Raising the roof of the world

HIMALAYAN mountains such as Everest, pictured here from Tibet, may have been raised higher in the late Cenozoic by an increase in erosion, according to Douglas Burbank (page 680). Perhaps paradoxical at face value, this conclusion is based on the pattern of river flow and sediment accumulation in the Indus–Ganges foreland basin of Pakistan and India, and it supports the hypothesis (P. Molnar and P. England *Nature* 346, 29–34; 1990) that mountain uplift can be climatically driven. The argument is as follows. Climate change, such as the cooling that took place in the late Cenozoic (the past 15 million years), might increase the rate of erosion by causing changes in precipitation and storminess. Removal of surface material then produces isostatic uplift of the range as a whole.

Rather than focusing on records of uplift and denudation in the mountains themselves, Burbank looked for sediment removed by increased erosion. He considers two extreme cases: one in which uplift was not caused by erosional unloading at all but by tectonic forces, specifically by accelerated underthrusting of the range by the Indian plate, and the other in which only erosion played a role. The first produces subsidence and deposition of sediments, and therefore steep slopes close to the foot of the range. Erosional unloading, however, increases the sediment influx into the basin, creating gentle slopes far into the foreland. In this case rivers can run parallel to the mountain range only far from it.

In principle, therefore, the distinction between the two cases can be made simply by looking at a map of the Ganges and Indus hinterlands. The two rivers tell different stories, however: the Indus is fed by tributaries running transverse to the Himalayan range, as predicted by an erosional scenario, whereas the Ganges system is longitudinal, suggesting the predominance of thrust loading. But the depositional patterns have changed through time. The Ganges system probably switched from transverse to longitudinal around 4 million years ago, post-dating by a considerable margin the principal uplift of the Himalayas. So erosional unloading seems to be the better candidate; but whether this can be attributed to climate change remains to be seen.

P.B.

liverworts) may represent sister groups to a lineage where G-type elements eventually gave rise to tracheids with scalariform pitting.

That the nexus of vascular elements present in the early Devonian is not wholly compatible with our concepts of the major plant groups is perhaps not surprising. All too often in these early land plants, those features which are recognized today as being characteristic of a particular evolutionary line or clade are distributed on a 'mix and match' basis. It has been noted[7] that differences between G-type, S-type and scalariform elements may have a developmental basis, and it is perhaps possible that changes in the degree of ornamentation or production of any of the components (thickenings, cellulosic layers, microporate structures) could give rise to any of these types of conducting element. The factor governing the outcome of the developmental process is not the ability to produce only one type of conducting element, but the degree to which a particular developmental process has become established and predominant.

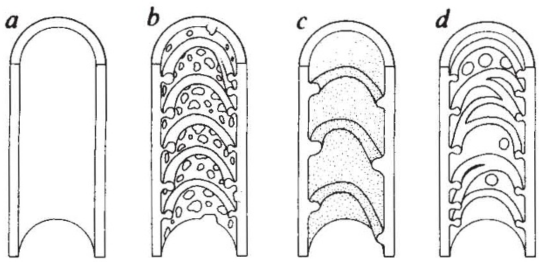

FIG. 2 The four types of vascular element described in the text. *a*, A simple tube element. *b*, The G-type element with a perforate wall and thickenings. *c*, The S-type element with a microporate inner layer covering the thickenings and wall. *d*, A tracheid with scalariform thickenings. (*b* and *c* after ref. 6.)

Many features of the early land plants (including *Cooksonia*) point to there having been a measure of plasticity and flexibility, as seen in basic vegetative and reproductive morphology and in propagule type, much of which may have stemmed from a basic 'looseness' in the underlying developmental processes. Indeed it would be surprising if the early land plants, which had undertaken one of the most dramatic changes of habitat experienced by plants, were not to have had a considerable flexibility in their requirements and responses. That phenomenon is perhaps being illustrated in the variety of conducting elements now known to occur in these early land invaders. □

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