evolution of planktonic foraminifera may be shifting the net flux of CO_2 towards the mantle. The carbonate shells of these organisms cover much of the ocean floor, whence subduction into the mantle is a likely fate.

The Dunkelsteiner marbles are only the latest in a long trail of evidence of deep sediment recycling. They are nonetheless more dramatic than much of the other evidence, which has been based largely on extremely subtle variations in the abundances of trace elements and isotopes. More importantly, these rocks may provide an opportunity to study at first hand the reactions that subducting sediments undergo and thus solve a number of stubborn problems. The processes by which subducted sediments find their way into island-arc magma is still not understood. Do the sediments themselves melt, or do they dehydrate, with fluids carrying the sedimentary chemical signature into the overlying mantle peridotite undergoing melting? What fraction of subducted sediment is quickly returned to the surface through island-arc volcanism rather than being carried to the deeper mantle? Do some elements preferentially take this shorter route while others take the deeper route?

The key to answering these questions is understanding the processes and reactions that occur as the subducting lithospheric plate passes beneath the island-arc volcanoes. What makes the Dunkelsteiner Wald marbles particularly interesting is that the maximum metamorphic pressures correspond to about 100–120 km, the typical depth at which the subducting plate passes beneath island-arc volcanoes. ☐

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QUANTUM OPTICS

Crystals with a light touch

Andrew Steane and Christopher Foot

THE recent remarkable progress in laser manipulation of atoms shows no signs of slowing. Two elegant experiments now give clear evidence of quantized motion of atoms confined in delicate potential wells set up by the laser light. The atoms move in a periodic potential created by a laser standing wave so that the motion resembles that of electrons in a crystal. In a crystal, the lattice is made of ions and produces a periodic potential for the motion of electrons; in the new experiments the lattice is formed by the light (standing wave), and quantum motion of whole atoms is obtained. The two experiments complement each other in that they use different atoms, and different methods to probe the atomic motion: the group at the Ecole Normale Superieure in Paris (P. Verkerk *et al. Phys. Rev. Lett.* **68**, 3861–3864; 1992) measured the absorption spectrum of a weak laser beam propagating through a collection of caesium atoms, while at National Institute of Standards and Technology, Gaithersburg, P. S. Jessen *et al.* (*Phys. Rev. Lett.* **69**, 49–52; 1992) used an optical heterodyne method to analyse the fluorescent light from rubidium atoms.

We usually think of the motion of an atom as a classical variable. This works well for high-lying quantum states because of the correspondence principle, but understanding the new experiments requires a quantum mechanical picture of the motion. The important new factor in these experiments, in addition to the atoms' low energies, is that each atom is confined in a very small region, so that their motion is quantized, with the separation between different states of motion rising as $1/r^2$ as the radius of confinement, r, decreases. The optical standing wave formed by two counter-propagating laser beams of suitable polarization gives the atoms a lattice of wavelength-sized potential-energy wells.

The well depth depends on the light's intensity; the more intense the light, the deeper the wells. But the radiation also excites the atomic motion to higher energies. These two effects are balanced in the new experiments, which use diffuse laser beams of a few milliwatts power to give wells deep enough to contain a few bound vibrational levels.

The second requirement is to reduce the atoms' energy enough for them to fall into the quantum well. (Indeed, when the prospect of trapping atoms in the optical potential wells of a standing wave was first considered, it was concluded that the atoms would rapidly 'boil out' of the wells: quantum fluctuations in

RÉSUMÉ

Poles together

OPPOSITE electric charges attract and so would magnetic monopoles — isolated north and south poles — if they existed and were point-like objects. Magnetic monopoles are in fact predicted by many theories in elementary particle phisics, but are extended, structured objects. As Y. Aharonov *et al.* note in the *Physical Review* (D**46**, 1877–1878; 1992) these monopoles certainly attract at a distance, but whether the force between them remains attractive at short distances is far from obvious. By finding a simple expression for the energy of two monopoles of opposite magnetic charge, the authors show that the energy always decreases with decreasing separation — there is always attraction. Curiously, though, the converse does not follow: extended monopoles of like charge may or may not maintain a repulsive force down to small distances, depending on their precise internal geometry.

Spectral zipper

THE spectrin family of structural, probably elastomeric proteins are made up of two antiparallel chains, which may be identical (α-actinin, dystrophin) or different (spectrin, fodrin), and consist of repeating units, typically of 106 residues. Whereas electron microscopy seemed to suggest that the two chains are united only at their ends, it is now clear that they interact along their lengths. D. W. Speicher *et al.* (*J. biol. Chem.* **267**, 14775–14782; 1992) now neatly establish that in red-cell spectrin the association depends on the first few (probably four) repeats at one end; these interact strongly and the remainder are then in register to close like a zipper, just as a DNA duplex forms by propagation of base pairing from an initially formed nucleus — a new kind of structural complementarity in proteins.

Nano-battery

NOT a year has passed since a micrometre-scale electric battery was devised (see *Résumé*, 31 October 1991), and already that record has been overtrumped. W. Li *et al.* (*J. phys. Chem.* **96**, 6529–6532; 1992) describe a nanometre-scale cell put together on graphite using a scanning tunnelling microscope. First, a pair of silver pillars just 150–200 Å across were deposited electrochemically beneath the microscope's two tips, from a solution of silver fluoride. Then (without disturbing the tips), the solution was changed for copper sulphate and copper pillars laid down nearby. Current flowed spontaneously through the graphite, dissolving the copper electrode and coating the silver 'cathode' with copper. For 45 minutes, the current remained at scarcely 5×10^{-18} A, displacing around 75,000 copper ions in all.