Iron meteorite fall at Bhuka village, Barmer district, Rajasthan

A meteorite fragment weighing about 2.5 kg fell at Bhuka village, Barmer district, Rajasthan on 25 June 2005. We report here the conditions of fall and preliminary description of this meteorite. The results of our study indicate that it is an iron meteorite. The meteorite has significant radioactivity of ^{54}Mn and ^{57}Co produced by cosmic rays, indicating small ablation during its atmospheric transit. These results imply that the meteoroid was a small body (spatial dimension: 30–50 cm) in space.

The meteorite fragment was seen to fall at 23.08 h in Sindhion ki Dhani, Bhuka village (25.41°N, 72°E), 15 km east of Sindhari on the Barmer–Balotara–Jodhpur road. The location of fall is shown in Figure 1. It fell in the farm of Mubeen, son of Ramdhan Sindhi. Mubeen being blind, could not observe the fall, but it was witnessed by his family members who saw a flash of light and loud cracking sound. The bright trail was seen as far as Jodhpur, some 110 km north-east of Bhuka by several persons, including two of the authors (K.L.S. and J.S.). At Jodhpur, the meteor trail was seen moving towards southwest with a high zenith angle, estimated to be about 80° to the horizon.

The meteorite (Figure 2 *a*) is about 10 cm × 4 cm × 4 cm in size and was handed over to the Police Department. A thorough search in the vicinity did not yield any more fragments, indicating that only a single fragment had fallen. The fragment made a 45 cm deep, 35 cm diameter crater in the sandy alluvium of the farm (Figure 2 *b*).

The meteorite has a thick black crust with occasional golden or brownish tinge, being frothy at places. The crust has well-developed regmaglypts (thumb marks) typical of meteorites (Figure 2 *a*). A 6.46 g fragment from one corner of the meteorite was made available to us for this study. The meteorite is magnetic, having high density typical of iron. Observations with a magnifying lens indicate that it contains less than 2% silicate inclusions, randomly distributed in the metallic matrix (Figure 2 *c*). Some white silicate inclusions were also observed in the interior cut face. Based on these observations the meteorite appears to belong to the iron group. More precise classification would require a study of characteristic trace elements.

This fragment was counted on a low background, hyper pure germanium gamma ray spectrometer located in a 10 cm thick lead shield. The fragment shows significant activity due to radioactive ^{54}Mn (0.084 counts per minute (cpm)) and ^{57}Co (0.034 cpm), produced by cosmic ray interactions in meteoritic iron and nickel. The activity is estimated to be about 304 ± 18 dpm/kg of ^{54}Mn and 38 ± 9 dpm/kg of ^{57}Co. Other radionuclides, e.g. ^{58}Co, ^{58}Ni

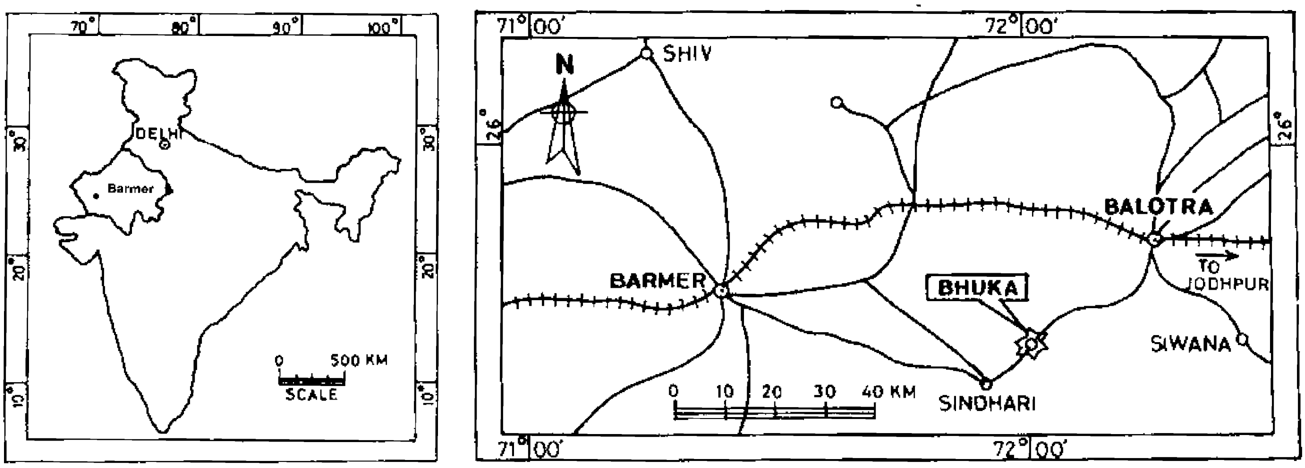

Figure 1. Location of fall of the Bhuka iron meteorite near Sindhari, Rajasthan.

Figure 2. ***a***, The 2.5 kg Bhuka meteorite showing regmaglypts on well-developed fusion crust. ***b***, Crater (about 45 cm deep) and its ejecta produced by fall of the meteorite in sandy alluvium field. ***c***, Fragment showing presence of white silicate inclusions.

and ^{60}Co also expected to be produced in meteoritic iron and nickel were not observed, the signal from the small fragment presumably being below our detection limit.

The meteorite has fallen at the time of solar minimum when the cosmic ray flux in the interplanetary space is high. The high activity of ^{54}Mn and ^{57}Co is consistent with the levels expected during solar minimum. The activity can be compared with the production profiles in meteoroids of different sizes[1,2], according to which maximum activity is produced at the centre of an iron meteorite of ~ 20 cm radius. The level of ^{54}Mn present indicates that the ablation of the meteorite during its atmospheric transit has been small (< 20 cm) and the size of the meteoroid in space was between 30 and 50 cm.

This is the seventh observed fall in the past 15 years in Rajasthan and the only iron meteorite, the other six stony meteorites being Didwana (H5, 12 August 1991), Lohawat (how, 30 October 1994), Devri Khera (L5/6, 30 October 1994), Piplia Kalan (euc, 20 June 1996), Itawa Bhopji (L3/5, 30th May 2000) and Bhawad (LL 6, 6 June 2002). All these meteorites belong to different classes and have different exposure ages (ranging between 8 and 110 Ma). Since only about 126 falls have been observed all over India in the past two centuries, this frequency of fall (one every two years) in a small area of Rajasthan is anomalously high, as we have noted earlier[3]. In comparison, only eight falls have been reported from the rest of India during the past 15 years. The question whether this is a regional or temporal statistical fluctuation or the Earth is going through an unusually dense swarm of interplanetary bodies, is strengthened due to this additional fall. Better awareness regarding meteorites may have also contributed to its efficient recovery in this desert area of India.

1. Bhandari, N. *et al.*, *Geochim. Comochim. Acta*, 1993, **57**, 2361–2375.
2. Leya, I. *et al.*, *Meteoritics Planet. Sci.*, 2000, **35**, 287–318.
3. Bhandari, N. *et al.*, *Meteoritics Planet. Sci.*, 2002, **37**, 549–563.

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Iron pyrites for reducing ammonia volatilization losses from fertilizer urea applied to a sandy clay loam soil

Ammonia volatilization (AV) is an important mechanism for the loss of nitrogen applied to farm fields and may range from 0 to 50% of applied N[1,2]. Sudhakara and Prasad[3] reported a loss of 8.37% of surface applied urea-N due to AV from a rice field, while Sarkar *et al*.[4] reported a loss of 15–20% of applied urea-N due to AV from a wheat field. After application to a moist soil, urea hydrolyses to ammonium carbonate, which increases soil pH (8.5 or more). Ammonium carbonate then breaks down to CO_2, NH_3 and water[5] and part of the NH_3 formed is volatilized. AV losses can be reduced by the addition of acids[6].

Large amounts of iron pyrites (about 350 million tonnes) containing 22% S found at Amjhore, Rohtas district, Bihar[7], are being currently recommended for the reclamation of alkaline (sodic) soils[8] and for meeting S deficiency in soil, which is widespread in the country[9,10]. Once applied to soil, iron pyrites are oxidized by the bacteria *Thiobacillus ferroxidans* according to the reaction given below[11]:

$$2FeS_2 + 2H_2O + 7O_2 \rightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+.$$

The acidity so produced may help in reducing AV losses. The present laboratory study was therefore conducted to find out if addition of pyrites to urea could help in reducing AV losses.

The laboratory incubation study was conducted on a sandy clay loam soil collected from the surface 0–20 cm layer of an experimental field under the rice–wheat cropping system for the last 15 years at the Indian Agricultural Research Institute, New Delhi. The soil had a pH of 7.9 (1 : 2.5 soil : water) and contained 5.4 g organic C and 0.5 g kjeldahl's N kg^{-1} soil.

The soil was air-dried and ground to pass through a 2 mm sieve. One hundred grams soil was taken in each of the desired number of 250 ml beakers and was brought to field capacity (–10 kPa) moisture by adding the required quantity of distilled water; this moisture content was maintained by adding drops of water through the side of the beaker as and when required during the entire period of study. Urea @ 56.6 mg N 100 g^{-1} soil without or mixed with pyrite in 1 : 1, 1 : 2 and 1 : 4 urea : pyrite ratios (w/w), was surface-applied. A 20 ml beaker containing 10 ml boric acid mixed with methyl red indicator, was kept on the surface of the soil and the 250 ml beaker was made airtight by covering with an aluminium foil. Each day, the 10-ml boric acid beaker was replaced by a new one of similar type. Ammonia evolved and trapped in boric acid was titrated with 0.05 N H_2SO_4 and the amount of ammonia evolved was estimated. During incubation, the maximum and minimum laboratory temperatures were 35 ± 2°C and 25 ± 2°C respectively.

AV loss from urea without pyrite was slow after the first day of incubation (1.28 mg N), peaked at 7.75 mg N after 2 days of incubation and then tapered down to 1 mg N day^{-1} after 5 days of incubation (Table 1). AV loss was lower when urea was mixed with pyrite and it decreased as the amount of pyrite in the mixture was