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ACKNOWLEDGEMENTS. The measurements were made at the National Geophysical Research Institute, Hyderabad. We thank the Director, NGRI for providing laboratory facilities. The cooperation extended by Dr M. S. Bhalla and Dr G. V. S. Poornachandra Rao of the Palaeomagnetic Division, NGRI is thankfully acknowledged.

Received 14 June 1993; revised accepted 3 February 1993

Magnetic susceptibility and mineralogical studies of the beach placer deposits, central east coast of India

B. Nagamalleswara Rao

Department of Geology, Andhra University, Visakhapatnam 530 003, India

Magnetic susceptibility (*K*) and mineralogical studies on the beach placer deposits in three different coastal regions of Andhra Pradesh show that *K* is highest in Hamsaladivi–Manginipudi (HM) placers rich in magnetite and lowest in Visakhapatnam–Bhimunipatnam (VB) placers where ilmenite is abundant. Higher concentration of ilmenite is associated with monazite and not with magnetite. Magnetic susceptibility increases with diminishing mean size. The Eastern Ghats provenance is the major source of ilmenite and monazite, while the Deccan Traps have contributed higher amounts of magnetite.

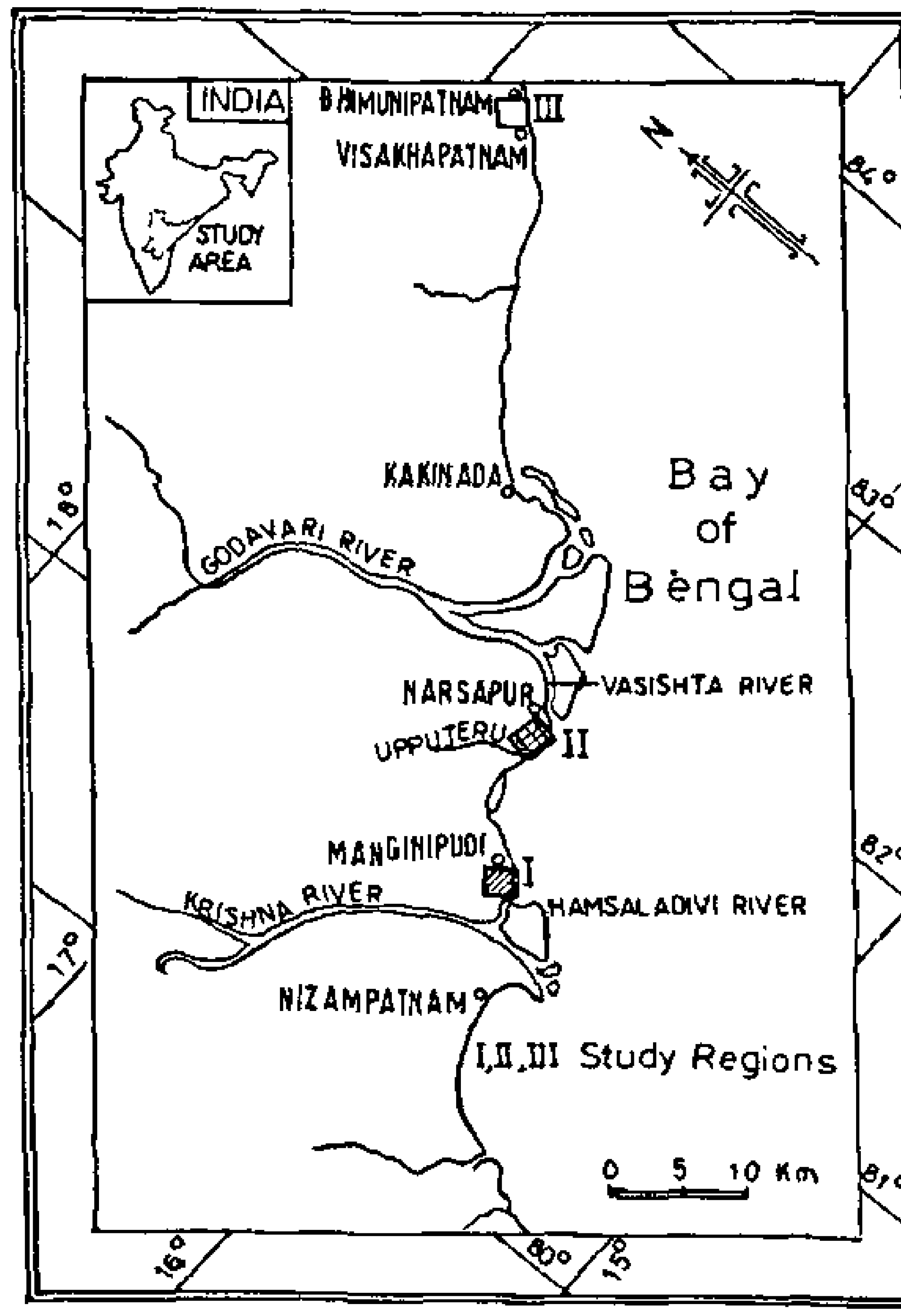

Figure 1. Location map of the study regions.

HEAVY minerals have earlier been reported from the beach sands along the Andhra Pradesh coast[1–3]. Since the last two decades, a variety of magnetic parameters have been applied to a number of sedimentological and environmental problems[4–6]. The present study attempts to correlate magnetic susceptibility and mineralogical studies of heavy minerals in three different beaches of Hamsaladivi–Manginipudi (HM), Vasishta Godavari-Upputeru (VGU), Visakhapatnam–Bhimunipatnam (VB) along the coast of Andhra Pradesh (Figure 1) to find out exploration tools useful in prospecting for heavy minerals. Gneisses, granites, charnockites and Khondalites form the hinter-land common to the three deposits.

Sixtynine sediment samples were collected from the placers on the back shore beaches and 25 from dunes in December 1989. All the bulk samples were sieved at 0.5 ϕ interval and grain size statistics were computed[7]. Heavy mineral composition of 21 samples, representative of beaches and dunes in the three regions, were determined following standard techniques[3]. Individual heavy minerals are expressed in wt% of total heavies. Volume magnetic susceptibility of the bulk samples as well as 63 (2.0–3.0, 3.0–3.5, 3.5–4.0 ϕ) size fractions of 21 samples were measured in the laboratory with a susceptibility meter[8].

Magnetic susceptibility ($K \times 10^{-3}$ *SI*) *was highest in* beach and dunes in HM (av. 70.5, 59.7), lowest in VB (av. 7.1, 3.7) and intermediate in VGU (av. 37.6, 6.6). In any region, beach placers were characterized by high magnetic susceptibility levels relative to adjacent dunes indicating poorer concentration of magnetite (Table 1). Intra-regional variations in susceptibility level in beach and dune placers were due to dilution of magnetite concentrates by variable amounts of non-magnetic minerals. Inter-region differences are attributed to differences in provenance. The dune hosted magnetite-rich placers in HM are indicated by high magnetic suscep-

Table 1. Range and average of magnetic susceptibility and magnetite wt% of samples from three regions

Regions/ Environment	No. of samples	Range and average $K \times 10^{-3}$ SI in			Range and average magnetite wt% in bulk samples	
		Bulk samples	Size fractions (ϕ)		Beach	Dune
HM			2 0–3.0	3 13–8 93 7.07		
Beach	17	50.29–90.16 70.50	3 0–3 5	18.76–85.47 65 83	40.10–49.50 44.00	43.00–43.12 43.06
Dune	10	31.79–70.35 59 70	3.5–4 0	62.54–96.93 85 75		
VGU			2 0–3.0	1.83–12.26 5.35		
Beach	15	20.85–47.95 37.57	3 0–3 5	8.29–51 07 25.95	31.77–38.98 34.79	20.36–27 90 24.38
Dune	6	2.29–12.51 6 55	3 5–4 0	10 49–62 54 42.26		
VB			2.0–3.0	1.51–2.08 1.83		
Beach	37	2.08–10.94 7.10	3 0–3 5	4.24–8 34 5 38	11.77–18 83 14 91	8.7–8 80 8.74
Dune	9	2 08–5.21 3 66	3.5–4 0	6 12–10.28 7 56		

tibility levels (av. 59.7) comparable with adjacent beach placers (av. 70.5), possibly the beaches in HM are covered with black sands throughout the year and eolian transport constructs the adjacent dunes with black sands from the beach. Ramachandran[9] noted that the magnetic susceptibility of samples depends on the amount of ferrimagnetic minerals present such as magnetite and not on the percentage of iron oxide minerals. The paramagnetic mineral, ilmenite, is dominant in VB, while ferrimagnetic magnetite is dominant in HM and hence the wide variability of magnetic susceptibility between the regions. Further the magnetite in VB is titanomagnetite with exsolution lamellae of ilmenite and haematite of more than one generation[10].

Magnetic susceptibility is observed to increase with decreasing grain size, indicating the tendency of magnetite to concentrate in finer size fractions, by virtue of its higher specific gravity. Magnetic susceptibility shows positive correlation with mean size (Figure 2) and negative correlation with standard deviation (Figure 3). This indicates that magnetite increases with diminishing mean size and as sorting improves. These trends are predictable because heavy mineral concentration is always associated with these conditions. The wt% of total heavies and magnetite shows positive correlation with magnetic susceptibility (Figures 4, 5).

HM beach placers are characterized by a magnetite–ilmenite–augite suite. Magnetite is most abundant (43%), followed by ilmenite (26%) and augite (19%). Garnet, sillimanite, hornblende, chlorite and zircon are 1–2% each; biotite, monzaite and kyanite are less than 1% each; VGU beach placers are characterized by a mag-

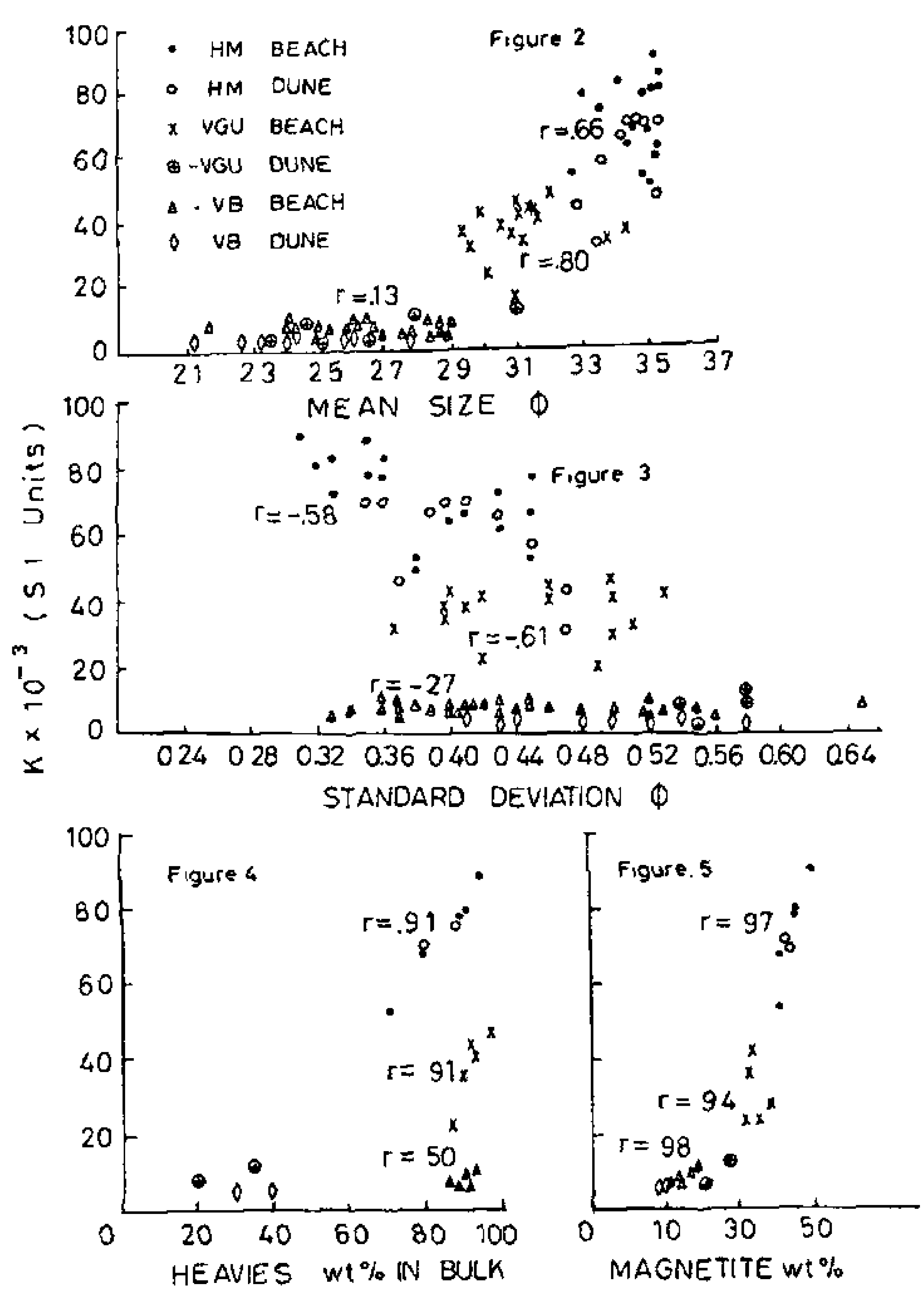

Figure 2–5. Scatter plots of magnetic susceptibility vs mean size, standard deviation, heavies wt% in bulk, and magnetite wt%.

netite–ilmenite–garnet–zircon suite. Magnetite and ilmenite are in equal proportions (32–34%), garnet, zircon and augite are less than 10% each, sillimanite and hornblende are about 2–5% each, chlorite, monazite and kyanite are about 1–2% and biotite, rutile and tourmaline are less than 1% each. An ilmenite–garnet–zircon–monazite suite characterizes VB beach placers. Ilmenite is most abundant (> 50%), followed by magnetite (13%), zircon (9%) and monazite (8%). Garnet is up to 9%, hypersthene is about 1% and hornblende, chlorite, biotite, kyanite, rutile and tourmaline less than 1% each. HM and VGU beach placers have higher amounts of magnetite, pyroxenes and amphiboles, indicating their derivation from the Deccan Traps. The Eastern Ghats provenance is the major source of ilmenite, rutile, monazite, zircon, sillimanite and garnet in VB. Higher percentages of magnetite, pyroxenes and amphiboles from HM and VGU[1,2] and ilmenite from VB[3] were also reported.

Magnetite and/or ilmenite constitute the bulk of black sand concentrates, other minerals are only an accessory. Magnetite being the major contributor to K merely indicates the magnetite abundance in sands and does not provide a measure of other minerals. On the other hand, magnetic susceptibility studies combined with radiometric studies reported earlier[11,12] provide criteria to estimate the relative abundance of magnetite, ilmenite and monazite in the beach placers of Andhra Pradesh. Magnetite is the most magnetic mineral in the beach sands along the Andhra Pradesh coast. Ilmenite, rutile, monazite, zircon, sillimanite and garnet contents are relatively high in the beaches north of Godavari River mouth, especially at Visakhapatnam–Bhimunipatnam and low in the beaches south of the Godavari River mouth as in Hamsaladivi–Manginipudi. The beach placer deposits are controlled by inputs from different provenances feeding the beaches. The Eastern Ghats provenance is the major source of minerals mentioned above, while the Deccan Traps have contributed higher amounts of magnetite, pyroxenes and amphiboles. Magnetic studies in conjunction with radiometric studies, would be an efficient tool in evaluating the relative abundances of magnetite, ilmenite, monazite and other associated economic minerals in the beach placers along the East Coast of India. The measurements are more rapid, easy and inexpensive than any other conventional exploration methods. These studies demonstrate that there is no mixing of mineral suites between the regions, since the river inputs and tidal-inlet currents act as a hydrodynamic barrier, trapping the longshore drift.

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ACKNOWLEDGEMENTS. I thank Profs T. V. S. R. Kshirasagar and M. Subba Rao for a critical reading of the manuscript and Dr G. V. S. Poornachandra Rao of NGRI, Hyderabad for help in magnetic studies.

Received 28 August 1993; revised accepted 23 December 1993

Influence of oxidative and non-oxidative pathways of radiation damage on peroxidase activity in barley seeds

Ashu Bhan Tiku, S. P. Singh and P. C. Kesavan
School of Life Sciences, Jawaharlal Nehru University, New Delhi 110 067, India

In comparison with nitrogen and nitrous oxide, oxygen-saturated medium greatly enhanced injury and peroxidase activity in eight-day-old seedlings raised from barley seeds exposed to ^{60}Co-γ-rays. The radiation damage in O_2-saturated medium not only increased peroxidase activity, but also induced two additional peroxidase bands, not present in any other situation, as detected by non-denaturing polyacrylamide gel electrophoresis (PAGE). These observations are briefly discussed in the light of available reports in the literature.

A wide range of cells and organisms respond to environmental stress, including oxidative stress, by forming stress proteins, some of which are similar to heat-shock proteins (hsps)[1–4]. When ionizing radiation is the causal agent of stress, the oxygen-dependent and oxygen-independent pathways account for the observed radiobiological effect[5,6]. It is generally believed that oxygen present *during* or after irradiation enhances radiobiological damage quantitatively, but does not produce any qualitative change. This accounts for the term oxygen enhancement ratio (OER)[7]. There is therefore a need to investigate whether oxic hydration merely enhances damage, or whether it also induces qualitative change(s). Use of seedling injury by radiation damage in barley seeds maintained in oxic or anoxic media, and/or chromosomal