might be the arrangements of the transmembrane helices which maximize charge interactions? A particularly simple solution emerges (see figure) if one takes into account evidence that the sequentially similar CD3-γ and CD3-δ subunits form distinct isomorphous complexes[11]. If each CD3 unit includes ε, ζ and either γ or δ, then a neutral complex can be formed because the two positive charges on TCRα are five residues apart and would point in almost opposite directions. The models shown are an arbitrary selection from many possible configurations. The rapidly accumulating evidence on pairwise interactions between chains expressed in artificial systems (see, for example, ref. 12) has not been fully taken into account and the new evidence may eliminate most or even all of these suggested arrangements. But the diagram shows a number of structural arguments which should be considered in the model-building exercises that will become feasible when the overall stoichiometry is more clearly established.

Other systems in which charged transmembrane anchors have an important role include the IgE receptor[13] and membrane fusion induced by the human immunodeficiency virus[14]. The experimental approach of combining site mutagenesis with expression of chimaeric constructs is a powerful method for analysing these systems, which are difficult to obtain in sufficient quantity for conventional studies.

Nevertheless, caution is required in interpreting the significance of complex formation in detergent, because in principle detergent could allow interchange between subunits from different membranes. Experimental studies to define the effect of charges in simpler systems are also desirable — for example, such studies could amplify the observations that although a foreign charge in a viral membrane anchor may not prevent insertion, it does lead to elimination through the lysosomes rather than assembly[15,16]. □

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GEOLOGICAL FAULTING

Do little things matter?

Geoffrey King and Armando Cisternas

SINCE geologists discovered both faults and folds in rocks, the relations between the two have been controversial. The focus of this debate, which started in the nineteenth century, is whether faults are a secondary consequence of ductile deformation or ductile deformation a secondary consequence of faulting. As shown by a study by J. Walsh, J. Watterson and G. Yielding on the extensional history of the North Sea, elsewhere in this issue (*Nature* **351**, 391–393; 1991), and an earlier study by C. H. Scholz and P. A. Cowie (*Nature* **346**, 837–839; 1990), the debate is very much alive.

A fundamental problem in geology concerns our ability to build models of structural change. Fashion has sometimes favoured models in which ductile behaviour predominates, at other times the vogue has been for those in which rigid blocks move between major faults. Because it has proved difficult, in practice, to produce realistic models that incorporate both features, imaginative effort has been expended in attempting to determine which of the two best approximates the behaviour of the Earth at various scales and various depth ranges.

Among geophysicists, though not most structural geologists, plate tectonics, by demonstrating the occurrence of block motion at the largest scale, dramatically shifted preconceptions towards concepts of blocks. The political analogy of 'buffer plates' that deform in a quasi-continuous fashion in response to the motions of larger and more powerful blocks started the idea that, for continental deformation, continuum models might prove to be better than rigid plates in some places. The dramatic laboratory model of a rigid indenter, representing the northward-moving Indian continent, extensively deforming southern Asia, made this new paradigm respectable. However, it has remained unclear whether this deformation is truly ductile, or whether it represents motion distributed over numerous faults.

Fractal descriptions entered this debate about 10 years ago, when it became clear that some of the finest examples of natural fractals exist in geological and geomorphological features and in the behaviour of earthquakes. Faults can look much the same over scales from centimetres to tens or even hundreds of kilometres, and the range of scales over which earthquakes behave in a broadly self-similar fashion exceeds six decades. Could ductile deformation be the consequence of self-similiar fault motion below any chosen scale of observation? The answer emerging is "sometimes and at some scales".

In California, if earthquakes are placed in fault-size classes with characteristic fault lengths varying by factors of two, the sum of all events smaller than any given class gives the same deformation as that class itself. In other words, smaller events are important. This happy result breaks down for the biggest events, those that contribute the most deformation. They are simply too big. Just where a fractal relation would be most useful, it does not work. The same appears to be true outside California and has led to the general statement that little earthquakes can be ignored. With this view in mind, the rate at which big earthquakes occur has been compared with that predicted by plate rates and declared to be too small. The implication that much motion does not occur on earthquake faults seems irresistible. Perhaps the missing deformation occurs on creeping faults as continuum deformation.

In principle, the scaling relations of degree of slip and dimensions of geological faults should resolve this issue. Geological faults include faults that move in earthquakes and those that slip by creep. But researchers determining the partitioning of geological motion between large and small faults appear to be stumbling on problems analogous to those for seismic faults. Scholz and Cowie have found data suggesting that the contribution of smaller faults can be neglected, but Walsh *et al.* find the opposite. As popular models for the lithospheric stretching needed to explain the amount the floor of the North Sea has subsided suggest that there should be much greater deformation than can be provided by the largest faults, the first interpretation supports fractal block motion and the latter a large role for continuum deformation.

It may be too early to take sides in this debate, particularly for those of us who lack a strong partiality in favour of one conclusion rather than the other. Although the data sets employed are greatly superior to those available only a decade ago, they are very far from complete. Nor can we be sure that our stretching models for the evolution of sedimentary basins provide a sure measure of extension. In the case of comparing seismicity with plate rates we must realize that seismicity rates have varied enormously within the time of instrumental recording and in historical time. We have no reason to suppose that such irregularity does not exist over even longer time spans. Thus comparisons with plate rates determined from magnetic reversals could be spurious. In resolving the question of continuum versus block deformation our tools are really very blunt. Consequently, it seems likely that this question, so fundamental to understanding the physics of the ground beneath our feet, will still be with us in the next century. □

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