water on the rate of crack growth, they have calculated the effective failure strength as a function of depth in each of the terrestrial planets. For Venus, assuming the partial pressure of H_2O in near-surface rocks to equal that in the lower atmosphere, they calculate a very low value of crustal strength (about 10 MPa) and conclude that plate subduction on Venus would be unlikely.

This author and J.W. Head (Brown University) took a different view. Venus must lose an amount of heat per mass roughly comparable to that known for the Earth[5]. Solid planets and satellites transfer internally generated heat to the surface by plate recycling, as on Earth[6], lithospheric conduction, as on the Moon, and hotspot volcanism, as on Io. Each has been suggested as the dominant mechanism for lithospheric heat transfer on Venus[6-8] and we argued that none can be ruled out given our present knowledge of the venusian surface. In particular, plate recycling cannot be excluded once it is recognized that the characteristics of plate divergence and convergence zones on Venus and Earth will be different because of the different surface temperatures (740K on Venus) and surface abundances of water. Whatever the dominant mechanism of lithospheric heat transfer, however, given a global heat loss per mass comparable to that for the Earth, we must conclude that most of the large-scale topographical features on Venus are young compared with the surface ages of the smaller terrestrial planets.

The galilean satellites, because their surfaces are cold and are composed of unusual materials, display landforms and surface histories that are difficult to understand simply by extrapolation from the known outcomes of processes on the terrestrial planets. Europa, for instance, has a high-albedo icy surface criss-crossed by numerous darker lineations of great length and probably of tectonic origin[9]. T.B. McCord (University of Hawaii) and colleagues reported on a new spectral unit map of Europa derived from Voyager multispectral images. At least four distinguishable units occur; the darker lineations are spectrally similar to other dark units. E. Schonfeld (Johnson Space Center) proposed that the brown colour of the lineations and the low reflectance of the satellite at 3-4 μm may be due to the presence of organic molecules erupted from Europa's interior during episodes of aqueous volcanism. Interpreting the lineations as lithospheric fractures, P. Helfenstein (Brown University) showed that they may be the result of tidal stresses, although the details of such an explanation are considerably more complicated than in earlier versions[10].

The galilean satellites Ganymede and Callisto are similar in size and bulk density, yet their surfaces differ markedly[9]. Callisto displays a surface that has been little altered since an era of heavy impact bombardment. Ganymede, however, preserves heavily cratered units but also contains younger and more lightly grooved terrain, thought to be of extensional tectonic origin, suggesting the hypothesis that Ganymede has undergone greater global expansion than Callisto since the period of high impact flux. P.Y. Huang (MIT) and this author tested this idea by calculating the lithospheric thermal stress that would accumulate from global thermal evolution, including the effects of subsolidus convection and phase changes in H_2O ice, and concluded that Ganymede and Callisto would have had similar stress histories if their initial conditions were similar. If, however, Ganymede began at higher temperatures because of thermal gradients in the proto-jovian nebula[11], the difference in stress histories can account for the different surface characteristics. New estimates of lithospheric thermal gradients versus time in Ganymede and Callisto were reported by Q.R. Passey (Caltech) and E.M. Shoemaker (US Geological Survey) from the distribution of viscously relaxed craters of various diameters and by W.B. McKinnon (University of Arizona) from the widths of concentric ring scarps, interpreted as graben, in impact basin structures. Both studies indicate higher thermal gradients on Ganymede than on Callisto in the period 3 to 4 billion years ago.

The detailed tectonics of grooved terrain formation on Ganymede continue to receive special study. M.T. Zuber (Brown University) estimated the displacement that has occurred between large units of cratered terrain on Ganymede under the assumption that concentric arcs of ring structures in different units were formed by a single event; different locations of the centres of curvature for different units suggest displacements of up to 40 deg arc. M.P. Golombek (Lunar and Planetary Institute) derived a limit of one per cent on the increase in satellite radius associated with extension in the grooved terrain on the assumptions that the grooves are graben and that the dip angles of the bounding normal faults are 60° or greater. This limit agrees with that of McKinnon[11] based on the lack of tectonic disruption of Galileo Regio. S.K. Croft (Lunar and Planetary Institute) proposed that grooved terrain is formed by hydraulic fracturing driven by overpressured water during the final phases of global freezing following early differentiation.

Many of the icy satellites of Saturn show extensional features broadly similar to those of Ganymede[12]. S.W. Squyres, R.T. Reynolds, P. Cassen (Ames Research Center) and S.J. Peale (University of California, Santa Barbara) drew particular attention to Enceladus, which shows features similar to the grooves of Ganymede and large areas of low crater density. Resurfacing of such younger areas could occur either by extrusion of fresh material or by complete relaxation of topography due to a high thermal gradient. A new model by D.J. Stevenson (Caltech) for magma migration by crack propagation through the lithosphere, when applied to Enceladus, suggests that volcanism may occur by comparatively infrequent eruptions of large volumes of H_2O–NH_3 fluids, lending support to the volcanic resurfacing hypothesis. Squyres and his colleagues showed that tidal dissipation is an adequate heat source for volcanism on Enceladus as long as a forced eccentricity several times higher than the current value existed continuously or episodically through a substantial part of its history.

As the data from Pioneer, Venera and Voyager missions continue to be analysed, hypotheses for the evolution of Venus and of the outer planet satellites will be refined. To test these hypotheses will require new spacecraft observations. The US Galileo mission to Jupiter will help provide data for the jovian satellites, and the Soviet Union has announced plans for additional landers to be sent to the Venus surface to conduct further chemical analyses and imaging experiments. A major gap in our knowledge of Venus, however, is a global map of the surface at sufficiently fine resolution to distinguish among the proposed hypotheses for the tectonic evolution of the planet. While the proposed Venus Orbital Imaging Radar mission has fallen victim to reductions in the NASA planetary programme budget, a less ambitious and less costly Venus radar mapping mission is currently being considered to fill this gap. Completion of such a mission would provide a major step towards a full understanding of the evolution of Earth-like planets. □

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Corrigendum

In the *News and Views* article on 'Cause and treatment of atherosclerosis' by C.T. Dollery (*Nature* **297**, 286; 1982), the sentence "C.T. Dollery (Royal Postgraduate Medical School, London) described a new method for measuring plasma 6-oxo-PGF, the hydrolysis product of PGI_2, which uses gas chromatography–negative ion chemical ionization mass spectrometry and has a sensitivity limit of 500 pg ml^{-1}" should read ". . . a sensitivity limit of 500 cg ml^{-1}".

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