Newly discovered copper mineralization in granodiorites in Meghalaya

We report here the discovery of copper mineralization near Rongkhinggiri village, in the Simsang valley, East Garo Hills district, Meghalaya. Rongkhinggiri is nearly 5 km south of China Baat village and could be approached from China Baat, which is on the Tura–Williamnagar road between 37 and 38 milestones, by a fair weather footpath. Copper mineralization is noticed in dykes of granodiorite intruding the Archaean gneissic group of rocks. The area exhibits a rugged topography with a relief of nearly 600 m. The Simsang river and its tributaries have eroded the otherwise flat plateau between the Arbela ranges in the north and Tura ranges in south.

Garo Hills form the western part of the Meghalaya plateau in northeastern India. The area is predominantly composed of Archaean gneissic group of rocks that are intruded by basic dykes and granitoid plutons[1]. Rocks of alkaline affinity and carbonatites intrude at places[2]. Southern and western parts of Garo hills are covered by a thick sequence of Tertiary sediments. The area between China Baat and Rongkhinggiri village exposes Archaean granitic gneiss, Proterozoic granitoids and basic dykes (Figure 1).

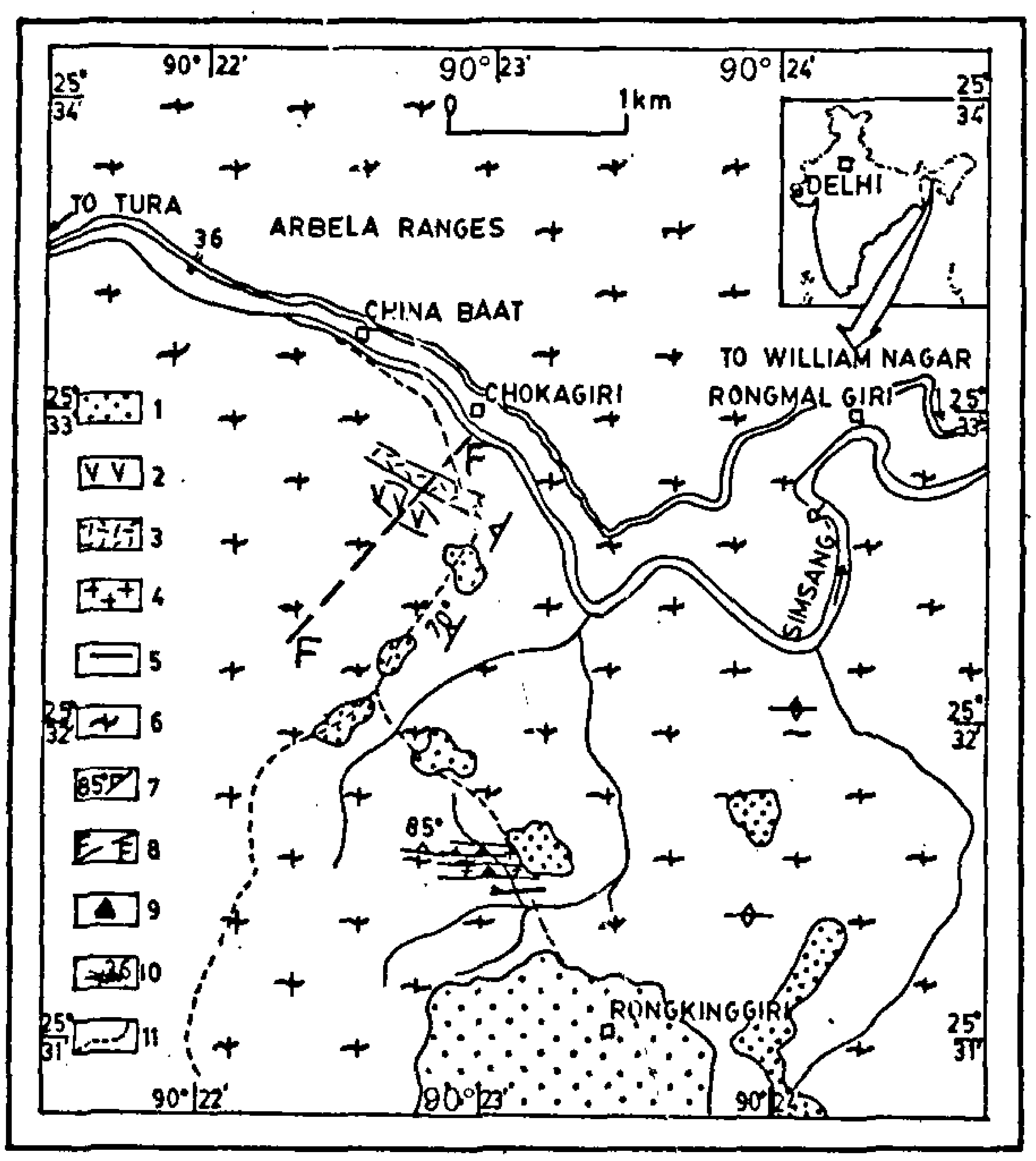

Figure 1. Geological map of Ronkhinggiri area, East Garo Hills district, Meghalaya. 1, Tertiary sandstone; 2, Basalt; 3, Pegmatite; 4, Granodiorite; 5, Dolerite; 6, Gneissic rocks/Migmatites; 7, Foliation; 8, Fault; 9, Copper mineralization; 10, Milestone and 11, Footpath.

Table 1. Copper and other elements in granodiorite (values in ppm)

Sample no.	Cu	Ni	Co	Zn	Pb	Mo
Granodiorite Dyke 1	60855	180	25	209	<10	–
Dyke 1a	15440	18	46	104	40	10
Dyke 1b	19000	47	48	147	37	30
Dyke 1c	19520	52	50	163	28	15
Dyke 2a	1990	20	52	67	39	75
Dyke 2b	25	13	27	63	23	6

The bed of a second order stream flowing 1 km west of Rongkhinggiri village exposes two parallel dykes of granodiorites, 20 m apart, intruding gneissic country rocks. These dykes trend E–W with near-vertical dips. One of the dykes is 1.7 m thick and could be traced for 3 m across the stream while the other dyke is 0.9 m thick and exposed on a vertical wall of the stream section whose extension on either side of the steam is covered under soil. The granodiorite is coarse grained and porphyritic with plenty of biotite and chalcopyrite, covellite, bornite, malachite and azurite. Bornite and chalcopyrite are highly altered with the development of malachite and azurite, resulting in the deep blue green colouration of the granodiorite outcrop. Disseminated grains and inclusions of bornite and covellite occur within phenocrysts of oligoclase. Chalcopyrite forms a rim around rounded grains of bornite. Malachite and azurite occur as fracture fillings within plagioclase and quartz grains. The copper mineralization is restricted only to the granodiorite. The surrounding and associated dolerite dykes are not mineralized. Wet chemical analyses of six rock samples (Table 1) collected from these granodiorite dykes reveal the presence of high content of copper (av. 2% Cu). However, it showed only low values of molybdenum, zinc, lead, cobalt and nickel that are generally considered as associated metals with copper mineralization hosted by granodiorite. Rock and mineralogical characteristics of this copper occurrence resemble a porphyry type copper mineralization of arc magmatic setup. Is this mineralization related to the arc magmatism of a Proterozoic plate tectonic cycle? Whether these dykes are only a small manifestation of a bigger granodiorite pluton nearby? Answers to these questions require further geological investigation in the virgin forests of Simsang valley.

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2. Golani, P. R., *J. Geol. Soc. India*, 1991, **37**, 31–38.

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COMMENTARY

Usability of parallel processing computers in numerical weather prediction

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On 23 November 1992, the Department of Science and Technology (DST) convened a meeting to discuss 'Future Supercomputing Strategies for Medium Range Weather Forecasting'. Subsequently it was decided to invite developers of indigenous parallel processing systems (PPS) to evolve suitable strategies of implementation of weather forecasting codes on their respective parallel machines. The aim of this project, as correctly stated by Basu in a recent report in this journal[1], was to demonstrate amongst the scientific community whether the PPS developed in India are capable of handling large applications with reasonable ease and also to benchmark the different PPS machines by running the same application code (namely the spectral model at T80 resolution) with identical initial and boundary conditions provided by a common agency (the NCMRWF). DST realized that India might have a head-start in the field of parallel computing, and its attempt to enhance and augment the indigenous technological base in this (then) emerging field for a well-defined national task was indeed commendable.

Basu was the co-odinator of this exercise and his paper summarizes his findings and views. In the present note, we present certain aspects which appear to have been overlooked by the author and therefore makes his assessment misleading, and offer a different perspective on the project and its international counterparts based on personal experience of one of us (RSN) in India and the US.

Are Indian PPS not good enough?

The title and abstract suggest that the paper is generally about the usability of parallel computing to weather forecasting, while the tone of the paper and its conclusion suggest that Indian PPS are not suitable to meet the requirements of NCMRWF. Basu tries to support this view with the following comments on the Indian exercise:

Poor sustained-to-peak ratio

Basu writes, 'The experience of parallelizing the global spectral forecast model operational at NCMRWF showed that the PPS computers designed and fabricated in India during 1994 could attain a sustained-to-peak performance close to 6%. Since this value is significantly less than the internationally accepted figure, it is possible that the basic design of processor boards used in the machines was not suitable for spectral forecast model.' During the same period as the Indian exercise, Drake *et al.*[2] have published sustained-to-peak ratios for the i860 processor (the processor used in India also by NAL, CDAC and BARC), and we reproduce their tables here. Table 1 displays the performance of the parallel computers in empirical studies, and Table 2 shows the processor's actual performance on meteorological codes.

Considering that the peak speed of i860 is 75 Mflop/s (according to Drake *et al.*[2]), peak of 6% achieved by the Indian PPS was on par with systems elsewhere. Drake *et al.*[2] admit that their experience with the i860 (one of the few processors that have been extensively used in parallel computing applications for meteorology) in regard to its sustained-to-peak speed ratio was less than satisfactory. Therefore it is wrong to conclude that the relatively low value of sustained-to-peak ratio is unique to the Indian PPS (as suggested by Basu). We are not aware on what basis Basu drew his conclusion about 'internationally accepted figures' in 1994.

Scalability

Discussing this issue Basu says: 'To ensure scalability of an application code is not a trivial task even for multitasking, shared memory, vector processing computer. Distribution of data and optimization of inter-processor communication make it even more difficult for a distributed memory PPS.' He further contends, 'Indian machines, however, have not demonstrated scalability clearly and some more effort is