Pressure demagnetization of rocks

from A.E. Mussett

IN THE EARLY DAYS of palaeomagnetism a major problem was whether rocks can retain their magnetization unaffected over millions of years. It was suggested that one of the many factors that might affect the magnetization is stress, and Graham[1] argued that, because of magnetostriction, igneous rocks might be affected by cooling stresses, and sediments by the loading and unloading of overburden. He went on to show in the laboratory[2] that uniaxial stress, equal to the weight of a column of rock half a kilometre high, changed the intensity of magnetization of most rocks, by up to a quarter or more, with accompanying directional changes. This stimulated research in a number of laboratories in the late 1950s, with the conclusion that though stress could affect magnetization it affected only the softer components and is roughly equivalent to applying an alternating field. With the development of routine 'cleaning' techniques it ceased to be a bogey and interest in the effects of stress largely faded, with the exception of its possible use as a harbinger of earthquakes.

The early work was concerned chiefly with the direction of magnetization, vital to such problems as the reality of continental drift, but in recent years interest has extended to intensity as well. Pearce and Karson[3] have conducted some experiments that indicate that pressure may well play an important role in situations of high pressure but low temperature, as may be found in subduction zones, meteorite impacts and the interiors of small, cool planetary bodies. They have used much higher pressures than did the earlier experimenters (up to 20 kbar, equivalent to about 60 km depth) and hydrostatic pressure, which is more realistic than uniaxial stress for great depths, but only investigated the effects of stress applied in near-zero fields. Broadly, their results confirm the earlier conclusions but with rather more pronounced effects. For instance, coercivities affected exceeded 0.05 T (500 oe) for some rocks and sometimes over half the natural remanence was removed. Such large effects are surprising with hydrostatic pressure because, for magnetostriction to operate, there needs to be a change of shape rather than size. Some of the effect may be due to the relation of the grains to the matrix in which they are embedded: if there is a difference in the elastic properties of grains and matrix an external hydrostatic pressure on the rock will generate non-hydrostatic forces on the grains, unless the grains have a high degree of symmetry. Indeed, Pearce and Karson confirmed this by showing that samples in jackets, which prevented fluid flowing into cracks and pores and so tended to produce true hydrostatic pressure on the grains, showed larger demagnetization than unjacketed samples. But this cannot be the whole explanation for magnetite powder suspended in oil still showed a large effect. The authors offer, as a partial explanation, the known decrease of both the magnetostrictive constant and the anisotropy with increasing hydrostatic pressure, and they point out, therefore, that, their high hydrostatic pressure would enhance the effect of any residual uniaxial stress, or changes of magnetization by any process, for that matter.

Pearce and Karson suggest that pressure magnetization may help to explain the absence of magnetic anomalies near oceanic trenches, and limit the depth to which magnetization can occur in a cool planetary interior. They also suggest it may play a part in remagnetization by meteorite impacts. Another question that comes to mind is what effect it may have on determinations of palaeointensities. Shaw's method[4] may have an advantage here over Thellier's method[5] since it usually entails demagnetizing samples to quite large alternating fields.

The ideas of Pearce and Karson are plausible; now they need to be substantiated. For instance, what happens if the Earth's field is present when pressure is applied? Further, how is pressure magnetization and demagnetization at these pressures affected by the rate of application and the duration of the pressure, since nature acts more slowly than most experimenters. Domen[6], more persistent than most of us, has conducted an 11-year experiment and claims that time is an important factor. It also would be nice to have a better understanding of what is happening, though this may be asking too much, for our understanding of rock magnetism is still inadequate. Best of all would be a geological test of their ideas. □

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A.E. Mussett is in the sub-Department of Geophysics, University of Liverpool.

Chemolithotrophic carbon dioxide fixation in tube worms — symbiotic primary production

from Don P. Kelly

THE chemolithotrophic bacteria have long been recognised as contributing to primary production through carbon dioxide fixation independent of solar energy. Sulphide-oxidising chemolithotrophs were subsequently shown to be at the base of food chains on hydrothermal vents in the Galápagos Rift and enable the growth of dense animal populations. A significant part of the carbon of Galápagos Rift mussels is derived from dissolved inorganic carbon apparently incorporated from filter feeding on such chemolithotrophs[2]. Recently most exciting observations have been made, showing that carbon dioxide fixation by chemolithotrophic bacteria seems to be the principal source of carbon for the vestimentiferan tubeworms such as *Riftia*[3,4]. These have been shown to contain chemolithotrophic bacteria in their tissues and consequently to have active CO_2-fixing Calvin cycle enzymes actually within the animal body. In this issue (see p.616) Southward *et al.* have extended these studies to the smaller members of the phylum Pogonophora from various habitats. These animals lack mouth, digestive tract and anus and consequently pose intriguing questions regarding their nutrition. The demonstration of bacterial cells in their tissues and the presence of high levels of ribulose bisphosphate carboxylase indicated that the autotrophic fixation of carbon dioxide is significant in these marine worm-like animals. The $^{13}C/^{12}C$ ratios in this and in other studies[3] support the view that much of the organisms' carbon could be derived from carbon dioxide. A picture is thus emerging of carbon nutrition among marine animals that may benefit from bacterial chemolithotrophic-energy-dependent carbon dioxide fixation not only in sulphide-rich environments but also in habitats where low levels of chemolithotrophic nutrients are available. Such symbiotic associations are clearly able to conserve to a high degree the total energy and carbon available within an ecosystem, and widen further our understanding of the role of chemolithotrophic bacteria in the environment.

Don P. Kelly is Professor in the Department of Environmental Sciences, University of Warwick.

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0028-0836/81/430609-01$01.00