translocation activity of some dyneins *in vitro* (Y. Toyoshima, personal communication).

Nevertheless, the mystery of dynein's tremendous size has not been resolved by the primary sequence data^{5,6}. Although the size of the β -DHC minimal motor element is not apparent from the sequence, generating movement *per se* cannot be the reason for constructing such a large molecule, as functional motor elements of the other known motor proteins are small (450–900 amino acids). Perhaps the β -DHC motor element(s?) is also as small as its fellow motor counterparts, in which case the rest of the molecule could be a series of regulatory or attachment domains, as is true of myosins and kinesins⁹. The large size of β -DHC could also allow it to function as a mechanical spring to regulate dynein activity in response to flagellar bending.

The availability of the sequence and of clones spanning the entire length of the coding sequence establishes a foundation for elucidating how the dynein motor works. First, and most important, properties such as motor activity, microtubule binding, ATP hydrolysis and regulation can now be ascribed to specific regions of the polypeptide chain by expressing and studying defined domains. Second, regions critical for function will be revealed by sequence conservation among the next few dynein heavy chains to be cloned and sequenced. Third, analogous to the situation in the kinesin and myosin superfamilies, proteins that have dynein-like motor regions linked to other types of domains may be identified by cloning and sequencing of genes not thought to be related to dynein. Finally, it is now possible to dissect the structure-function relationships of the dynein molecule by taking advantage of the availability of dynein clones together with the recently developed methods for DNA-mediated rescue of flagellar mutants in *Chlamydomonas*¹⁰. □

Lawrence S. B. Goldstein is in the Department of Cellular and Developmental Biology, Harvard University, Cambridge, Massachusetts 02138, USA. Ron D. Vale is in the Departments of Pharmacology and Biochemistry, University of California San Francisco Medical School, San Francisco, California 94143, USA.

1. Warrick, H. M. & Spudis, J. A. *Rev. Cell Biol.* **3**, 379–421 (1987).
2. Vallee, R. B. & Shpetner, H. S. *Rev. Biochem.* **59**, 909–932 (1990).
3. McDonald, H. B. *et al. Cell* **63**, 1159–1165 (1990).
4. Walker, R. A. *et al. Nature* **347**, 780–782 (1990).
5. Ogawa, K. *Nature* **352**, 643–645 (1991).
6. Gibbons, I. R., Gibbons, B. H., Moc, G. & Asai, D. J. *Nature* **352**, 640–643 (1991).
7. Vale, R. D. *et al. Cell* **59**, 915–925 (1989).
8. Sale, W. S. & Fox, L. A. *J. Cell Biol.* **107**, 1793–1797 (1988).
9. Vale, R. D. & Goldstein, L. S. B. *Cell* **60**, 883–885 (1990).
10. Mitchell, D. R. & Kang, Y. J. *Cell Biol.* **113**, 835–842 (1991).

Earthquakes in aseismic zones

PEOPLE who live near the margins of tectonic plates face the familiar but harsh reality that damaging earthquakes can disrupt their lives at any time. In contrast, people who live in the interior of continental plates do

deformation like that shown here, revealed by newly exposed, unweathered rock (John Adams is the reference height), provide valuable data on the style and extent of deformation caused by plate interior earthquakes.

Uplift of 1 m created by the Ungava earthquake of December 1989.

not consider earthquakes to be a serious threat to their lives and property. The Ungava earthquake, which occurred in northern Canada in December 1989 and is described by John Adams *et al.* on page 617 of this issue, serves as an important reminder that earthquakes are unpredictable, and especially so for those that occur in the interior of tectonic plates. The Ungava earthquake is only the tenth historical intraplate earthquake in the world to produce documented surface ruptures, so it offers earth scientists a rare opportunity to examine intraplate earthquakes using both geological and seismological data. Metre-scale

The Ungava earthquake exemplifies the challenges and obstacles faced by earth scientists who try to evaluate the hazards posed by potentially damaging intraplate earthquakes in the 'stable' interiors of continental plates. Such earthquakes occur much less frequently than those along plate margins, so seismologists have relatively few events with which to seek common traits of fault behaviour. In addition, many large intraplate earthquakes occur in areas of little or no previous seismicity, so seismological data are of limited use in identifying potentially hazardous intraplate faults. Furthermore, we know of few places in continental interiors where geologically young faulting is clearly expressed at the surface, but it is likely that our inventory is very incomplete, which makes it difficult to estimate the number of intraplate faults that might generate damaging earthquakes. The concept of plate tectonics provides a broad geological framework to explain the cause of plate-boundary earthquakes, but the factors that govern the occurrence of intraplate earthquakes are largely unknown. Seizing rare opportunities like the Ungava earthquake will permit scientists to assemble a more complete geological and seismological picture of the processes that cause crust in the 'stable' parts of continents to rupture catastrophically. (Photos courtesy of Arch Johnston.) **Anthony J. Crone**

Part of the Ungava fault viewed from a height of 10 m.

Anthony J. Crone is at the US Geological Survey, Denver, Colorado 80225, USA.