pounds that would exploit tankyrase to control cell life span[25].

Notwithstanding, extreme correlation between telomerase expression and failure to undergo replicative senescence underlines potential usefulness of telomerase activity as a diagnostic and prognostic tool in cancer. Also, the *in situ* measurement of telomeric motifs through quantitative FISH can further facilitate such analysis. Further, identification of novel agents that activate or inhibit tankyrase may promise far reaching consequences for cell-based therapies/utility by extending their lives or halting uncontrolled cell proliferation through controlled intervention of telomerase activity.

---

1. Bodnar, A. G., Ouellette, M., Frolkis, M., Holt, S. E., Chiu, C-P., Morin, G. B., Harley, C. B., Shay, J. W., Lichtsteiner, S. and Wright, W. E., *Science*, 1998, **279**, 349–352.
2. Faragher, R. G. A., Jones, C. J. and Kipling, D., *Nature Biotechnol.*, 1998, **16**, 701–702.
3. Rubin, H., *Nature Biotechnol.*, 1998, **16**, 396–397.
4. Shippen, D. E. and McNight, T. D., *Trends Plant Sci.*, 1998, **3**, 126–130.
5. Weinberg, R. A., *Nature*, 1998, **396**, 23–24.
6. Lavania, U. C. and Sharma, A. K., *J. Heredity*, 1985, **76**, 395–396.
7. Dernburg, A. F., Sedat, J. W., Cande, W. Z. and Bass, H. W., in *Telomeres* (eds Blackburn, E. H. and Greider, C. W.), Laboratory Press, Cold Spring Harbor, 1995, pp. 295–338.
8. Kirk, K. E., Harmon, B. P., Reichard, I. K., Sedat, J. W. and Blackburn, E. H., *Science*, 1997, **275**, 1478–1481.
9. Zakian, V. A., *Cell*, 1997, **91**, 1–3.
10. Riha, K., Fajkus, J., Siroky, J. and Vyskot, B., *Plant Cell*, 1998, **10**, 1691–1698
11. Slijepcevic, P., *Chromosoma*, 1998, **107**, 136–140.
12. Willinger, R. J., Ethier, K., Labrecque, P. and Zakian, V. A., *Cell*, 1996, **85**, 423–433.
13. Makrov, V. L., Hirose, Y. and Langmore, J. P., *Cell*, 1997, **88**, 657–666.
14. Allsopp, R. C., Vaziri, H., Patterson, C., Goldstein, S., Younglai, E. V., Futcher, A. B., Greider, C. W. and Harley, C. B., *Proc. Natl. Acad. Sci. USA*, 1992, **89**, 10114–10118.
15. Autexier, C. and Greider, C. W., *Trends Biochem. Sci.*, 1996, **21**, 387–391.
16. Zakian, V. A., *Science*, 1995, **270**, 1601–1607.
17. Linger, J., Hughes, T. R., Schevchenko, A., Mann, M., Lundblad, V. and Cech, T. R., *Science*, 1997, **276**, 561–567.
18. Blasco, M. A., Lee, H., Hande, M. P., Samper, E., Lansdrop, P. M., DePinho, R. A. and Greider, C. W., *Cell*, 1997, **91**, 25–34.
19. de Lange, T., *Science*, 1998, **279**, 334–335.
20. Kim, N. W., Piatyszek, M. A., Prowse, K., Harley, C. B., West, M. D., Ho, P. L. C., Covielo, G. M., Wright, W. E., Weinrich, S. C. and Shay, J. W., *Science*, 1994, **270**, 2011–2015.
21. Kilian, A., Stiff, C. and Kleinhofs, A., *Proc. Natl. Acad. Sci. USA*, 1995, **92**, 9555–9559.
22. Bryan, T. M., Englezou, A., Gupta, J., Bacchetti, S. and Reddel, R. R., *EMBO J.*, 1995, **14**, 4240–4248.
23. van Steensel, B. and de Lange, T., *Nature*, 1997, **385**, 740–743.
24. Marcand, S., Gilson, E. and Shore, D., *Science*, 1997, **275**, 986–990.
25. Smith, S., Giriat, I., Schmitt, A. and de Lange, T., *Science*, 1998, **282**, 1484–1487.
26. Pennisi, E., *Science*, 1998, **282**, 1395–1398.
27. Vaziri, H. and Benchimol, S., *Curr. Biol.*, 1998, **8**, 279–282.
28. Kiyono, T., Foster, S. A., Koop, J. I., McDougall, J. K., Galloway, D. A. and Klingelhutz, A. J., *Nature*, 1998, **396**, 84–88.
29. Jacks, T. and Weinberg, R. A., *Science*, 1998, **280**, 1035–1036.

U. C. Lavania is in the Central Institute of Medicinal and Aromatic Plants, Lucknow 226 015, India; Seshu Lavania is in the Botany Department, Lucknow University, Lucknow 226 007, India and Y. Vimala is in the Botany Department, Ch. Charan Singh Meerut University, Meerut 250 005, India.

SCIENTIFIC CORRESPONDENCE

Characterization and utilization of iron-rich dry ash from an electric arc furnace

Fine drosses generated from various metallurgical operations present serious environmental problems on account of their large volume and difficulty in handling. A typical example is pulverized coal fly ash generated in thermal power stations which has attracted the worldwide attention of researchers and environmentalists alike[1–5]. A similar waste, rich in iron content, produced from steel mills has not received the attention it deserves. In fact, iron-rich ash is a significant waste product from several steel-making industries.

A case in point is the Wheel and Axle Plant, a Ministry of Railways concern, situated at Yelahanka in Bangalore, which employs a state-of-art technology for melting steel scrap in an ultrahigh frequency electric arc furnace. In this process, about 20 tonnes of scrap steel is melted at 1700°C along with 300 kg of graphite powder and 1.5 tonnes of limestone as flux. The final composition is maintained by adding ferrosilicon, ferromanganese, etc. The process generates about 3 tonnes of fine-sized dry ash per day.

From the environmental point of view, the ash generated in this plant poses some disposal problems as it may contain toxic heavy metals such as lead, chromium, manganese, copper, nickel and cobalt[6]. It was therefore thought worthwhile to characterize this material and explore possibilities for its economic utilization.

The dross sample was collected on several days and a composite sample of 2 kg was prepared by quartering and coning. Two batches of samples were prepared and examined by various physical and chemical methods for their constituents.

Proximate analysis of the sample reveals that the moisture content is very low (< 0.05%), which seems to have been picked up on storage. The carbon content varies from 2.20 to 2.38% which poses problems in sample dissolution. The material was also found to be highly corrosive to nickel crucibles during dissolution. The results of chemical analyses using acid dissolution (HNO_3–H_2SO_4) have been summarized in Table 1.

It is evident that the sample contains about 50% of iron with calcium, magnesium, aluminium, and silica constituting the rest. When the sample was analysed for trace elements, arsenic, chromium and copper could not be detected but lead was present up to 0.1%. Therefore, land impoundment of this material may cause lead toxicity in the soil.

The ash has a bulk density of 1.00 g/cm^3 with large surface area of 1.5593 m^2/g. Particle size distribution analysis using Malvern Particle Size Analyser showed that typical particle diameters range from 1 to 10 µm. But particles of 100–300 µm have also been found in the sample which is attributed to fusion and agglomeration processes that can occur at high temperatures. Particle size distribution is shown in Figure 1.

SEM photographs of the sample using standard procedures at × 1000 are shown in Figure 2. A detailed examination of these photographs reveals that most of the iron particles are spheroidal. Since a large fraction of the particles are of irregular shape, it is evident that some cenospheric activity coupled with homogeneous and heterogeneous nucleation on the surfaces of already fused and subsequently solidified particles must have occurred.

X-ray diffraction pattern of the sample was taken (Figure 3) using an X-ray diffractometer (JDX-8030) fitted with Philips 2243/20 X-ray tube operated at 2 kW, with an iron target, PMT detec-

Table 1. Chemical composition of ash

Chemical analysis	Sample 1 (%)	Sample 2 (%)	Average (%)
Proximate analysis			
Moisture	0.05	0.05	0.05
Total carbon content	2.20	2.38	2.29
Bulk analysis			
Iron (as Fe_2O_3)	50.80	48.80	49.90
Calcium (as CaO)	24.64	24.00	24.32
Magnesium (as MgO)	8.06	8.27	8.165
Aluminium (as Al_2O_3)	6.45	6.43	6.44
Silicon (as SiO_2)	8.60	8.06	8.33
Manganese	2.12	2.24	2.18
Boron	0.38	0.32	0.35
Trace analysis			
Cobalt	0.14	0.09	0.125
Lead	0.091	0.091	0.091
Chromium	*	*	*
Arsenic	*	*	*
Copper	*	*	*

*Not detected.

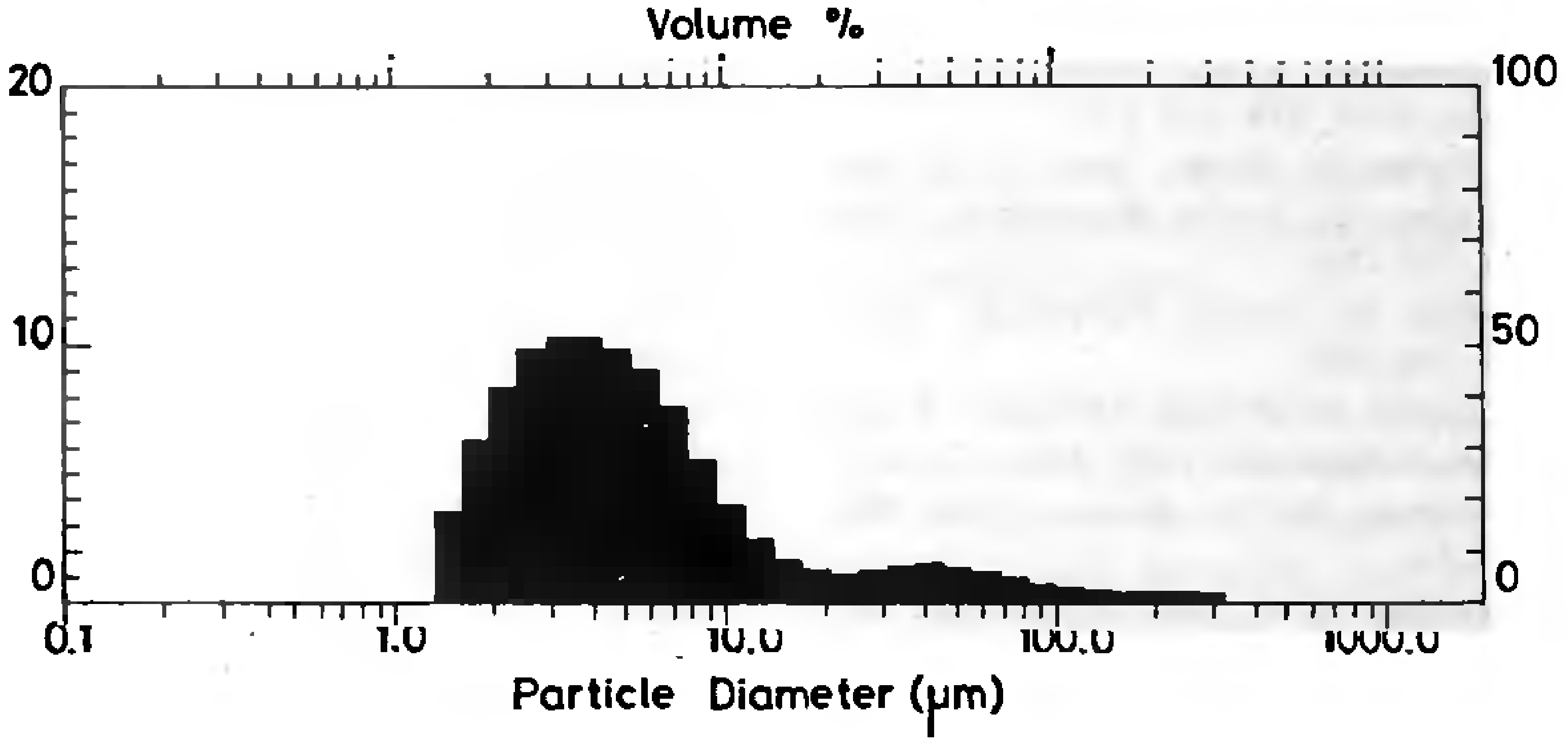

Figure 1. Particle-size distribution of the ash sample.

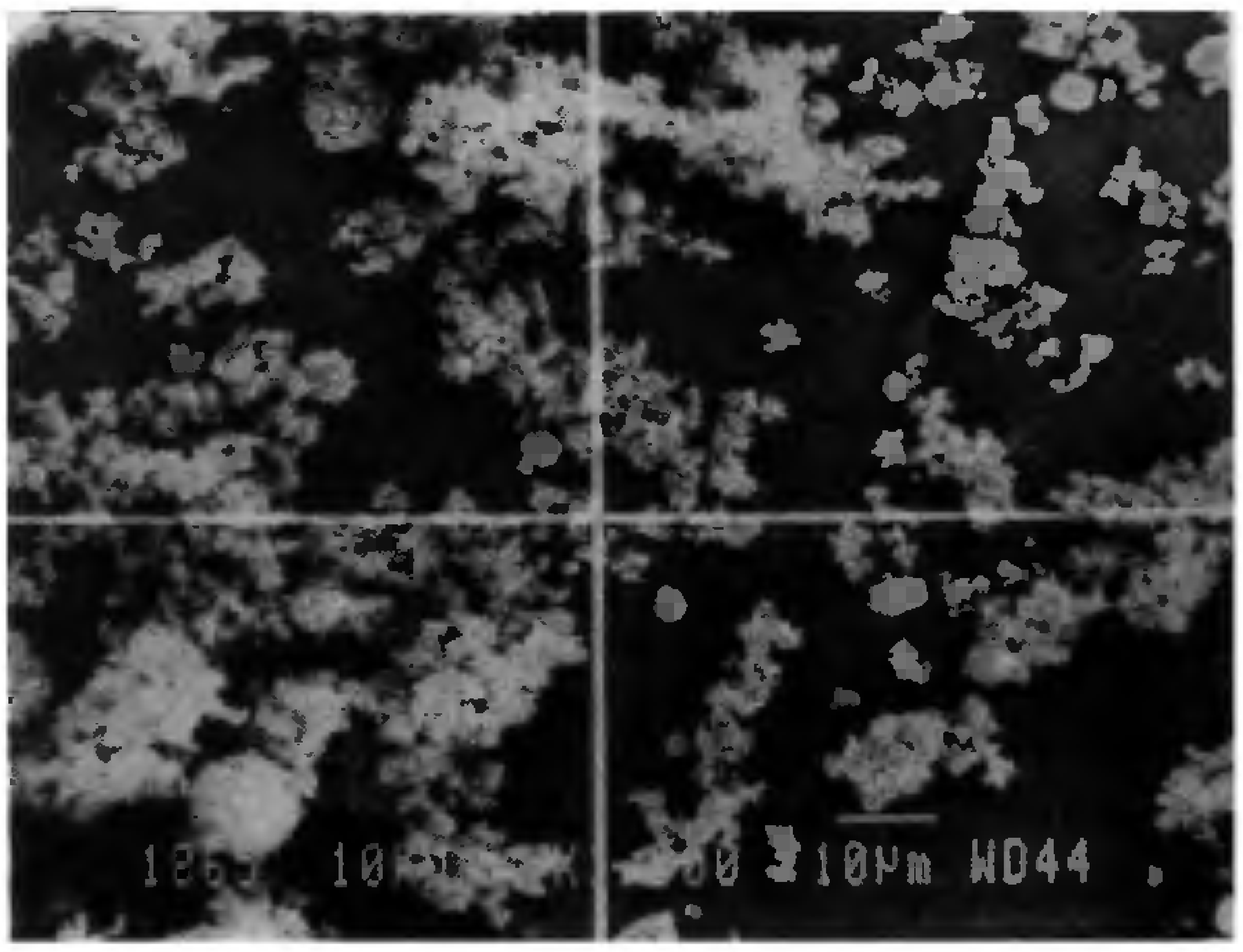

Figure 2. Scanning electron micrograph showing distribution and agglomeration of particles at × 1000 magnification.

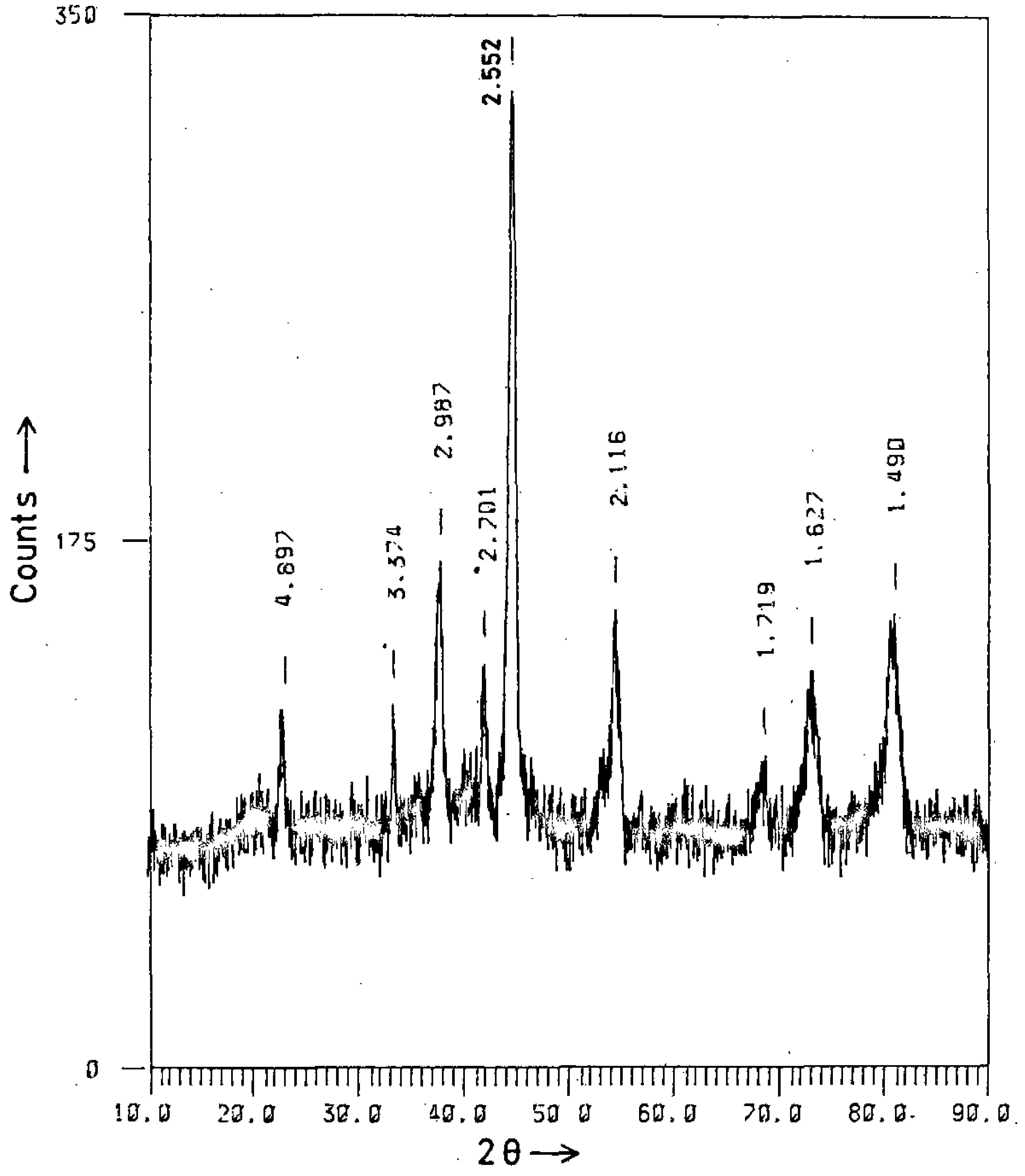

Figure 3. XRD pattern of the ash exhibiting diffraction lines corresponding to magnetite and β-Fe_2O_3 as major phases.

tors and necessary accessories. A comparison of various peaks and their intensities with the available data banks[7] reveals that:

1. most of the iron is in the magnetite form as evidenced by *d* values with peaks at 2.53 Å, 1.48 Å and 2.97 Å which matches with the available data.
2. low intensity of the peak at 2.715 *d* value suggests that it is a transitional, short-lived compound (β-Fe_2O_3) in the high thermal regime of the furnace.
3. magnesium is present as periclase (2.11 Å and 1.49 Å).

From the foregoing presentation, it is clear that iron-rich ash produced in the Wheel and Axle Plant is a product of highly variable composition. This is understandable, given the wide variety of steel scrap employed. Further, furnace operating conditions also influence the composition of the minor and trace elements. However, its high iron oxide (about 50%) is incentive enough for the recovery of iron.

One way of utilizing this ash is to recharge it back into the furnace for remelting. However, the large volume of this waste causes handling problems. Alternately, the ash can be treated with sulphuric acid. This treatment converts the iron oxide to crystalline ferrous sulphate which finds extensive use as a reductant and precipitant for the treatment of chromium in effluents from electroplating and tanning industries. Further refinements of this process are necessary to obtain the same with greater than 98% purity.

A few experiments were also carried out to utilize iron ash as a cement additive. The results are very encouraging. When mixed with granite powder and additives and heated to about 1000°C, very good tiles were obtained with excellent surface finish. The properties of the product obtained are given below:

Bulk density (g/cm^3)	1.85
True density (g/cm^3)	1.87
Porosity (%)	< 1
Young's modulus (GPa)	35

These values are comparable to the tiles made from coal fly ash.

1. Capp, J. P. and Engle, C. F., in *Bureau of Mines Information Circ. 8348*, US Department of the Interior, Washington DC, 1967, pp. 210–220.
2. Chang, A. C., Lund, L. F., Page, A. L. and Warneke, J. E., *J. Environ. Qual.*, 1977, **6**, 267–270.
3. Kovacic, W. and Harely, R. G., *Kansas Geol. Surv. Bull.*, 1972, **204**, 29–31.
4. Page, A. L., Elseewi, A. A. and Straughan, I., *Residue Rev.*, 1979, **71**, 83–120.
5. Capp, P. and Adams, L. M., *Div. Fuel. Chem.*, ACS, 1971, **15**, 26–31.
6. Purves, D., *Trace Element Contamination of the Environment*, Elsevier Scientific Publishers, New York, 1977, pp. 24–26.
7. Powder Diffraction file: Inorganic Phases, 1990, International Centre for Diffraction data, Swarthmore, USA (4–829), pp. 370, (19–629), pp. 320 and (39–238), pp. 320.

J. R. MUDAKAVI
B. V. NARAYANA
R. KIRAN

Department of Metallurgy,
Indian Institute of Science,
Bangalore 560 012, India