Growth ring features in *Sahnioxylon* from Rajmahal Hills and their climatic implications

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Growth ring features of *Sahnioxylon* from Rajmahal Formation in Rajmahal Hills, Bihar indicate the existence of distinct climatic seasonality. The wide and complacent ring sequences in the fossil wood point towards very favourable climate. Presence of well-developed latewood in comparison to earlywood indicates that the growing season would have been very long. It is suggested that the trees of *Sahnioxylon* might have thrived under sub-tropical to warm temperate climate during the Lower Cretaceous period.

TREES growing in seasonal climate areas produce distinct growth rings. Variations in thickness of growth sequences from such areas reflect the environmental conditions of the concurrent period[1,2]. Tree ring features of fossil woods from geological periods have been used as important proxy data to decipher the palaeoclimatic conditions and even forest productivity[3–10].

Sahnioxylon is a petrified fossil wood described from the Rajmahal Formation in Rajmahal Hills, Bihar[11–13]. Based on radiometric dating[14] and other palaeobotanical evidences this formation is considered to be of Lower Cretaceous age. Here we describe detailed growth ring features of *Sahnioxylon rajmahalense* (Sahni) Bose and Sah[13] and *S. andrewsii* Bose and Sah[13] and their palaeoclimatic implications. Growth rings are well preserved in specimens of *Sahnioxylon*. The thickness of growth ring sequences was measured under the stereozoom binocular microscope along the radial line on a polished slab of *S. rajmahalense* described from Mandro near Mirzachowki in Bihar. The specimen measuring 21.2 cm in radial direction possessed 67 growth rings. From measurements of the width of each of these rings some of the standard statistical parameters used to evaluate ring characteristics have been derived. Variations in the thickness of growth ring sequences are very important in gleaning climatic informations. For this, mean sensitivity (*ms*), which is a measure of high frequency climate variations[1], was calculated by using the formula:

$$ms_x = \frac{1}{n-1} \sum_{t=1}^{t=n-1} \left| \frac{2(X_{t+1} - X_t)}{(X_{t+1} + X_t)} \right|$$

where X is the ring width, n the total number of rings in the sequence and t the year number of the ring. It ranges from zero, where there is no variation in the thickness of neighbouring rings to values up to two, when either of the ring is missing.

Intra-ring cellular details were studied from the type slides of *S. andrewsii* where good structural details are preserved. Individual cell diameters along a radial file were measured to classify the rings according to the scheme proposed by Creber and Chaloner[4]. Radial diameter changes of cells across a ring provide information of environmental conditions during a single growing season.

Two type specimens of *Sahnioxylon* viz. *S. andrewsii* and *S. rajmahalense* housed in the BSIP museum, showed well-defined growth rings. This illustrates that their growth environment was characterized by distinct seasonality of climate. Widths of growth rings were measured only from one specimen from a polished petrified slab of *S. rajmahalense* which has sixty-seven growth rings. These rings are found to be very wide with average width of 3.16 mm. Wide growth rings imply high biomass productivity indicating favourable climatic conditions. Another important feature of the ring width series (Figure 1) is the uniformity in the thickness of rings from year to year with mean sensitivity 0.16, such low value indicates a complacent type. The trees with low mean sensitivities are considered to be complacent type which grow in stable forest environments where no climatic factor is limiting the tree growth[1,18].

The cell radial diameter variations of each ring throughout the ring series in *S. andrewsii* show very

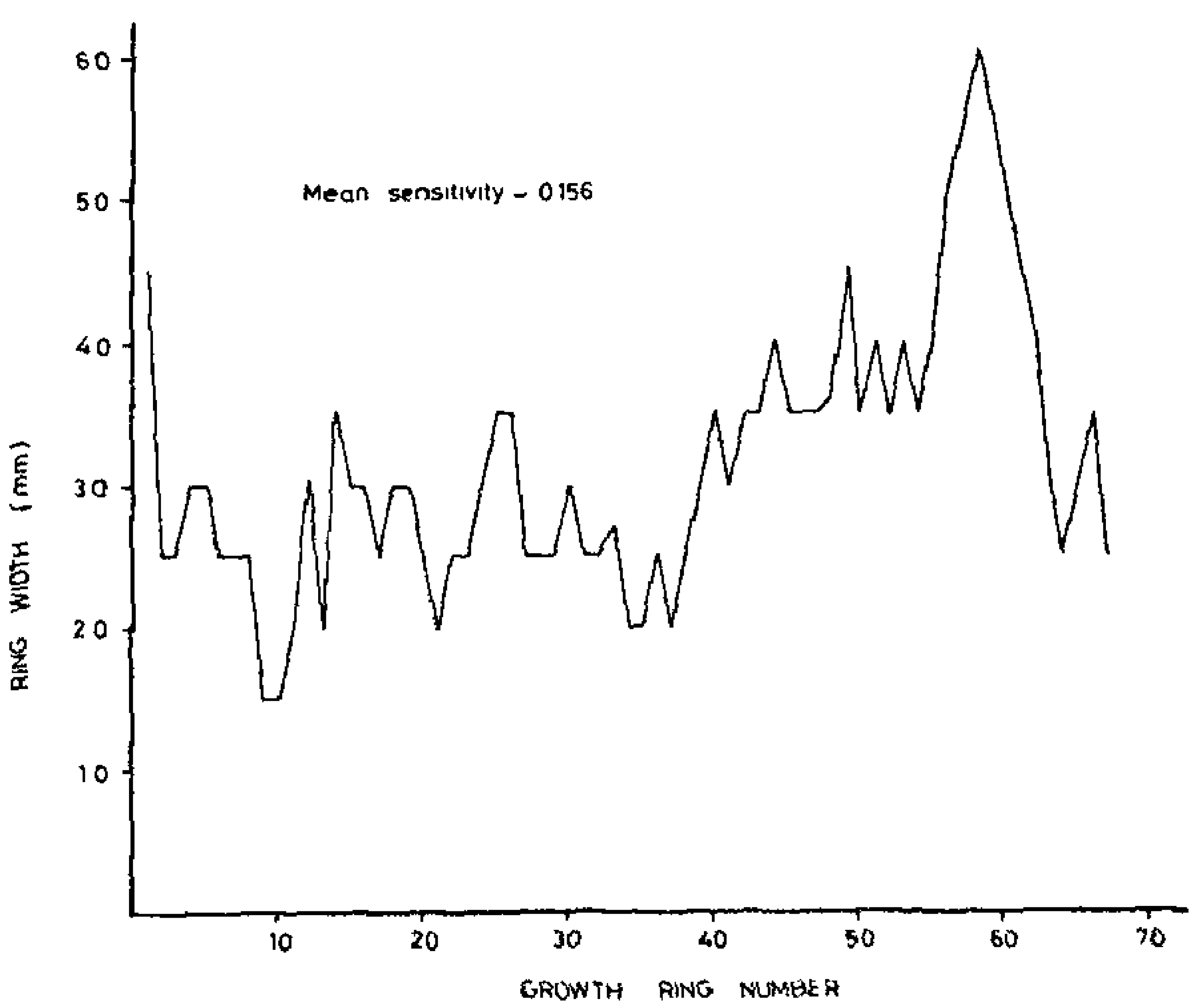

Figure 1. Ring width series of *Sahnioxylon rajmahalense* (Sahni) Bose *et* Sah showing year to year fluctuations

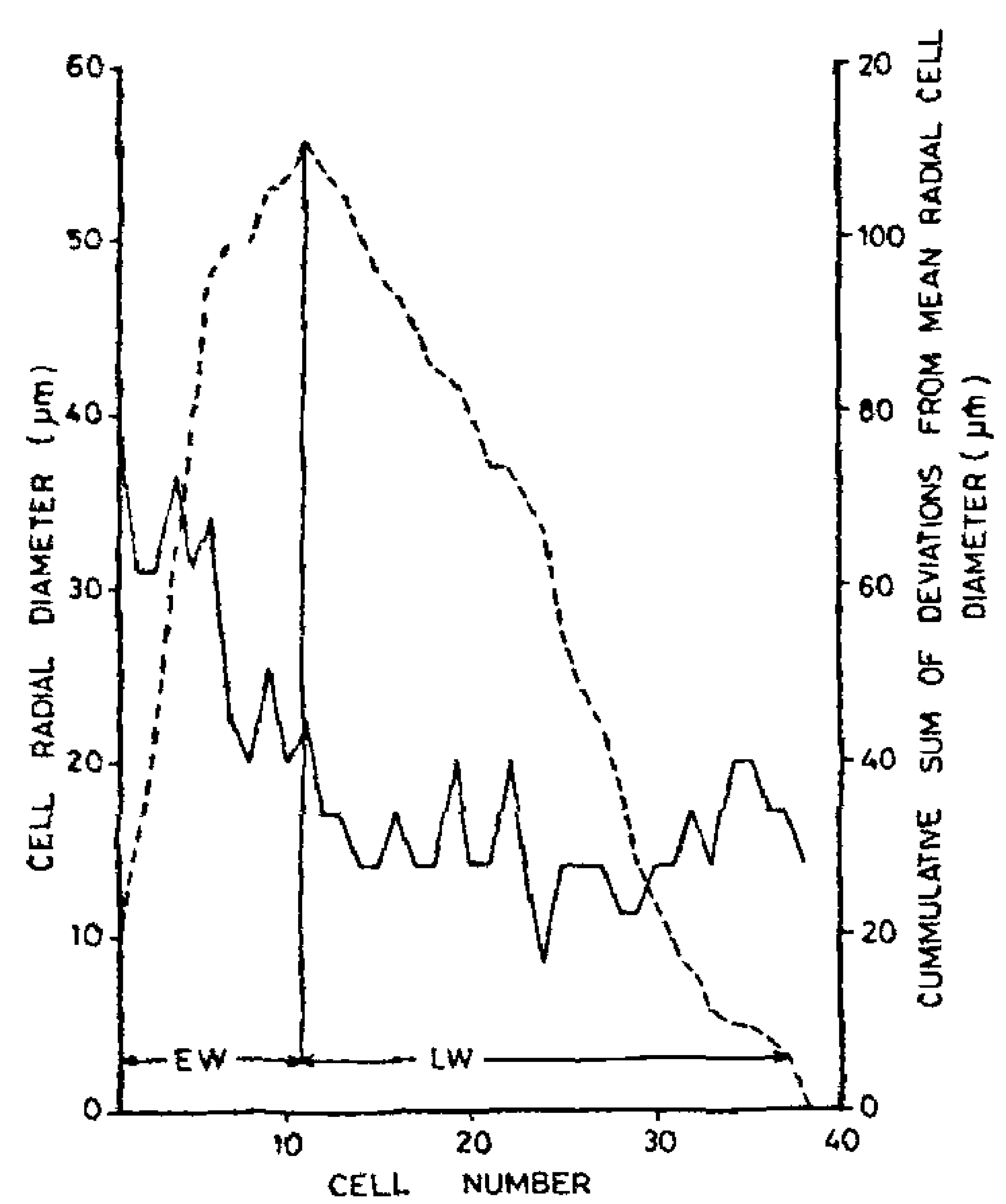

Figure 2. Cell radial diameter changes across a ring in *S andrewsii* Bose *et* Sah Points from where the cumulative sum of deviations turn sharply towards zero indicates the earlywood/latewood boundary. EW, earlywood; LW, latewood.

little amount of early wood in comparison to latewood. This type of curve (Figure 2) is characteristic of 'A' type after Creber and Chaloner[4]. It has been shown earlier that the development of earlywood largely depends on the stored food reserves, however, the latewood is dependent on the current years assimilates which are available throughout the growing season[19]. The presence of large amount of latewood in the fossil wood of *Sahnioxylon* shows the extended growing season with favourable conditions when this tree flourished in the Rajmahal area during the early Cretaceous.

Based on palaeofloral evidences from Rajmahal Formation in Rajmahal Hills, Bihar a sub-tropical to tropical type of climate has been suggested[17]. However, the growth ring features of *Sahnioxylon* (*S. rajmahalense* and *S. andrewsii*), especially very wide rings with large amount of latewood, are indicative of a sub-tropical to warm temperate climate.

1. Fritts, H. C, *Tree Rings and Climate*, Academic Press, London, 1976.
2. Schweingruber, H, *Tree Rings: Basics and Applications of Dendrochronology*, Kluwer, Netherlands, 1988.
3. Chaloner, W. G. and Creber, G. T., *Implications of Continental Drift to the Earth Sciences* (eds Tarling, G T. and Runcorn, S. K), Academic Press, London, 1973, pp 425–437.
4. Creber, G. T. and Chaloner, W. G, *Bot Rev*, 1984, **50**, 357–448.
5. Creber, G. T. and Chaloner, W. G., *Palaeogeogr. Palaeoclimatol Palaeoecol.*, 1985, **52**, 35–60.
6. Jefferson, T. H., *Palaeontology*, 1982, **25**, 681–708.
7. Jefferson, T. H, *Antarctic Earth Sciences* (eds Oliver, R L., James, P. R and Jago, J B), Australian Academy of Sciences, Canberra, 1983, pp. 593–598.
8. Francis, J. E, *Palaeogeogr. Palaeoclimatol. Palaeoecol*, 1984, **48**, 285–307.
9. Francis, J. E., *Palaeontology*, 1986, **29**, 665–684.
10. Ash, S. R. and Creber, G. T., *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 1992, **96**, 299–317.
11. Sahni, B, *Mem. Geol. Surv. India, Palaeont. Indica* (n.s), 1932, **20**, 1–19.
12. Hsu, J. and Bose, M. N., *J. Indian Bot. Soc.*, 1952, **31**, 1–12.
13. Bose, M. N. and Sah, S C. D., *Palaeobotanist*, 1954, **3**, 1–8
14. McDougall, I. and McElhinny, M. W., *Earth Planet. Sci. Lett.*, 1970, **9**, 371–378.
15. Maheshwari, H. K. and Jana, B. N., Proceedings of the symposium on Cretaceous of India: Palaeoecology, Palaeogeography and Time Boundaries (ed. Maheshwari, H. K.), Indian Assoc. Palynostratigraphers, Lucknow, 1983, pp. 158–192.
16. Singh, H. P. and Venkatachala, B. S., *Palaeobotanist*, 1987, **36**, 168–176.
17. Sukh-dev, *Palaeobotanist*, 1987, **36**, 161–167
18. LaMarche, V. C. *Science*, 1974, **183**, 1043–1048.
19. Larson, P. R., *Silvae Genet.*, 1967, **10**, 58–65

Received 21 March 1994; revised accepted 4 August 1994

Growth-phase-dependent binding of hematoporphyrin derivative to human glioblastoma (U-87MG) cells

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Studies on the binding of hematoporphyrin derivative (HpD) to asynchronous and synchronized human glioblastoma (U-87MG) cells were performed using fluorescence spectroscopy. Cell-bound HpD exhibited three fluorescence bands. The intensity distribution of fluorescence spectrum was found to be dependent on the growth phase of cells. The relative intensity of 636 nm band increased as the cells progressed through the growth curve. A more distinct change was observed when the fluorescence spectrum of Hpd bound to M-phase cells was compared with G1-phase cells. M-phase cells exhibited maximum fluorescence emission at 615 nm, with a small shoulder at 636 nm whereas in G1-phase cells the 636 nm fluorescence band showed enhancement. HpD binding to synchronized cells was also studied during the cell division cycle. A clear variation in the intensity ratio of 636 to 615 nm fluorescence bands was observed along the cell division cycle. This intensity ratio was maximum in mid G1 and early G2 phases of growth, whereas a minimum was observed in mid S phase. The photosensitivity of asynchronous as well as synchronized cells was determined under above-mentioned experimental conditions. The photosensitivity also varied with the growth phase of the cells. A good