

Fe and Ti and high in Cr, V, Zn, Ni, Co and Mn. The V content in Chalingal lodestone exceeds that reported for titaniferous magnetite bands from southern parts of the Dharwar craton (Vasudev and Srinivasan, 1979).

### ORIGIN

The cumulus texture shown by the lodestone confirms that the primary minerals in the rock are formed by gravitational settling from a crystallising basic magma. The fairly high concentration of trace elements like Cr, V, Mn, Ni and Co in magnetite and ilmenite of the lodestone indicates incorporation of these elements during the early phase of magmatic crystallisation. Further, occurrence of a serpentinised body in the vicinity and the presence of serpentine and pyroxenes in the lodestone imply its possible association with a layered complex in which the lodestone

may be a rhythmic layer. Obviously the area calls for detailed exploration not only for its scientific interest but also for its economic potential.

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## ARSENIC RICH PHASES IN AQUIFER SEDIMENTS FROM SOUTHERN WEST BENGAL

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### INTRODUCTION

Arsenic pollution in groundwater of southern West Bengal, India and adjoining Bangladesh is an alarming environmental problem. Many alternatives have been suggested, dealing with the likely minerals contributing arsenic and also the likely processes responsible for release of the element in groundwater (Nickson et al. 1998, 2000; Acharyya et al. 1999, 2000; McArthur et al. 2001). We present here the identity of the phases with high arsenic content recovered from the aquifer material.

Arsenic concentration greater than 0.05mg/l in groundwater is found to be confined in the Ganga-Padma delta region. Hooghly river, a tributary of the Ganga-Padma river system, marks the western limit of the incidence of such high values. It is also observed that such high values are restricted to the shallow aquifers (20-100m) of the region. Two areas Chakdah in Nadia District and Baruipur in 24-Paraganas(S) District of West Bengal (Fig. 1), with reported incidence of greater than 0.05mg/l arsenic in groundwater, have been selected mainly for studies of the shallow aquifer

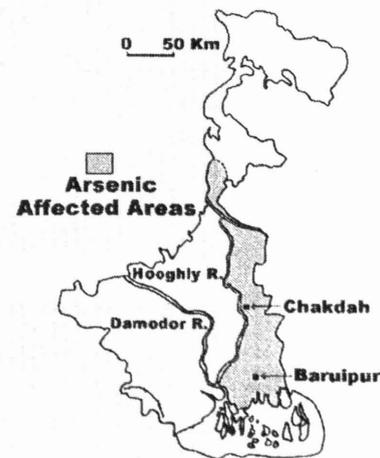


Fig.1. Arsenic affected areas of West Bengal with the locations of Chakdah and Baruipur areas.

material and to identify the arsenic bearing phases in it. In the two areas of Nadia and 24-Parghanas (S) Districts, the greater than 0.05mg/L values in groundwater (arsenous zone)

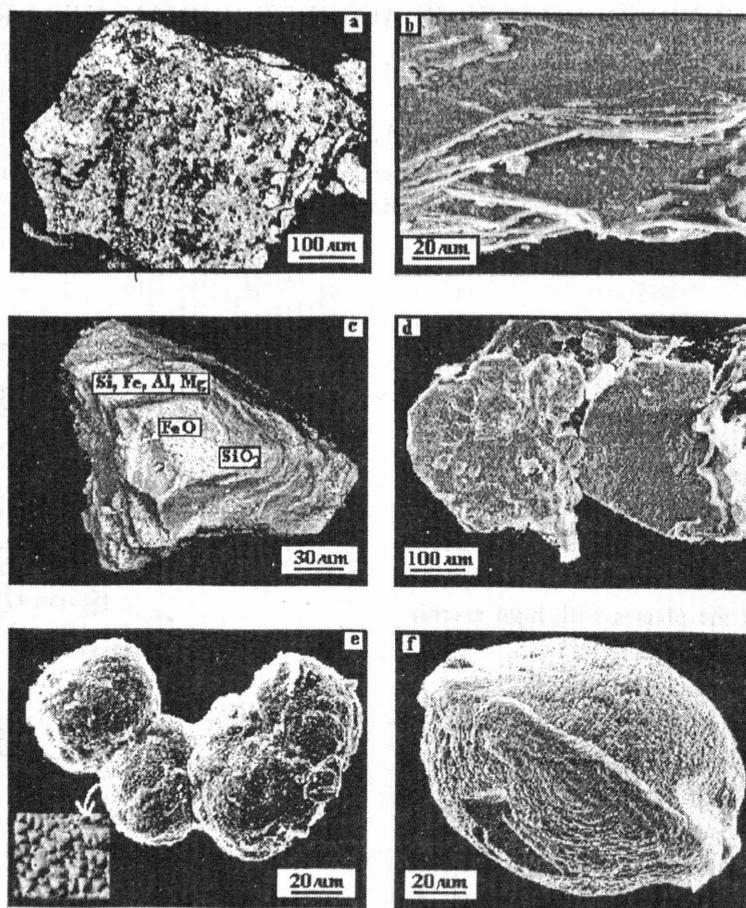
are found clustered in isolated pockets occupying small areas, and surrounded by values less than 0.03mg/l of arsenic (safe zone) recorded over larger part of the area.

#### AQUIFER SEDIMENTS AND MINERALOGY

Holocene sedimentary columns encountered in eight 60 m bore holes in the Nadia and 24 Paragans Districts of West Bengal show a fining upward sequence from medium to fine sand, silt and to clay with impersistent peat layers. The average values of arsenic in the different components in the columns are as follows: clay layer (10-30 mg/kg), silt layer (4-24 mg/kg), peat layer (40-42 mg/kg) and medium to fine sand (2-6 mg/kg). The only noticeable difference between the sedimentary columns from zones with contrasting arsenic values in groundwater is the presence of 25-30m thick clay cap in safe zones and its total absence or partial preservation in the arsenous zone. It is suggested that these should be the deciding criteria for identifying the safe water zones for future tube wells. The presence of thick

clay layer in association with peat layer (both with high arsenic content) in the safe zone clearly demonstrates that these are not the contributors of arsenic in groundwater.

The aquifer material in both the zones consists of silt to sand-sized grains (96-99%) and interstitial clay (1-4%). The coarser fraction consists of (a) quartz and feldspar constituting the bulk and (b) minerals with variable magnetic intensity constituting 10 to 34% of a sample. The latter includes (i) magnetite and ilmenite coated with iron oxyhydroxide, (ii) accessory silicates, (iii) illite in the form of books, (iv) biotite books showing hydroxide stains along cleavage laminae, (v) iron oxyhydroxide coated sand grains, (vi) chlorite and (vii) siderite concretions. All these components have been analysed for their arsenic content in the Chemical Laboratory of Geological Survey of India, Kolkata by Atomic Absorption Spectroscopy. It is observed that magnetite and ilmenite (10-40 mg/kg), illite (10-41 mg/kg), chlorite (5.5-31 mg/kg), siderite concretions (7-9 mg/kg), biotite (9 mg/kg) and iron coated sand grains (30 mg/kg) are the mineral phases storing most of the arsenic



**Fig.2.** SEM images of arsenic-rich phases. (a) Iron oxyhydroxide with residual magnetite and ilmenite, (b) Illite in the form of books, (c) quartz coated with iron oxyhydroxide, (d) biotite, (e) Multiglobular siderite concretions with rhombohedral crystal faces, shown in inset and (f) Uniglobular siderite concretion.

in the aquifer. In addition, the interstitial clay also contains arsenic in the range of 10-12 mg/kg. The non-magnetic fraction from the two areas has analysed less than 1 mg/kg arsenic.

It has been experimentally proved (Fuller et al. 1993; Bowel, 1994; Carrillo and Drever, 1998) that iron oxide/hydroxide phases adsorb arsenic onto their surface. The high arsenic values in oxyhydroxide-coated magnetite, ilmenite and quartz grains of the present samples are contributed by the element adsorbed to the coating of these minerals. That arsenic in groundwater originates from the iron hydroxides as suggested by Nickson et al. (1998, 2000) from their studies in Bangladesh. The suggestion of iron-coated quartz grains being responsible for contributing arsenic in water has been mentioned by Acharyya et al. (1999). In this study illite, biotite, chlorite and siderite concretions are identified as additional mineral phases storing high arsenic, which could be responsible for causing high values in groundwater under suitable conditions. Figure 2 represents the SEM images of these arsenic-rich phases in subsurface sediments of the southern West Bengal. It is likely that arsenic is adsorbed onto the surface of these mineral phases also, though no experimental verification for the fact is yet available.

Concretions in the aquifer material are constituted of siderite as identified by XRD. These have been further analysed by EPMA to be (Fe, Mn, Ca, Mg) CO<sub>3</sub> with FeO ranging from 25.75 to 49.58%, MnO from 0.24 to 16.75%, CaO from 2.01 to 12.23% and MgO from 0.15 to 0.74%. These are multi-globular or uni-globular objects (Fig. 2e,f), which are aggregates of tiny rhombohedral crystals producing a honeycomb-like appearance. The globules appear to be built of concentric layers, with each layer having stacks of carbonate crystals. It is observed under electron microscope that these concretions enclose single or multiple grains of quartz and potash feldspar. These are inferred to be products of early diagenetic growth. Similar siderite concretions have been suggested to have grown under bacterial influence by Fisher et al. (1998).

## CONCLUSIONS

The total absence of detrital pyrite and arsenopyrite in the aquifer sediments from the area of investigation clearly indicates that these arsenic bearing minerals could not have regenerated to contribute arsenic in groundwater of these locations as suggested by earlier workers (Mallick and Rajagopal, 1996; Chowdhury et al. 1999). The very rare pyrite grains reported in our study are all diagenetic framboidal pyrite, suggesting reducing condition at the time of their growth. It has been suggested by Carrillo and Drever (1998) that at pH=7-9 iron oxyhydroxide adsorbs maximum arsenic and higher pH induces desorption of the element. It has also been suggested (Nickson et al. 1998; Acharyya et al. 1999) that under reducing condition iron oxyhydroxide would dissolve, contributing its adsorbed arsenic to ground water. Siderite concretions are stable in pH ranges of natural environment. At pH<7, siderite concretions would dissolve with resulting increase in the arsenic level of groundwater. It is, therefore, suggested that pH of natural environment would promote growth of these concretions and these together with iron coated minerals, illite and biotite would capture the arsenic, thus becoming potentially dangerous with the possibility to contaminate the groundwater. With subtle changes in conditions, all these arsenic traps would either release the adsorbed arsenic or themselves dissolve. Both the processes would increase the arsenic level of ground water. The same process will simultaneously elevate the level of dissolved iron and bi-carbonate in groundwater leading to a positive correlation of these two with arsenic. Such correlation has been reported by earlier workers (Nickson et al. 1998, 2000; McArthur et al. 2001) in the groundwater from Bangladesh and in our present study. It is proposed that local development of anoxic, acidic environment due to degradation of organic matter present in the aquifer sand might trigger the process of release of arsenic in groundwater only at isolated sites, resulting in patchy occurrences of high incidence of arsenic in the groundwater of southern West Bengal.

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## AN INDIGENOUS APPROACH TO LOW COST PORTABLE VIBRACORING IN DELTAIC ENVIRONMENTS

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**Abstract:** A simple but very effective and inexpensive indigenous method of vibracoring has been developed for acquisition of continuous cores in subaqueous environments at water depths of below 2m. The principal components are the following: 3.5 HP concrete vibrator, irrigation PVC tube, tripod and pulley. The entire system weighs 50 kg. and approximately costs about Rs.25,000/-. This system was operated successfully in the transitional sedimentary environments of the East Coast deltas by collecting around 100 cores averaging to 2 m in length. Sediments ranging from clay to coarse sand have been recovered using this system. Percentage of recovery was usually 60 to 100 and distortion of delicate sedimentary structures was generally minor.

**Keywords:** Vibracoring, Deltaic environments, Andhra Pradesh.

### INTRODUCTION

Vibracoring has to a large degree solved the problem of collection of cores of unconsolidated sandy or compacted sediments in deltaic environments (Sanders and Imbrie, 1963; Ginsburg and Lloyd, 1956). However, most of the existing vibracore systems are designed for shipboard and land use, but are too large to be used on small boats in shallow water environments (Stone and Morgan, 1992). Therefore, for facilitating core sampling in both coastal and shallow water environments, a portable vibracore system has been developed by us. The entire system is relatively light in weight requiring only 2 to 3 persons for operation. The system can also be transported in small boats to remote locations.

### UNIT COMPONENTS

The essential components are gasoline-powered concrete

vibrator and PVC irrigation tubing as items of stock, besides the other fabricated items.

**Vibrator:** The vibrator needle is a commercially manufactured concrete vibrator powered by 3.5 HP gasoline engine (Plate 1a). The engine powers the cylindrical vibrating head internally through a flexible cable 3.8 cm in diameter. These cables come in lengths of 4 to 6m (Plate 1b).

**Clamp:** The clamp is made of steel strips that are welded together in opposition and are bolted to the vibrating needle and core tube. The clamp remains bolted to the vibrating needle at all times and is bolted to the core tube only during coring (Plate 2).

**Core Tube:** A 6 m long standard 63mm PVC pipe (Plate 2b).

**Tripod:** A simple tripod to support the pulley (Plate 3a)

**Pulley:** A winch with an endless chain hoist to withdraw the core tube from the substratum (Plate 3b).