the absence of tubuliform and extremely elongate shell and from dacryoconarids in lacking pronounced tear-drop bulb at the apex, thin shell, bilateral symmetry and larger growth angle. By elimination thus and also on the basis of apex shape, slightly curved shell with faint transverse ridges, thick shell wall, size and growth angles[2], these are found comparable with *Tentaculites*.

The *Tentaculites* have a stratigraphic range from Silurian to Devonian[2]. Its presence in the basal part with conformable sequence right up to Carboniferous fossil bearing beds[1], suggests that the basal part of the Lipak Formation represents a Devonian age—possibly Upper Devonian. Such an age assignment is apparently supported by the record of late Devonian brachiopods, conodonts and fish remains from the Lower Lipak limestone of this very section[3-5]. However, the lithology immediately overlying the Muth Formation described in the above cited publications (50 m shale[3] and 10 m grey limestone[4]) is contradictory and the veracity of the fossils described therein has been questioned[6].

Tentaculites are exclusively marine and prolific in shallow lagoons. These are regarded as nektonic to benthonic scavengers in relatively warmer, more agitated waters. Lagoonal, shallow and warm environments are also suggested by the presence of corals and gypsum in the Lipak Formation. Parallel orientation of *Tentaculites* cones suggests the presence of mild bottom currents in the Lipak lagoon.

1. Hayden, H. H., *Mem. Geol. Surv. India*, 1904, **36**, 1.
2. Fisher, D. W., *Treatise on Invertebrate Palaeontology* (ed. Moore, R. C.), University of Kansas Press, 1962, p. 98.
3. Gupta, V. J. and Janvier, Ph., *Bull. Indian Geol. Assoc.*, 1979, **12**, 161.
4. Gupta, V. J. and Struve, W., *Bull. Indian Geol. Assoc.*, 1987, **20**, 25.
5. Gupta, V. J., *J. Geol. Soc. India*, 1987; **30**, 315.
6. Talent, J. A., Geol, R. K., Jain, A. K. and Pickett, J. W., *Courier, Forsch.-Inst. Sennckenberg*, 1988, **106**, 1.

18 September 1989; revised 16 November 1989

Abundance of Jurassic bivalves during marine transgressive–regressive cyclic events

K. M. Krishna* and O. P. Upadhyay**
Departments of *Geology and **Mining Engineering, Banaras Hindu University, Varanasi 221 005, India

Jurassic (Callovo–Oxfordian) rocks in Kachchh show evidence of marine transgressive–regressive events. The Oxfordian bed, deposited during the transgressive phase, is characterized by greater abundance of infaunal bivalves, while the Callovian beds, deposited during the regressive phase, show predominance of epifaunal bivalves.

THE present note concerns the study of the abundance of epifaunal–infaunal groups of bivalve during marine transgressive–regressive cyclic events from the Jurassic rocks of Kachchh, Gujarat. On the basis of data obtained from field, a graph (Figure 1) has been prepared showing the abundance of fauna during Callovo–Oxfordian time.

During Callovo–Oxfordian age, a large-scale deposition of the sediment took place in the Kachchh basin as a result of marine transgressive–regressive cyclic events. The characteristic bed, 'Dhosa Oolite' (Oxfordian) comprises of small thickness throughout the Kachchh which has been deposited during the transgressive phase, whereas the Callovian beds, which constitute huge deposition of shale over sandstone beds are supposed to have been deposited during the regressive phase[1].

The rate of supply of terrigenous sediments has a direct relationship with the thickness of the deposition, i.e. with increase in the terrigenous sediments the thickness of the strata also increases and vice-versa. Such a variation in the rate of supply of terrigenous sediments has also influenced the basin environment. The shallowing of the basin is favoured by an increase in the rate of supply of terrigenous sediments (during regression) while the reduced supply of the terrigenous sediments in the basin (during transgression) suggests deepening of the basin.

In the modern ocean life context, the epifaunal bivalves are more abundant in the shallow regions of the sea, whereas the infaunal bivalves are predominant at greater depths[2]. The above argument of Hedgpeth agrees well with our graph in which abundance of three

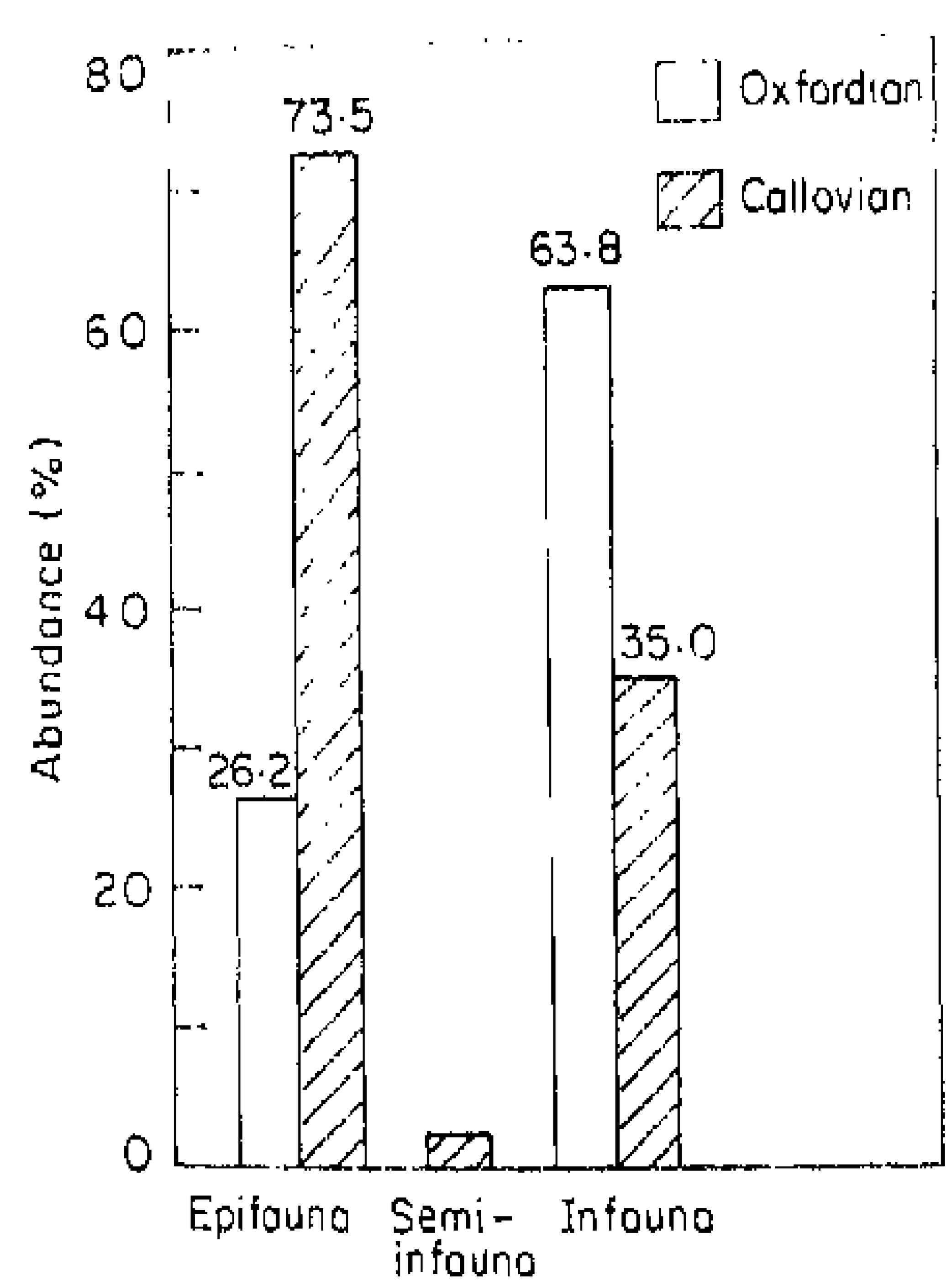

Figure 1. Relative abundance of fauna in Callovo-Oxfordian time.

groups of bivalves are shown during Callovo–Oxfordian time (Figure 1). Among the three groups of bivalves, the epifaunal–infaunal groups represent their greater abundance from the Callovo–Oxfordian beds, whereas the semi-infaunal bivalves show only 2% of the population from the Callovian beds. The abundance of epifaunal–infaunal groups of bivalves from the Callovo–Oxfordian beds (which could be furnished as a result of marine cyclic trangressive–regressive events) is significant not only with the associated lithology but also with the marine cyclic events.

Finally, on the basis of the present study, it is interesting to note that the Oxfordian bed (in which the marine transgressive event took place) is characterized by the greater abundance of infaunal bivalves, whereas the Callovian beds (in which marine regressive event took place) constitute predominant epifaunal bivalves.

1. Biswas, S. K., *Q. J. Geol. Min. Met. Soc. India*, 1981, **49**, 1.
2. Hedgpeth, J. W., (ed.), *Treatise on Marine Ecology and Palaeoecology*, 1957, Colorado.
3. Agar, D. V., *Principles of Palaeoecology*, McGraw Hill, New York, 1963.

ACKNOWLEDGEMENT. We thank Dr S. Kanjilal, Dr A. K. Jaitely and Mr R. N. Singh Yadav for guidance and help rendered in the preparation of this paper.

13 September 1989

Electromagnetic field-induced *in vitro* pollen germination and tube growth

M. P. Alexander and S. Ganeshan
Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore 560 089, India

The effect of electromagnetic pulsing on pollen germination and tube growth of *Carica papaya* L., cv. 'Washington' was studied. Pollen germination and tube length showed significant increase over controls. The results show that the pollen grains exposed to magnetic field germinate faster and produce longer pollen tubes than the controls. The technique of electromagnetic excitation provides a new tool for evaluating a large number of cryopreserved pollen grains rapidly and would be of immense value in pollen storage and breeding strategies.

MAGNETIC field induces morphological[1–3], physiological[4] and biochemical[2,5,6] changes when biological systems are exposed to it. The effect of magnetic field on biological systems generally deals with morphological changes in germinating seeds[7,8] and seedlings[9,10]. Magnetic response in mice[11], mud-snails[12], eggs of sea-urchins[13], micro-organisms[14,15] and mitotically dividing plant cells[16] has also been studied earlier. All these relate to effects at organ, cellular and molecular levels. However, with reference to plant gametophyte (pollen), information is not available. Therefore, a series of experiments were conducted on the pollen of horticultural crops during 1986–88. The present results pertain to studies on the pollen of papaya exposed to a magnetic field of 96 G for 10 min at 12 DC and 0.5 A (strength and time were prestandardized in preliminary experiments).

Two identical bar electromagnets were fabricated by winding 720 turns of 22 gauge enamelled copper wire on 50 mm core. The power supply consisted of a 2 A step-down transformer with tappings at 3, 6, 9, 12, 15, 18, 21 and 24 V AC which was converted into DC by a 5 A bridge rectifier and by a 50 MFD 150 V DC electrolytic capacitor. The electromagnets were connected in parallel circuit to the DC supply and placed one above the other with opposing polarity keeping an air gap of one inch between them.

The pollen of *Carica papaya* L. cv. 'Washington' was mounted in hanging drops containing 6% sucrose. The cavity slides with hanging drops were placed in a hardboard tray, specially fabricated, to enable correct positioning and uniform exposure in the region of maximum flux. After exposure to the magnetic field, the slides were incubated at 25 ± 1°C along with controls in a chamber with 100% relative humidity. Fourteen replicates, each with a parallel control, constituted the experimental set-up. The hanging drops were stained with a versatile stain[17] after 2 h of incubation, remounted on a flat slide and sealed with epoxy resin. Observations on pollen germination and tube lengths were recorded from 10 randomly selected microscopic fields using a Leitz Neopromar projection microscope, following standard procedures[18]. Tube lengths were measured from 10 germinated pollen grains randomly selected from treated and control sets.

Figures 1 and 2 show normal germination and germination of pollen grains exposed to the magnetic field. Pollen germination and tube growth were significantly higher ($P < 0.01$) in magnetic field-induced germination. The mean germination recorded for the induced set was 23.1%, compared to 12.7% for controls. Likewise the tube length was 154.8 μm in the induced set, compared to 104.3 μm for controls. Pollen tubes in the induced set were healthy and normal. Initiation of pollen tubes in the induced set took place after 30 min, while it was after 45 min in the controls. Papaya pollen which takes 3 h *in vitro* to record 25% germination showed a germination of 23.1% in 2 h under the influence of electromagnetic field.

Some of the magnetic influences reported are enhancement of germination and seedling growth (barley)[19], chromosomal aberrations[16], enlargement of nucleus[20], increase in RNA content at growth zone (barley)[20], triggering of enzymatic activity[6,21], and