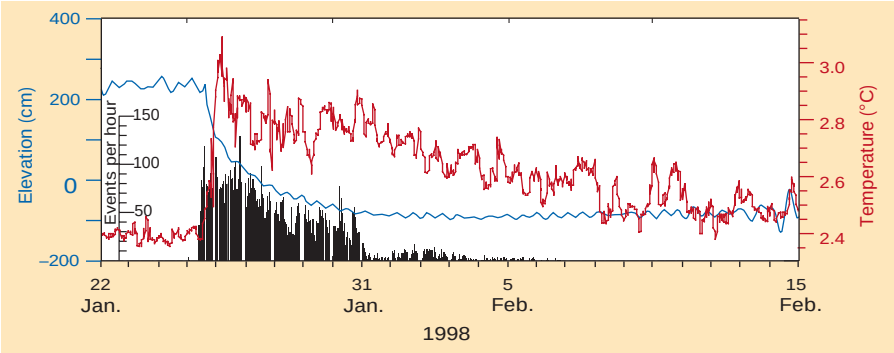


Figure 2 **Sequence of eruption-related events at Axial Seamount from 22 January to 15 February 1998. Shown are the number of earthquakes identified per hour from SOSUS acoustic data (black)[1]; subsidence of the sea floor of the seamount's caldera (arbitrary absolute scale) (blue)[2]; and temperatures measured 15 m above the sea floor (red)[4].**

and in the water column above the caldera detected a temperature anomaly[2,4] (Fig. 2).

While the caldera remained active, seismic activity also began to migrate along the southern rift zone. Initially the rate was rapid, but it then stabilized to 20 km per day for about three days and ended roughly 70 km away (Fig. 2). Detectable activity continued for about ten days at the extremity of the rift zone, but at a much lower level[1]. A low level of activity at the caldera was observed to continue for nearly two months with ocean-bottom hydrophones placed near the seamount summit[8]. The correlation between caldera subsidence and the migration of seismicity (Fig. 2) led to the conclusion that the eruption, fed along a sheet-like dike beneath the southern rift zone, had partially drained the magma chamber located about 3 km below the caldera floor.

Despite the possibility of winter storms, an immediate event-response cruise (followed by three more in the summer) was organized to take a closer look. The ship arrived 18 days after the initial detection of the earthquake swarm. Comparison of new swath-echo-sounding data and visual observations with previous information provided constraints on the thickness and extent of new volcanic rock erupted at the sea floor[5]. It is estimated from this and from the 3-m magnitude of the caldera subsidence that roughly $1–2 \times 10^8$ m^3 of magma had been supplied from the summit magma chamber to seafloor flows and to the feeder dike beneath the southern rift zone during the eruption. Eruption of seafloor lavas extended 9 km down the rift, although this was only a fraction of the dike-propagation distance indicated by the seismic data.

Action at Axial Seamount was not confined to seismicity and volcanism. Initial signs of hydrothermal activity were seen in the monitoring data, and thermal profiling during the first response cruise revealed a large 'lens' of warm water southwest of the summit[4], one with an anomalously low ^{3}He/heat ratio[6]. This 'fingerprint' suggests that the warm lens had been produced rapidly by heat exchange during the ten-day eruptive phase, and was subsequently swept some 20 km from its source by ocean currents. The increased rate of hydrothermal heat transfer was estimated to be as much as 200 gigawatts, more than two orders of magnitude greater than the typical heat output from the caldera during quiescent periods[4].

One intriguing finding was the increase, relative to typical values in hydrothermal vent water at Axial Seamount, of methane concentrations in the plume created by the volcanic activity[7]. Although the source is unknown, one possibility is that microbiologically 'mature' water in the crust, cool enough to support life, was suddenly heated by the volcanism and buoyantly ejected.

None of these observations runs counter to our general ideas about how volcanism and associated hydrothermal activity might operate. Nevertheless the data provide excellent quantitative information about the relationships between tectonics, volcanism and hydrothermal circulation at seafloor-spreading centres, and about the magnitude of one particular episode of activity at this site. They show that such events happen often enough for monitoring over a period of decades to bear results. And they make it clear that they are sufficiently short-lived to make continuous observatory monitoring essential. How typical this particular episode might be will emerge from continuing studies, and with expanded undersea technologies it will be possible to catch more of the action the next time it happens. ■

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1. Dziak, R. P. & Fox, C. G. *Geophys. Res. Lett.* **26,** 3429–3432 (1999).
2. Fox, C. G. *Geophys. Res. Lett.* **26,** 3437–3440 (1999).
3. Chadwick, W. W. Jr *et al. Geophys. Res. Lett.* **26,** 3441–3444 (1999).
4. Baker, E. T., Fox, C. G. & Cowen, J. P. *Geophys. Res. Lett.* **26,** 3445–3448 (1999).
5. Embley, R. W., Chadwick, W. W. Jr, Clague, D. & Stakes, D. *Geophys. Res. Lett.* **26,** 3425–3428 (1999).
6. Lupton, J. *et al. Geophys. Res. Lett.* **26,** 3449–3452 (1999).
7. McLaughlin-West, E. A. *et al. Geophys. Res. Lett.* **26,** 3453–3456 (1999).
8. Sohn, R. A., Crawford, W. C. & Webb, S. C. *Geophys. Res. Lett.* **26,** 3433–3436 (1999).

Daedalus

No more feelings

Last week Daedalus decided that consciousness, as a product of evolution, must be coded for in the genome of all conscious creatures. Anaesthetics abolish it selectively. 'Dissociative' anaesthetics, such as ketamine, even leave a degree of responsiveness. By identifying the gene or genes for consciousness, and working out the actions of the proteins they code for, DREADCO biochemists now plan to synthesize the ultimate dissociative anaesthetic. It will abolish awareness, but no other brain function. Like an alcoholic in a state of palimpsest, the user will seem entirely normal. But he will be a pure robot, reacting in all the usual ways but without feeling. Behind his fluent mannerisms and animated face, inside his skull, there will be nobody at home.

'Nothingness', as the new anaesthetic will be called, will bring compassion to modern farming. The ruthless brutalities of agri-business will still make its animal victims cry and cower in seeming misery. But these will be empty, robotic reactions, no longer denoting real suffering.

Human demand for Nothingness will also grow rapidly. It will be smuggled into prisons, releasing the inmates from their extended ordeal without brutal warders or interrogators suspecting anything. A prisoner on Nothingness will still eat, walk, talk, spit defiance or yell with pain without anyone suspecting that he is not suffering. People trapped in ghastly jobs or marriages, debilitating illnesses or grinding poverty, will also welcome the chance to erase their miseries while still fulfilling their obligations.

Nothingness will raise in an acute form the old philosophical problem of telling if anyone or anything is truly conscious, or is merely reacting without feeling. Alan Turing's famous test challenges a judge to distinguish the subject's responses from those of a computer simulation. In effect, the judge assesses the consciousness of man or machine by comparing them with an authentic sample of consciousness — his own. A robotic individual on Nothingness, with no internal standard of consciousness, could not do this. So Daedalus, cunningly, will judge the effectiveness of his product by a 'meta-Turing' test. A robotic, unconscious man will reveal the fact by being quite unable to judge a Turing test.

David Jones

***The Further Inventions of Daedalus* (Oxford University Press), 148 past Daedalus columns expanded and illustrated, is now on sale. Special *Nature* offer: m.curtis@nature.com**