shows the kinematic similarity between simple frontal ramps, cleavage duplexes and pull-aparts in transferring displacement between stepped fault segments.

Individually then, the separate contributions in this Special Paper are interesting. Yet it is unclear why the individual authors decided to present their material in this way rather than through conventional journals where surely they would have enjoyed a wider readership. Presumably the answer lies in the persuasive powers of the editors. Regrettably, the volume as a whole does not satisfy the need for an overview of thrust tectonics in general, nor Appalachian geology in particular. While it may not inspire another generation of geologists to examine thrust tectonic problems, it does impress the need for solid field work "at all scales from the thin section to the cross-section". This sentiment is most timely, given current fashions towards technological solutions for data collection. The cheery cover photograph shows a party visiting a cutting during a winter field excursion to the Appalachians. The leader has a large geological map, the audience listen attentively (apart from three well-known devotees chatting at the back) and gaze at an asymmetric anticline (what might now be called a fault-bend fold). The debt they owe to the quarrymen and miners is there for all to see.

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Putting laccoliths in their place

Corry, C. E. 1988. *Laccoliths: Mechanics of Emplacement and Growth*. Geological Society of America, Special Paper 220. Geological Society of America, Boulder, Colorado, U.S.A. 110 pp. Price $27.50.

Corry's Special Paper is divisable into four parts. The first consists of a review of work on laccoliths from Gilbert (1877) to the present time. The second part describes the results of gravity and magnetic surveys over laccoliths. The third forms the core of the Special Paper. In it, three chapters deal with the emplacement and growth of laccoliths, and the finite element models Corry uses to investigate the latter. The fourth part includes a glossary and a 23 page list of published references to laccoliths, drawn from the GEOREF database of the American Geological Institute.

Corry defines the laccolith as a floored igneous body, forming through forcible intrusion high in the lithosphere, and fed from below by a dyke. This allows him to include lopoliths in the category. However, throughout the Special Paper he uses the term laccolith in the more familiar restricted sense for an intrusion with a flat floor, and a roof that is either continuous and domed, or fault-bounded and flat. He recognizes four stages in the development of such intrusive bodies, suggesting all except the largest laccoliths take less than a 100 years to form. The first stage involves the necessary rise of magma into the lithosphere. In the second, the change from magma ascent to horizontal spreading begins. In the third stage, spreading ends. It is succeeded in the fourth by thickening of the intrusion, accompanied by the necessary deformation of the roof.

Corry suggests laccoliths vary in character between two extremes. The first is said to preserve the essential features of Gilbert's well-known fault-bounded version. This is Corry's punched model. According to him such laccoliths probably formed at relatively shallow depths within the epizone. The other end member, apparently suggested to Corry by comments and sketches of Gilbert, is named the christmas-tree laccolith. It corresponds with the cedar-tree laccolith of earlier authors. With a domed roof displaying thinning of the country rock, Corry suggests the formation of the second type of laccolith is favoured by the conditions of the mesozone. Gilbert's ideal laccolith (Corry fig. 1a, Fig. 1 here) is placed by Corry between these two extremes.

The growth of these two types of laccolith (stage 4) is investigated by Corry in a series of finite element simulations, including the effects of body forces. All Corry's models are shown at the point of instability. At the next step the solution becomes numerically unstable and the experiment ends. His models provide one horizontal fracture for a laccolith of the punched variety, but a christmas-tree laccolith is developed from a stack of horizontal fractures, centred one above the other and decreasing in length upwards. The members of this stack are

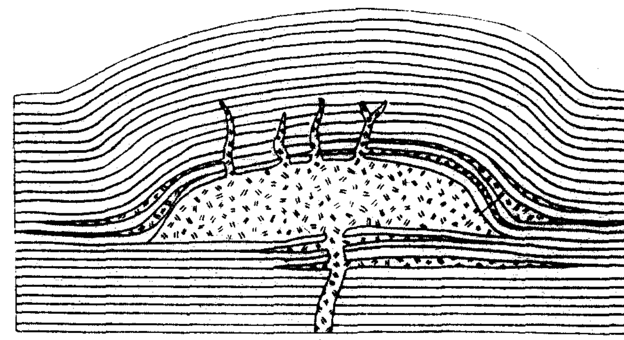

Fig. 1. The ideal form of a laccolith according to Gilbert (1877).

considered as inflated one after the other from bottom to top. Here the strong peripheral differential shear stresses of the punched model are absent, a condition regarded by Corry as suitable for the development of the smoothly domed roof shown by this type of laccolith.

All models share the same boundary conditions. The significance of variations in the latter are outside the scope of the experiments. The models allow the demonstration of what is possible in closely defined circumstances. They do not have the mechanical character which Pollard and Johnson have tried to give to their models of laccolith formation (e.g. Pollard & Johnson 1973, Koch *et al.* 1981).

This then in brief is the scope of Corry's work. What about his conclusions? He says he does not depart in any important way from Gilbert (1877), suggesting that this is remarkable only in that nearly all other investigators have differed substantially from the latter. These opinions surprise me and I do not think that Corry's account of the history of enquiry into laccoliths sustains them. At the same time I think he underestimates the extent to which he himself differs from his mentor Gilbert. Here, of course, I rely on an interpretation of Gilbert's work that Corry presumably would not share.

Bearing in mind this qualification, let us examine Gilbert's sketch (1877) of his ideal laccolith (Corry fig. 1a) (Fig. 1). I find its most interesting feature one not mentioned by Corry. This is the presence of subsidiary sheets with sigmoidal profiles sited on the flanks of the main bell-shaped intrusion. Is it not of interest that these profiles are those appropriate to formation during intrusion at the same time as the main body, and not after it? Corry regards simultaneous intrusion as not usual; does Gilbert here mean to imply the reverse? Is it by chance or design that the latter has placed the subsidiary sheets so that they allow the strata they enclose to be folded while retaining initial thicknesses? Simultaneous intrusion has another advantage: major intrusions are able to grow through rupture of strata separating subsidiary intrusions. Thus the presence of earlier, already-crystallized components is avoided and the country rock is not increasingly stiffened so as to make further developments more and more difficult. We may account through simultaneous intrusion for the common existence of inwardly protruding slabs of country rock, such as shown by Corry from the Wax Factory laccolith (fig. 44). This mode of formation also allows the proportions of country rock and intrusive rock to vary very readily from one laccolith to another, as they evidently do in nature.

I have three more points to make. Firstly, Corry refers with approval to the description of a laccolith (Hyndman & Alt 1987), regarding the example as confirming his own view that laccoliths lie directly above feeder dykes. Hyndman & Alt, however, described in this case a parent dyke as diverted from its course and forming a laccolith only through the effect of a volcanic load above. Here we have a different upper boundary from the horizontal, planar Earth's surface of Corry's models. Moreover, the dyke is described as bodily transforming into a sill by rolling over sideways, before locally thickening into a laccolith. It seems to me that we still have too few data on the anatomy of laccoliths to neglect any well-established field descriptions.

Secondly, I should like to point to an omission from Corry's list of laccoliths. The excluded examples are from Wales, and were described by Jones & Pugh in the *American Journal of Science* in 1949. Anticipating Corry, these authors suggested that the form forced on the country rock bounding a laccolith is determined broadly by the arrangement of places at which the country rock is successively fed with magma. The modifications imposed on the country rock in this way often may be better explained, as I suggest above, by intrusion of magma into several, side-by side fractures at the same time.

Thirdly, I should like to think that Corry's Special Paper will be read widely and that this will help the subject to gain the place in teaching it deserves. The study of laccoliths has the considerable merit of demonstrating on a manageable scale the operation of many of the fundamental processes studied in structural geology.

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Guided through the Cordillera

Hill, M. L. (editor) 1987. *Centennial Field Guide: Cordilleran Section*. The Geological Society of America, Boulder, Colorado, U.S.A. 532 pp. Price $43.50.

Geologists are fundamentally concerned with the study of the solid earth, that is the study of rocks and minerals, their byproducts, and their behavior. Thus, I am pleased to see that as part of the DNAG series of the Geological Society of America is publishing a collection of Centennial Field Guide volumes describing field trips where one can look at classic examples of rocks and their behavior.

The Cordilleran Centennial Guide describes 100 trips in the States of Alaska (nine trips), Arizona (six), California (44), Hawaii (four), Nevada (12), Oregon (eight), Washington (13) and the Province of British Columbia (four). These trips deal with the topics of accreted terranes (12 trips), active faults (14), archeology (one), Cenozoic volcanism (24), economic geology (12), engineering geology (12), geomorphology (41), landslides (6), metamorphic and igneous rocks (37), stratigraphy and sedimentation (61), and structural geology (50). Each field trip guide, 2–6 pages long, includes sections on the site location, accessibility, significance, description and useful references.

Although not a book one would read from cover to cover, this set of field guides is well written and informative. The consistent organization of individual sections and layout of the text as a whole provide a means of quickly finding trips of interest. Clearly the space constraints did not allow for an in-depth discussion of each region Thus the reader should be aware that some of the interpretations reflect the bias of the author(s), and that other interpretations for some of the areas do exist. But this is a common aspect of scientific writing, and would be hard to get around, given the length of each article. Each guide does provide an easily read, quick overview of an area and lists sources of additional information (including maps, additional articles, and the authors). I think this format will be particularly useful to teachers in search of good field trips, and to anyone interested in learning about new areas in the Cordillera.

I presume space constraints also dictated the number of field guides included. Some 'classic' localities are notably absent, for example the accessible and spectacular Sierra Nevada batholith in California. However, overall I found the text well organized and well written. I think that anyone interested on Cordilleran geology will find this a useful reference book.

The field guide costs $43.50 in the U.S., and is well constructed with a hardbound cover. The cover consists of a superb photograph showing the eastern escarpment of the Sierra Nevada. I found the price very reasonable given the construction and amount of text.

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The Tangshan earthquake disaster, 1976

Chen Yong, Kam-ling Tsoi, Chen Feibi, Gao Zhenhuan, Zou Qijia and Chen Zhangli (editors) 1988. *The Great Tangshan Earthquake of* 1976: *An Anatomy of Disaster*. Pergamon Press, Oxford. 153 pp. Price £20.00, $36.00 (hardback).

This book records what happened when an earthquake reported to be *M* 7.3 struck an area of northeast China within which neither seismological nor geological evidence indicated the likelihood of such a major event. Coming only just over a year after Chinese scientists had successfully predicted the *M* 7.3 Haicheng earthquake, the Tangshan shock dealt a blow not only to that city and its surroundings but also to confidence in earthquake prediction in China. That before 1976 Chinese seismologists and tectonicians did not regard the Tangshan area as likely to experience an event exceeding intensity VI on their scale (one comparable to the modified Mercalli scale) was not surprising in view of the evidence available to them. In the event, the maximum intensity recorded during the Tangshan earthquake was XI.

From the perspective of readers of the *Journal of Structural Geology* the principal benefit to be gained from this account of the Tangshan earthquake is the poignant reminder that brittle deformation events are not just ancient and of theoretical interest, but happen today and can profoundly alter peoples lives and the economy of a nation. The main shock of the 1976 Tangshan earthquake occurred at 3.42 a.m. on 28 July during a period of hot weather, which shortly after the earthquake was followed by several days of heavy rain; weather which slowed and hampered rescue efforts. An *M* 7.1 aftershock also caused much additional damage. The focal depth of the main shock was 11 km, wave-front modelling indicating that 120 km of the fault was ruptured. The displacement on the nearly vertical N30°E-trending fault is thought, from ground surface measurements, to have caused 1.5 m of right-lateral slip combined with 20–70 cm of vertical motion. The latter involved the uplift of the block to the northwest of the fault and the subsidence of the one to the southeast of it. Surface breaks, mainly fissures, associated with the earthquake were numerous, but only a few are classified as of tectonic origin. The remainder are interpreted as superficial phenomena related to the liquefaction of 25,000 km^2 of the alluvial plain.

In addition to geophysical and geological information, and an analysis of the main shock and its aftershocks, much of the book is concerned with describing the physical and social impact the earthquakes had on the Tangshan area. There is a thoughful discussion of how the effects of future earthquake disasters can be mitigated by planning and the efficient management of rescue services. In this context, the editors (all from the State Seismological Bureau) stress importance of accurate earthquake zoning and urban planning, and also point out the value of a city's parks during rescue operations.

The death toll of the Tangshan earthquake was, according to this book, 240,000 with 7000 families completely eliminated. Estimates by some Western experts of fatalities caused by the Tangshan earthquake were higher, even as great as 1,000,000. Seventy-eight per cent of the city's industrial plant is reported to have been destroyed, together with 650,000 of 680,000 residential buildings. Some damage was even reported from Beijing, about 150 km from the epicentre. Another consequence of the Tangshan earthquake was the spread of earthquake phobia throughout China, with many people, including the residents of Beijing, leaving their homes in the period immediately after the shock.

The half-tone illustrations, though of poor quality, are mainly illuminating and, in some cases, even moving. The captions to a few of the half tones seem inappropriate and propagandist. For example, the caption to fig. 2.3 reads—"A local unit of the People's Liberation Army hurrying to the disaster area", the photograph showing a slightly blurred column of soldiers with shovels over their shoulders running past collapsed buildings. The author's description, in the text, of the the efforts of medical staff to carry out emergency operations using makeshift equipment, such as a catheter made from the rubber tubing surrounding copper wire, is, however, both sensitive and vivid.

In summary, although this is a book that records what happened during a tragically disastrous tectonic event, and which heightens awareness of the risks accompanying great earthquakes, it is difficult to identify the market at which it is aimed. At £20.00 for a slim hardback, I suspect there will be few purchasers other than earth science and engineering institutions.

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