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General Discussion

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General discussion

E. V. Artyushkov (*Institute of Physics of the Earth, Moscow, U.S.S.R.*). Shortening of the crust has been modelled by compression of a continuous medium. It has also been supposed that compression can start in continental crust of normal thickness. Mathematical models of the same type have recently been used by some other authors.

It should be noted that an intense shortening of the crust in fold belts never occurred in such a way. In the main Phanerozoic fold belts (the Urals, Appalachians, Scandinavian Caledonides, the Alpine and Verkhoyansk belts, and others) no cratonic block with a normal continental crust and lithosphere was shortened (Artyushkov & Baer 1983, 1984, 1986). An intense compression took place only in deep basins on oceanic or continental crust. Most oceanic crust disappeared from the surface in the process of subduction. Now the fold belts are mainly built up of a strongly compressed crust of deep basins on continental crust. How can it be proven that this crust was really thin?

First, according to the condition of isostatic balance, it can be expected that deep basins of large width should have been underlain by a strongly attenuated crust. Second, many present folded mountain ranges were produced by shortening of deep basins in continental crust by 2–3 times. In most of them, the present crystal thickness is only 40–55 km (Alps, Dinarides, Carpathians, Caucasus and others). The average amount of eroded material is comparatively small. Hence it can be expected that before the compression the crustal thickness in deep basins was *ca.* 15–25 km (figure 1*a*).

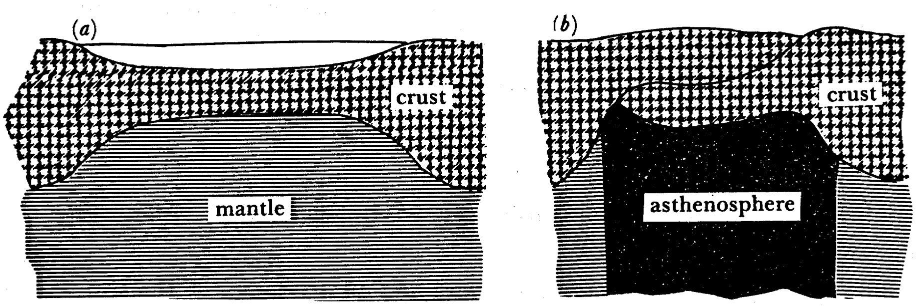

Figure 1

It is well known that shortening of continental crust commonly produces juxtaposition of thin plates of the attenuated crust (*b*). This is often associated with splitting of the crustal layer into the sedimentary cover and consolidated crust. Under such conditions a model of continuous medium can hardly be applied to the process of crustal shortening. Juxtaposition of thin plates of the attenuated continental crust indicates that during compression this crust is underlain by the asthenosphere. Thus an intense shortening of continental crust takes place only in the regions underlain by both the attenuated crust and thin lithosphere.

We have also been discussing the origin of metamorphic rocks that are observed near the surface. I would like to draw attention to the processes that can probably be associated with a deep seated metamorphism.

Consider an example of the west Siberian hydrocarbon basin (Artyushkov & Baer 1986). A shallow-water shelf existed in west Siberia in the late Jurassic. A slight crustal uplift above sea level took place for *ca.* 1 Ma in the late Jurassic. Then a deeper-water basin rapidly formed in the inner part of the area. It was *ca.* 900 km wide and *ca.* 200 km long. After the subsidence, shallow-water deposits were abruptly overlain by deeper-water black shales. The duration of the subsidence was *ca.* 1 Ma. The basin was rapidly filled with clinoforms 400–600 m high. Taking into account the isostatic response to their formation, the initial water-depth can be estimated as *ca.* 0.5 km.

The crustal thickness is considerably reduced under the region of the rapid subsidence as compared with the adjacent regions. This indicates the crustal thinning of *ca.* 10 km during the subsidence. If this thinning and subsidence were produced by stretching the stretching factor would be $\beta \approx 1.3$. In this case, shallow-water strata deposited before the subsidence must be significantly disrupted. Seismic and drilling data, however, show that they are continuous all over the basin (figure 2) and cover the same area as deeper-water strata formed after the

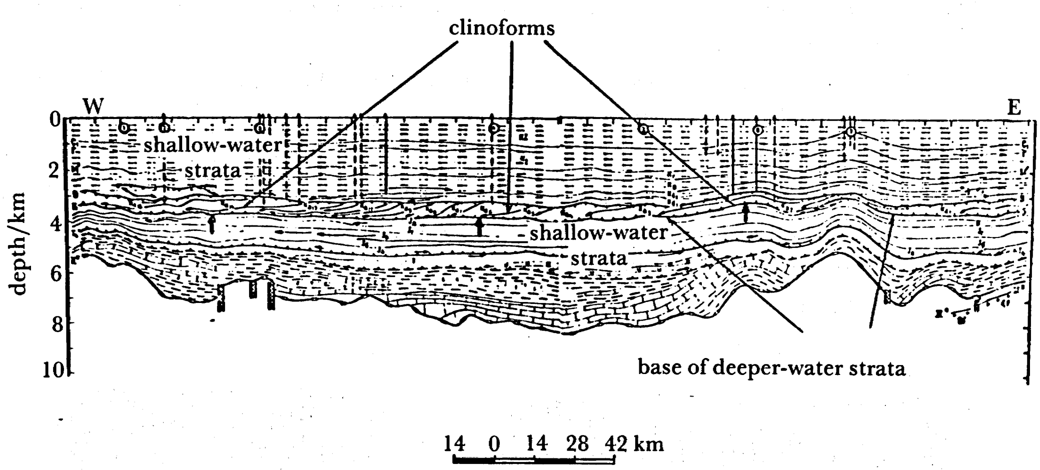

FIGURE 2

rapid subsidence. This means that the subsidence was not associated with significant stretching at the surface.

The crustal thinning by *ca.* 10 km without significant stretching at the surface requires the destruction of the lowermost crust, which is *ca.* 10 km thick. Subcrustal erosion by convective flows in the mantle or stretching of only the lower crust would remove the material from beneath the basin to the surrounding regions. This would produce a considerable crustal uplift there. No uplift took place in these regions during the subsidence. This probably indicates that the matter of the lower crust sank into the underlying mantle. Sinking of the lower crust into the mantle is apparently possible only under the asthenospheric upwelling to the base of the crust. Upwelling of the asthenosphere at moderate temperature can probably be indicated by a slight crustal uplift that preceded the subsidence. Furthermore, the lower crust should become denser than the underlying asthenosphere. Only in this case can it sink into this layer. Thus the formation of the West Siberian basin required a certain kind of metamorphism in the lower crust that is associated with a large increase in density.

Many other basins were formed on continental crust in a similar way. Thus rapid subsidence without significant stretching at the surface represents a phenomenon of a very wide occurrence and an adequate explanation should be found.

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