Development of pencil joints in a red bole bed at Dighi, Raigad district, Maharashtra, India

Towards the close of Cretaceous, a large part of Peninsular India witnessed the fissure type of volcanic eruption which gave rise to Deccan Traps. A geological investigation of various lava flows at selected places near Shrivardhan and Dighi on the Western Coast of India (Figure 1) revealed a red bole horizon at Dighi sandwiched between two basaltic flows. The red bole is fine-grained, friable and made up of clay-like matter which is distinctly red in colour and occurs as prominent horizon.

The red bole at Dighi is exposed on the wave-cut platform. It is nearly half a metre thick and crumbles into lumps when struck with a hammer. In a vertical section it displays very well-developed fine polygonal jointing pattern (Figure 2, the pen of 13 cm length on the top of the outcrop is used as a scale). Transverse section of the red bole in hand specimen reveals that the diameter of these polygonal columns range from 0.4 to 0.2 cm and a length of more than 20 cm (Figure 3). Based on this character, these slender polygonal columns have been described as pencil joints.

Wilkins *et al.*[1], based on a detailed petrography and geochemical analysis suggest that the red bole horizon is typically a weathered/altered product of pyroclastic rock or volcanic tuff sitting on top of an altered flow top, which grades downwards into fresh basalt flow. According to them, the pyroclastic rock or volcanic tuff would have been more porous to water penetration, thus accelerating the weathering process. In the area under investigation, the thin section studies reveal a highly weathered reddish, fine-grained matter containing yellowish-brown altered glass

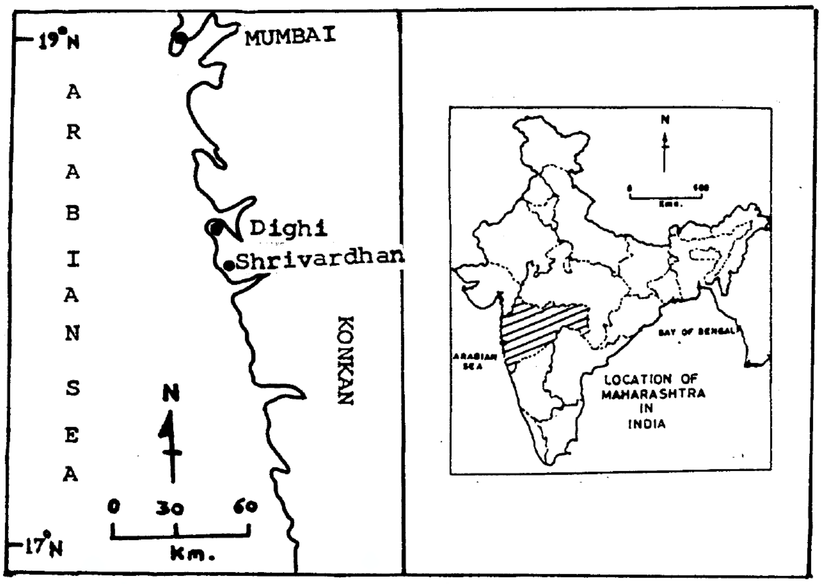

Figure 1. Location map of Dighi, Raigad district of Maharashtra, India.

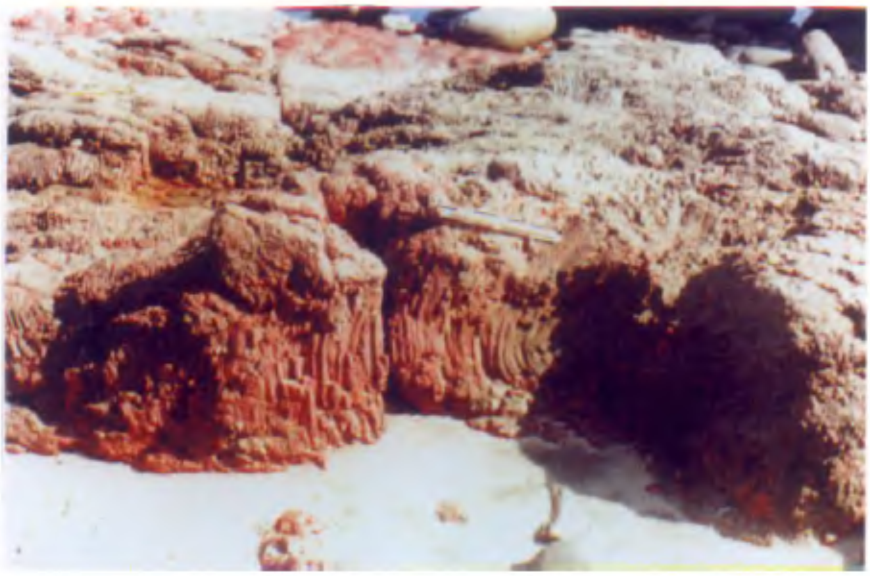

Figure 2. Field photograph of the red bole at Dighi (the pen of 13 cm on the top of the outcrop is used as a scale) exhibiting fine polygonal pencil joints. Note the buckling and dragging effects on the joints.

Figure 3. Transverse section of the red bole in hand specimen. Note the development of perfect polygonal shrinkage cracks formed due to evaporation.

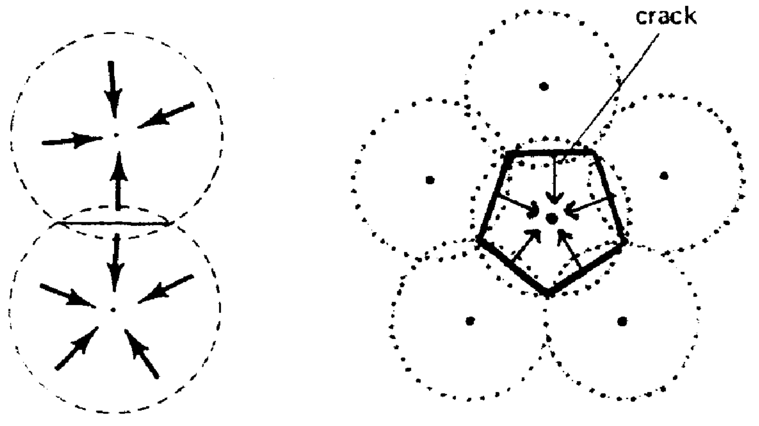

Figure 4. ***a***, Theory for the mechanism of formation of shrinkage; Polygonal cracks due to evaporation (after Brainerd Mears, Jr.[2]).

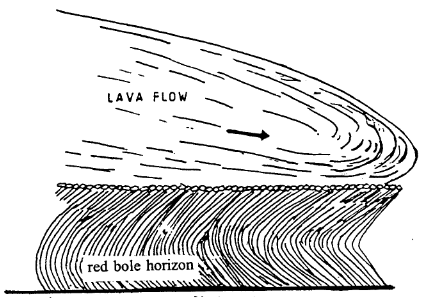

Figure 4. ***b***, Overloading pressure of the lava flow on the red bole bed causing buckling and dragging effects on the pencil joints.

fragments along with a frequent occurrence of fresh glass shards. Thus the petrographic characters clearly suggest that the red bole at Dighi is a typically weathered or altered product of pyroclastic rock as suggested by Wilkins *et al.*[1].

The heat provided by the younger lava flow which erupted onto this weathered, fine-grained pyroclastic material (which retained enough moisture) caused baking effects and the development of numerous evenly dispersed centres of shrinkage, similar to polygonal racks that develop when wet clayey sediments are subjected to evaporation (Figure 4 *a*).

According to Brainerd Mears, Jr.[2], although the causes for development differ, this shrinkage theory of cracking in mud applies far more spectacular forms, such as giant columns of basalt formed by contraction of freezing lavas. As the overloading pressure of the younger lava flow continued over the weathered, fine-grained matter has brought about a plastic deformation (buckling) of these pencil-jointed columns, the lateral movements of the younger lava flow caused the upper part of the pencil-jointed columns to be dragged tangentially in the direction of the movement of the younger lava flow (Figure 4 *b*). In the field this has also helped in determining the direction of the younger lava flow from west to east.

While the development of fine, perfect pencil joints has been explained, it is also pertinent to note that the plastic deformation (buckling) of the slender polygonal jointed red bole horizon and its dragging in a particular direction, helps to determine the direction of movement of the younger lava flow on its top.

1. Wilkins, A., Subbarao, K. V., Ingram. G., and Walsh, J. N., *Volcanism*, Radhakrishna Volume (ed. Subbarao, K. V.), Wiley Eastern Ltd, New Delhi, 1994, pp. 217–232.
2. Brainerd Mears, Jr., *The Changing Earth, Introduction to Geology*, D. Van Nostrand Comp, NY, 1970, 2nd edn, p. 575.

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Mapping of Indus ophiolites: Need for introspection

This concerns a research communication published recently in *Current Science* by Philip *et al.*[1] about the utility of high resolution IRS-IC/ID satellite data in 'mapping of ophiolites in the hostile and inaccessible mountainous terrains'. The objective of the study is to 'map the geological features in the Nidar Ophiolitic Complex' and thereby bring 'refinement of the existing geological maps'. It claims that satellite images from the area of study 'have helped not only in delineating the lithological boundaries more precisely but also in demarcation of a number of subunits within the already mapped litho-units'. It is unfortunate that the authors did not consult the published geological map from the specific area[2]; consequently, most of their claims became invalid and faulty.

The Geological Survey of India had been engaged in the study and systematic geological mapping of Indus Ophiolite belt and Indus Suture Zone for many years[3,4]. Neither these early nor later studies from the selected area[2] by this premier organization has been referred[1]. It is a fact that maps in none of the referred studies[5,6] involving the authors provide much details on the ophiolitic