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STRUCTURAL MAPPING IN TIBET USING LANDSAT IMAGERY

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Tectonic research on earth during the last fifteen years has been dominated by the need to acquire new information on the plate structure of the lithosphere (1). Satellite derived data have, as yet, contributed relatively little to this work for several reasons: (a) resolution of the earth's gravity and magnetic fields at satellite elevations is too poor to permit discrimination of many plate boundary phenomena; (b) critical plate boundaries commonly lie below sea level and are inaccessible to satellite remote sensing; (c) in some very well known land areas satellite-derived data have little to add to existing structural data (d) some early users of LANDSAT imagery concentrated on mapping linear features indiscriminately (the new basement tectonics) not apparently realizing the importance of separating structures of different ages. The widespread failure of this approach led to the value of LANDSAT imagery as a tool in tectonic studies being seriously underestimated.

It is our experience that LANDSAT imagery can provide an exceptionally powerful tool in structural and tectonic studies in cases where both applicability to specific well-defined scientific problems is appreciated and the limitations of the method are recognized. We have also profited from the peculiar advantages of LANDSAT imagery in studying remote and inaccessible areas. As an example of the use of LANDSAT imagery in structural and tectonic studies we report here on work we have undertaken on the tectonics of the Tibetan (Qinghai-Xizang) plateau.

Terrestrial plate tectonics involves complex, interwoven, cycles of the opening and closing of oceans. Continental collision, marked by the suturing together of two continents, is a particularly significant stage in this sequential process because major structural and compositional changes are achieved within continents at this time. The only places on earth where active collision has reached the stage of complete suturing are in the zone of collision between the Turkish-Iranian plateau and Arabia and in the zone of collision between the Tibetan plateau and India (2).

Three possibilities have been suggested for the elevation of the Tibetan Plateau: (Fig. 1) (A) It may be underlain by crust of normal thickness and is high because beneath it there is anomalous (hot and/or less dense) mantle. (B) It may be underlain by a doubled thickness of continent because India has been thrust below Tibet as Argand suggested (3) or (C) It may be underlain by a doubled thickness of continent because the Asian continent has thickened, concertina-fashion after collision. Fig. 2 is an interpretation of a representative LANDSAT image of central Tibet which seems consistent only with the third possibility. A traverse by Sven Hedin on which rock identifications were made and strikes and dips recorded has been used as ground control.

The LANDSAT images show that rocks on top of the Tibetan Plateau which have yielded Late Cretaceous fossils have almost everywhere been strongly folded and probably thrust indicating substantial N-S shortening (? > 50%). Volcanic rocks are widespread (e.g. on Fig. 2) and are younger than the folding. Our geochemical studies on samples of these volcanic rocks indicate that they are calc-alkaline in character and perhaps result from partial melting of the thickened Asian continent. Studies of old terrains thought to be the sites of ancient continental collisions have shown evidence of substantial shortening and partial melting reminiscent of that seen in Tibet. Elsewhere in Tibet and much of China huge strike-slip faults are seen on imagery indicating motion of an enormous area toward the Pacific (4) as if escaping from the jaws of the Indian-Asian vise. However, in addition to this faulting, active folding and thrusting in the Tsaidam Basin-Nan Shan region is well displayed on the LANDSAT images. We interpret this area as being in an intermediate stage of development relative to the main Tibetan Plateau, with the shortening and thickening of the crust in progress and the volcanism yet to come. (1) Wilson, J.T. (1965) Nature, v. 207, p. 343-347. (2) Şengör, A.M.C. and Kidd, W.S.F. (1979) Tectonophysics, v. 55 p. 361-376. (3) Argand, E., La Tectonique de l'Asie (1924) C.R. Congr. Geol. Intern. 13 e, 1:171-372. (4) Molnar, P. and Tapponier, P. (1975) Science, v. 189, p. 419-426.

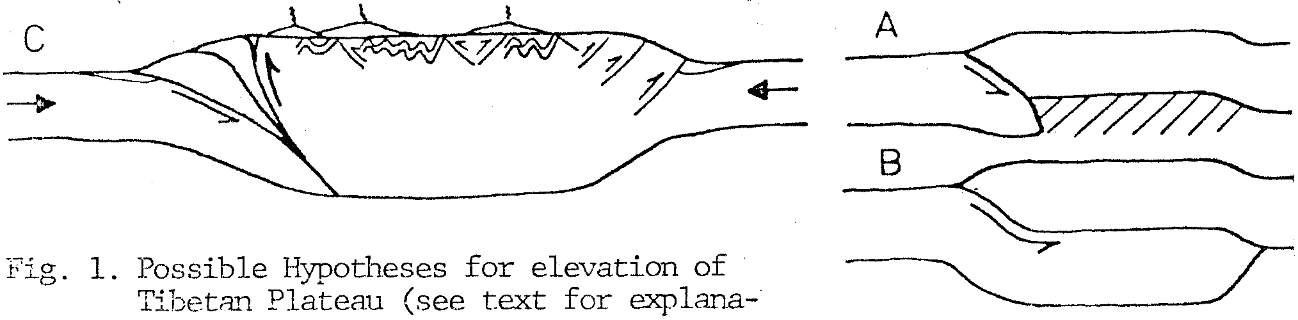

Fig. 1. Possible Hypotheses for elevation of Tibetan Plateau (see text for explanation).

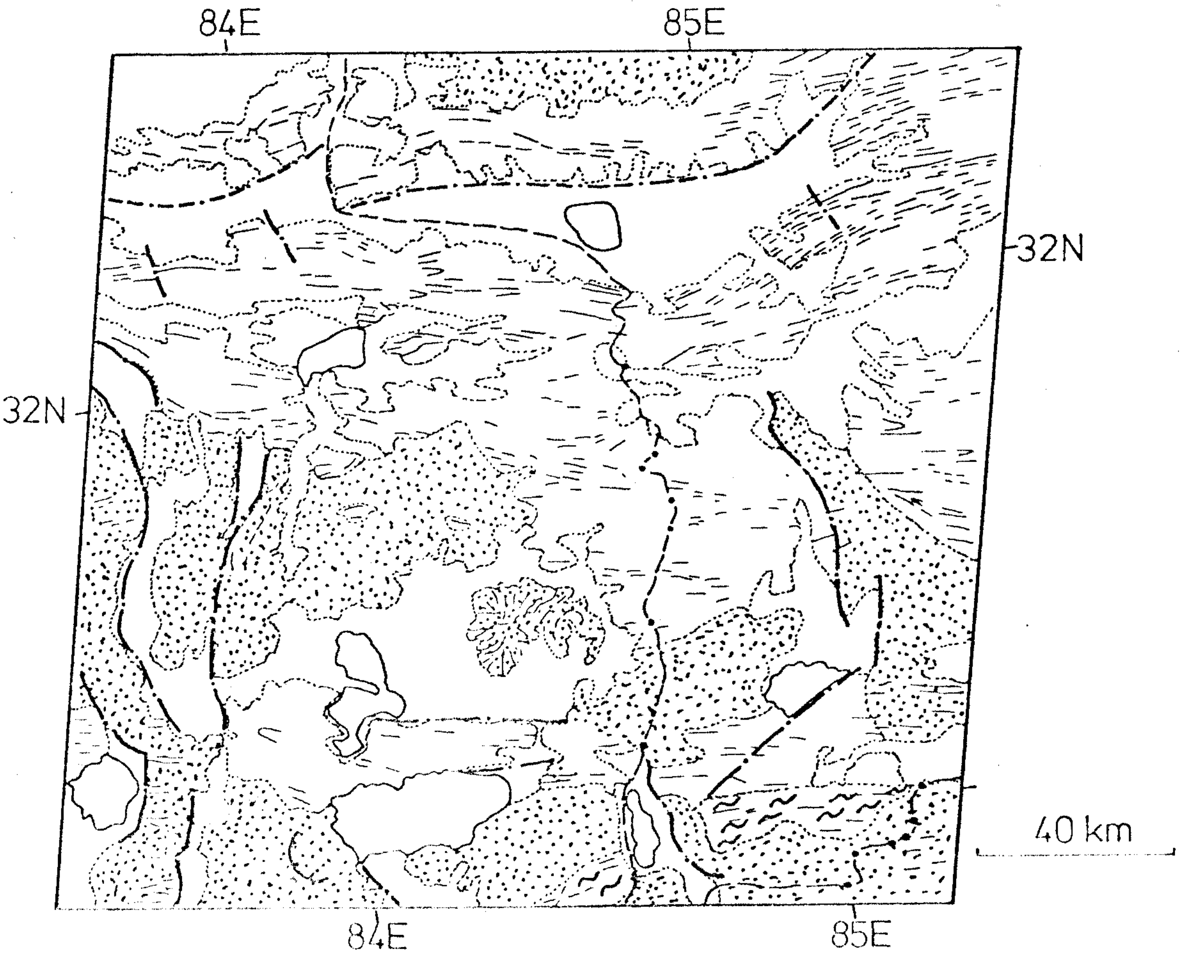

Fig. 2. Geological interpretation of Landsat image #81164-04274-5. White-Lakes and alluvium; dots-volcanics; thin dashes-strike lineaments in Mesozoic limestones and sandstones; ∿ and dashes-pre-Mesozoic phyllites; thick dash-dot lines-faults; dashed lines with few dots-Hedin's traverses with sample points