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Ujjain clay as low-cost sealant and liner for artificial ponding and bentonite alternative

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Synthetic and natural clay (bentonite) liners are commercially used to protect leakage from a variety of earthy ponding and containments in order to conserve water and for the wastewater not to contaminate the groundwater. The present study evaluates the sealant property of the local clay hitherto used intensively in the manufacture of earthenwares, bricks, smearing materials and sealant in roof cracks. Extensive deposits of fluvial sediments occur along the bank of River Kshipra in and around Ujjain situated on Malwa plateau in Madhya Pradesh. Field-collected clay samples were analysed by X-ray diffraction and ethylene glycol treatment (EGT), and compared with standard bentonite procured from Gujarat Mineral Development Corporation. The X-ray diffraction profile analysis with basal reflection (001) at 14° to 15° clearly confirmed the identification of smectite group of the clay under study. The EGT substantiated the presence of smectite in the Ujjain clay as well as in the standard bentonite, which is diagnostic to the swelling property of the clay. The overall study thus characterizes the potentiality of Ujjain clay as a mineral-based hydraulic barrier material and a component of natural liner in surface-water impoundments and lagoons.

WATER and wastewater being resources in tropical India, have been subjected to loss through downward and sideward seeping from stationary and mobile waterbodies, such as small-scale freshwater/industrial ponds, lagoons, lakes, storage dams and reservoirs, irrigation canals, constructed wetlands[1], sewage effluent irrigation, landfill sites, etc. To control this loss, synthetic polymers such as PVC, plastic, heavy and low density polyethylene (HDPE and LDPE)[2], fibertex, geotextile and naturally occurring commercial bentonite clay are in vogue as sheet piling, but are expensive items as liners. Swelling to several times its original volume when wet, the bentonite layer is able to seal potential leaks in the artificial ponds and acts as an excellent hydraulic barrier[3].

The yellow clay deposits occur in the form of fluvial sediments with ridges and linear bars along the bank of

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River Kshipra in Ujjain. Preliminary geological survey indicated at least five occurrences of clay deposits intimately associated with river alluvium as shown in Figure 1. The clay deposits at the site in the present study have a strike length of 500 m to over a kilometer, and vary from place to place with an average width of 100 m. Study of clay exposures shows a relief of 50 m above the ground surface and a few well sections indicate a depth up to 10 m below the surface. This clay has been extensively utilized locally since decades and the material is being mined manually by opening pits. Its applications include partition wall construction in earthen homes, floor and wall smearing, sealing materials in roof cracks, earthen pottery, and earthen containment for grain storage in rural areas. The purpose of the present study was to characterize the field samples in terms of clay mineralogy and to establish the scientific credibility as a clay liner in the hydrated state, and applicability at par with the natural bentonite of consistently low permeability.

Samples were collected using pick-axes from exposures of clay sediments near River Kshipra in Bhairogadh area, a village near in Ujjain. Samples were brought to the laboratory, air dried, finely powdered in glass pestle mortar, sieved using a 0.25 mm sieve and stored in a cool place until analyses. The samples were preliminary examined at Inter University Consortium for DAE Facilities, Indore, and finally subjected to X-ray diffraction (XRD) and ethylene glycol treatment (EGT) at Department of Earth Sciences, Chiba University, Japan, using copper target. The diffraction profile analysis of the clay samples remains incomplete unless they are subjected to EGT for interpreting the extent of their swelling property[4,5]. For comparison with the local yellow clay, the standard bentonite samples procured from Gujarat Mineral Development Corporation, were also analysed simultaneously.

The detailed XRD profiles in Figure 2 indicate significant peaks of the constituent minerals with angle of diffraction (2θ), intensity, and d-spacing in yellow clay and bentonite. Table 1 highlights the minerals identified on the basis of significant XRD peaks using standard charts of the American Society of Testing Materials (ASTM). Thus the diffraction profile analysis with basal reflection (001) at 14° to 15° A led to the identification of smectite group[6] of the yellow clay mineral under investigation. The presence of smectite in both the clay samples as a predominant mineral phase was confirmed and substantiated by EGT (Table 2). In fact, glycol treatment enhanced the d-spacing to the order of 17° A, characterizing the presence of smectite[7]. Comparing the d-spacing values between the clay and bentonite as recorded in Table 2,

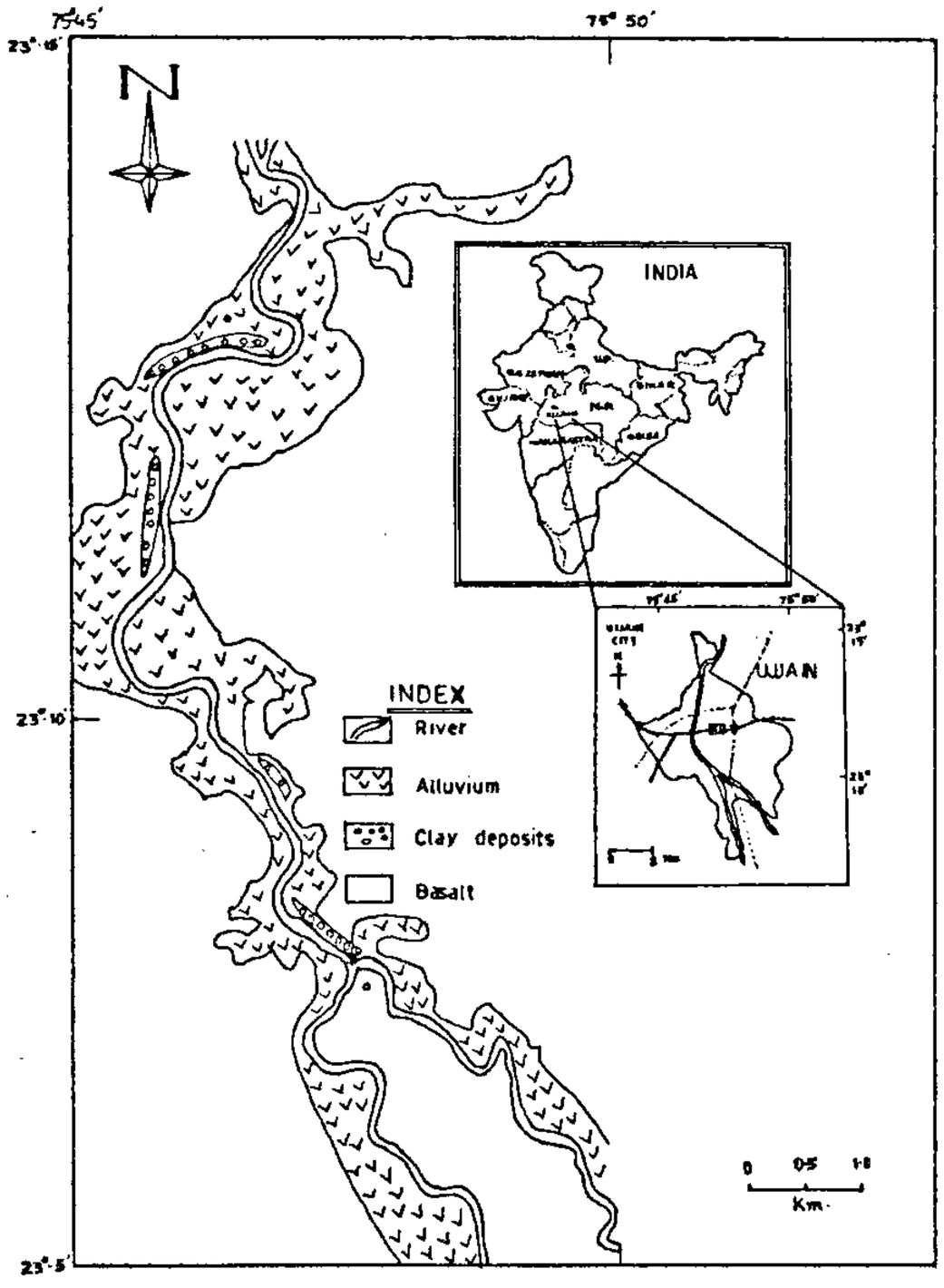

Figure 1. Map of the study area around Kshipra River, Ujjain (modified after Kanungo[8]).

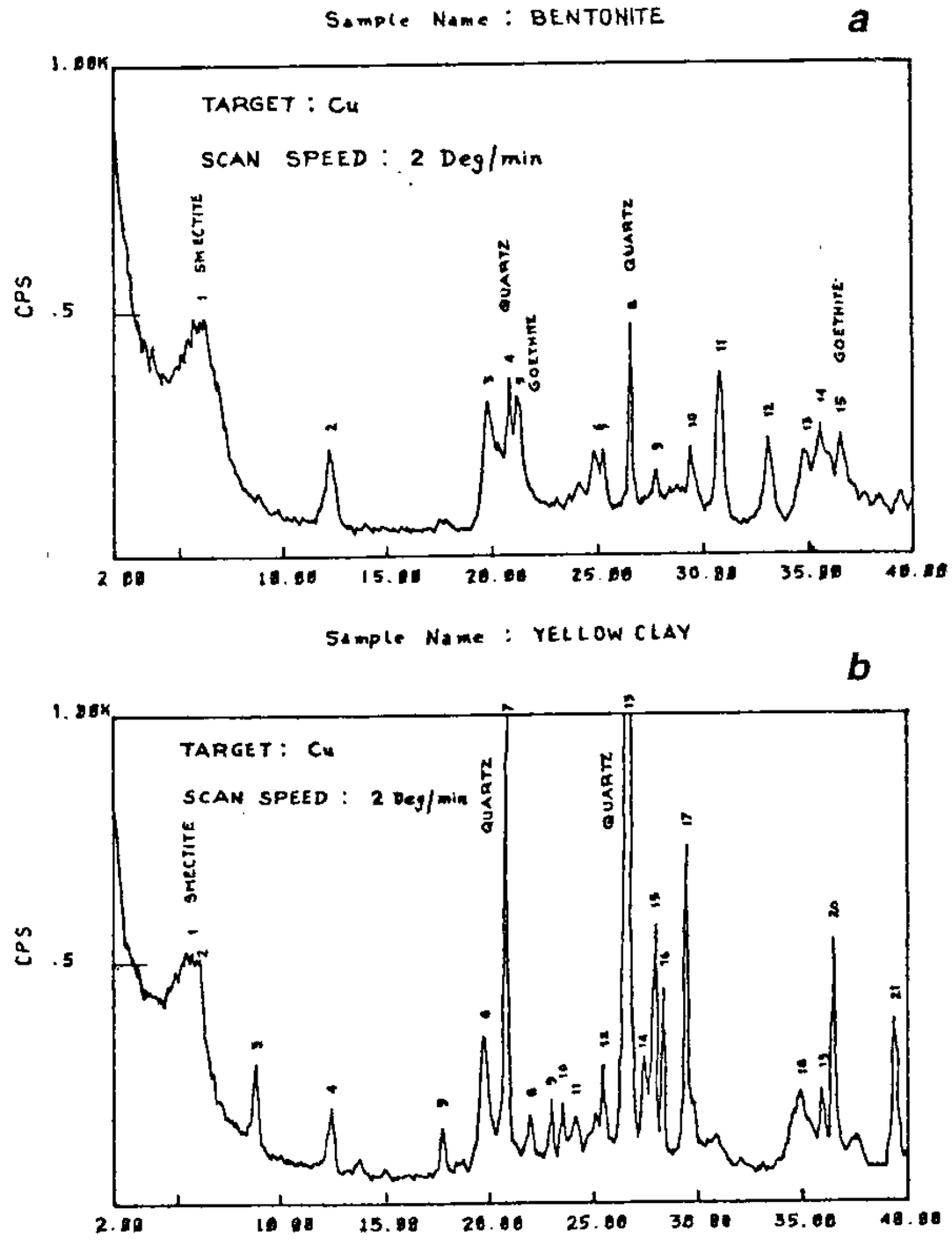

Figure 2. X-ray diffractograms of (*a*) bentonite and (*b*) Ujjain yellow clay.

Table 1. Details of significant X-ray peaks of Ujjain clay and bentonite using copper target

Sample	2θ	d-spacing	I/I_0	Mineral identifed
Ujjain clay	5.74	15.384	13	Smectite
	20.85	4.257	26	Quartz
	26.64	3.343	100	Quartz
Bentonite	6.11	14.453	100	Smectite
	20.86	4.254	74	Quartz
	21.30	4.168	64	Goethite
	26.64	3.343	96	Quartz
	36.63	2.451	50	Goethite

Table 2. Characteristics of X-ray diffraction after ethylene glycol treatment for Ujjain clay and bentonite

Sample	2θ	d-spacing	I/I_0	Mineral identified
Ujjain clay	5.020	17.589	100	Smectite
Bentonite	5.210	16.948	100	Smectite

clearly indicates an elevated swelling capacity of the Ujjain clay. EGT further ensured better swelling property of the clay under study and diagnostic for the comparison, thereby emphasizing its potential as a promising alternate to bentonite as a low-cost naturally occurring sealant.

Overall we feel that it is worthwhile to further evaluate the detailed physico-chemical and hydraulic properties of the clay deposits and to tap the valuable natural resource as clay liner or as geotechnical material to prevent seepage. Detailed geological prospecting and drilling into the study area can give precise information on reserves and economic evaluation of the clay deposits.

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