Figure 1.  a. The logical interconnection of the host and nodal processors used for simulating the discrete Hopfield model of neural networks. The figure illustrates a system consisting of four processors (P = 4), and the nodal interconnection topology is a directed ring. b. The domain decomposition strategy adopted here in parallelizing the discrete Hopfield model. The number of nodal processors (P) in the system is taken as four. The major data items to be partitioned are the interaction matrix J of size n × n and the network state vector σ of size n. The dashed lines divide the interaction matrix and the state vector into four parts, to be downloaded into the respective processors. For the sake of simplicity n is assumed to be exactly divisible by P. J^m and σ^m denote interaction submatrix of size (m/P) × (m/P) and network state subvector of size (m/P) respectively.

processors P is fixed and the problem size n is increased, then one always gets an increase in performance, and the speed-up approaches P asymptotically.

Table 1 gives the results of the simulation experiments. The times were obtained using the UNIX operating-system function 'clock'. Usually one observes a standard error of about one to two per cent in the values returned by this 'clock' function. The main source of this error is perhaps the time-slicing mechanism employed to schedule jobs in a multi-user environment. Hence the numerical order of the experimental speed-ups in the last two or three rows should not be taken seriously. Thus, excluding the order of the experimental speed-ups in the last two rows, the agreement between the theoretical and experimental data is quite good. These results show that the PACE architecture is very effective for simulating the discrete Hopfield model of neural networks.

Palaeomagnetism of calc-granulites from Sadanandapuram in the manganese ore belt of Vizianagaram District of Andhra Pradesh

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Calc-granulite is a prominent formation associated with manganese ore, in Eastern Ghats, in the Vizianagaram District of Andhra Pradesh. We carried out palaeomagnetic measurements on calc-granulites from Sadanandapuram in the manganese ore belt of Vizianagaram District. The corresponding palaeomagnetic pole is 14°N and 12°E and coincides with that of Visakhapatnam charnockites. We point out the inadequacy of available palaeomagnetic results from this part of Eastern Ghats Belt and stress the need for more palaeomagnetic investigations.

The calc-granulites are regionally metamorphosed impure calcareous sediments consisting of calcite, wollastonite, diopside, garnet, quartz, scapolite, orthoclase, microcline and albite. Apatite, sphene, muscovite, pyrite, serpentinite, biotite and chlorite are relatively in smaller proportions. Ferruginous and chloritie material are distributed around the grain boundary of calcite. We carried out palaeomagnetic measurements on the calc-granulites for the purpose of correlating them with other known results.

Ten oriented block samples of calc-granulite were collected from Sadanandapuram (lat. 18°16′N, long. 83°33′E) in the manganese ore belt. Cylindrical specimens of 2.5 cm in diameter and 2.2 cm in length were drilled in the laboratory. At least two specimens were prepared from each sample. The natural remanent
magnetization (NRM) ($J_m$) of specimens was measured on a Spinek magnetometer. Volume magnetic susceptibility ($K$) was measured on a low field susceptibility apparatus at a field strength of 0.05 mT. The Koenigsberger ratios, $Q_m$ ($J_m/KH$), were calculated.

The NRM intensities of calc-granulites are in the range $1.3 \times 10^{-3}$ and $350 \times 10^{-3}$ A/m. The magnetic susceptibilities are between $0.5 \times 10^{-3}$ and $35.7 \times 10^{-3}$ (SI) with an average of $9.4 \times 10^{-3}$. The $Q_m$ ratios are from 0.24 to 8.6 and the average value is 2.7 (SI). From the specimen directions of all the specimens of a sample, a sample mean was calculated using Fisher's method and all the sample means from the site were projected on Schmidt's equal area net and presented in Figure 1, a. The specimens were subjected to A.F. demagnetization for isolating the stable component of remanent magnetism. The demagnetization was carried out in progressively increasing field strengths of 2.5, 5, 10, 15, 20, 30, 40, 60, 80 and 100 mT. The optimum demagnetizing field for effective removal of secondary components was decided by observing the vector rotation and the dispersion of directions.

The changes brought about in the remanent magnetic direction by successive field strengths for two specimens are shown in Figure 2, a. The decay in intensity during the same demagnetization operation is shown in Figure 2, b. It is observed that the vector rotation is minimum for demagnetizing fields of 5 to 30 mT. This is evident from Figure 2. Beyond 30 or 40 mT, the change in directions is random. Directions for a peak alternating field of 30 mT have less dispersion than for any other field strength and they are shown in Figure 1, b. The mean direction obtained, the corresponding pole position and other palaeomagnetic parameters are listed in Table 1. The pole position almost coincides with that of one of the two mean directions reported for Visakhapatnam charnockites (Table 1).

The Eastern Ghats are composed of parallel layers of khondalites and charnockites and their variants. The evolutionary history of the charnockite–khondalite system is marked by successive geosynclinal facies of sediments and volcanic effusives with the associated intrusives. In the Eastern Ghats belt, at least three episodes of metamorphic activity are known to have occurred. Metamorphically, the rocks in this belt are of the granite facies. The coincidence of the pole position of calc-granulites with that of Visakhapatnam charnockites probably means that the two formations were magnetized during the same period of metamorphism or other process. Though it is known that the two formations are affected by regional metamorphism, the coincidence of pole positions may further indicate that none of them has been disturbed as far as the magnetization is concerned by any local geological

Figure 1. a, NRM directions. b, Direction after a f. demagnetization. → Mean direction.
process. There are very few palaeomagnetic results reported from the Eastern Ghats belt of southern Andhra Pradesh. Though the geologic history of Eastern Ghats is known on a broader scale, there is need for palaeomagnetic investigations to bring out any local variations in metamorphic or tectonic activity.

Table 1. Magnetic properties and palaeomagnetic data of calc-granulites compared with those of Visakhapatnam charnockites

<table>
<thead>
<tr>
<th>Rock type</th>
<th>$J_x \times 10^3$ [A/m]</th>
<th>$K \times 10^8$ [SI]</th>
<th>$Q_n$</th>
<th>$D_n$</th>
<th>$I_m$</th>
<th>$k$</th>
<th>$\alpha_{01}$</th>
<th>$\varphi_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calc-granulite</td>
<td>1.3-350</td>
<td>0.5-35.7</td>
<td>0.24-8.8</td>
<td>273° +38°</td>
<td>18.4</td>
<td>13°</td>
<td>14°N 12°W</td>
<td></td>
</tr>
<tr>
<td>Visakhapatnam</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>charnockite (A)</td>
<td></td>
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Discovery of Proterozoic boninite from Jagannathpur volcanic suite, Singhbhum craton, Eastern India

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Jagannathpur volcanic suite occurs as faulted outcrops within the Noamundi–Koira sequence of banded iron formation. Recent chemical studies have delineated some quartz normative samples from this suite which, similar to boninites, have high MgO, Ni and Cr content at an intermediate SiO$_2$. These are differentiated along a calc-alkaline trend and their low CaO/Al$_2$O$_3$, Ti/Zr, Ti/Y and high Zr/Y ratios along with the high LILE and Zr are comparable with those of modern boninites. We infer that they are derived from MORB-type mantle source and represent an early phase of arc volcanism.

Although Proterozoic volcanism has a significant position in the geologic record of the Singhbhum craton several various volcanic suites have not received adequate attention. Their chemical affinity and/or tectonic setting has not yet been interpreted in terms of plate tectonics. Recently, in course of a geochemical study on Jagannathpur volcanic suite, samples containing low TiO$_2$ attracted much attention because of their possible tectonic significance in relation to the origin of ophiolites and because of their recognition as distinctive, if not a diagnostic feature of boninitic lavas. This prompted us to identify some boninitic samples from this suite. Here we report the boninite discovery and discuss its significance.

On the western side of Singhbhum Granite, Jagannathpur volcanic suite occurs as faulted outcrops within the Noamundi–Koira sequence of banded iron formation. It has been dated to be 1629 ± 30 Mys (million years) by K-Ar method. Unlike the other Proterozoic suites of the region, viz. Dalma, Ongaribira, Dhanjori, Simlipal and Bonai volcanic suites, it does not have any sedimentary rock association and is free from regional metamorphism. It appears to be made up of a large number of block lava flows, individual flow sets have a plan width of 100 to 200 m. Banerjee identified the number of flows between 25 and 30. Less abundance of vesicles in the flows and lack of pyroclastics suggest that volcanism was predominantly nonviolent and had low volcanic content.

Cameron et al. used mineralogical and petrographical features to identify boninites. As these features mainly reflect the modes of eruption and consolidation of a volcanic rock, they vary widely in any magma type and hence they may not be considered reliable. The chemical characteristics more consistently reflect the genetic differences between boninite and other magma types.

The most striking features of the samples (Table 1) are the high concentrations of refractory elements such as MgO, Ni and Cr, combined with silica saturation and high values of large ion lithophile elements Al$_2$O$_3$.