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Supplementary Information

Beneficiation of Clays from Ramgarh-Naudiha Region of Sonbhadra District Uttar Pradesh, Impart Improved Properties for Ceramic Industries

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Stratigraphy

The landscape of Sonbhadra district is comprised of a variety of rock formations e.g., Chhotanagpur Granite Gneiss Complex (CGGC), Mahakoshal Group, Vindhyan Supergroup and Gondwana Supergroup ranging in age from Archaean to Permian.

Table S1 — Stratigraphic succession of Sonbhadra (District survey report, Sonbhadra 2016; Maharana and Tripathi 2018)[23].

Group	Sub-groups and Formation	Lithology	Period
Quaternary	Alluvium	Sand, Silt and Clays	Recent
Gondwana Supergroup		Shale and Coal	Permo–Carboniferous
		Unconformity	
Vindhyan Supergroup	Kaimur	sandstone, shale, minor carbonates	Neoproterozoic
	Semri	Limestone, Sandstone, Porcellanite, Shale	Meso–Proterozoic
		Unconformity	
	Mahakoshal Group	Slate, Phyllites, Dolerite dykes, Sandstone	Palaeo–Proterozoic
		Tectonic Contact	
Chhotanagpur Granite Gneiss Complex (CGGC)		Granite, Amphitotite, Magnatite, Gneisses, mica–schist	Archean

The CGGC is represented by the Dudhi Group of rocks in the present area. In the south of the WNW-ESE striking Son-Narmada South Fault, CGGC rocks are exposed. The rocks of the CGGC are represented by the schist, gneiss, amphibolites with subordinate granite, migmatite, dolerites and marble at few places. In almost all foliated rocks of the area, complex mesoscopic and macroscopic folds have been observed[24].

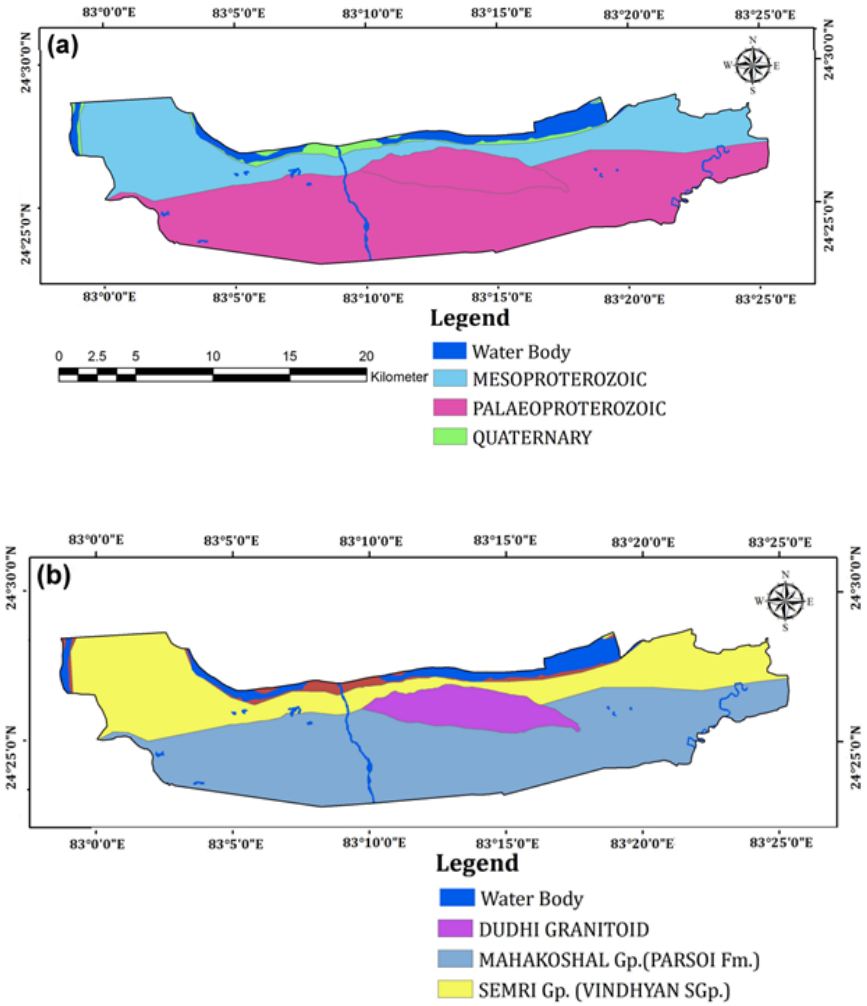

Fig. S1 — Map of the study area of Ramgarh-Naudiha, Sonbhadra district, UP showing (a) Age of the rocks, and (b) Group of the formation.

Plasticity by hand feel

The crushed sample was passed through 60 mesh Tyler sieve. It was then mixed with sufficient water to form a soft mass, then covered with a wet cloth and was allowed to soak for 24 h. The plasticity of the mass– very low < low < moderate < fair < good < very good– was then determined by hand feel after proper mixing.

Water of plasticity

The plastic mass, prepared for noting plasticity by hand feel, was used for the determination of water of plasticity. A known weight of the plastic mass is dried at 110°C and the loss in the weight was noted to calculate the water of plasticity (%).

Dry linear shrinkage

30 mm diameter and 10 mm thick discs were made by pressing the plastic mass and then, dried in air and then in an oven at 110°C and cooled in a desiccators. The distance between the shrinkage marks (originally 25 mm apart) was measured and the dry linear shrinkage (%) was calculated.

Grit content

The well dispersed clay slurry was allowed to pass through 325 mesh Tyler sieve. The residue retained on the sieve was reported as grit.

Particle size distribution

The particle size of clays was determined by Andreasen pipette method based on Stoke's law of sedimentation. The clay was dispersed in water containing sodium pyrophosphate as a deflocculant in a mechanical shaker and then it was transferred to a graduated pipette for undisturbed settling. A measured quantity of suspension was drawn off at certain fixed intervals, without disturbing the suspension and dried in air oven at 110°C and weighed accurately. The size distribution was calculated from the Stoke's law using the dry weight of the fine clay fractions collected in petridishes.

Rational analysis

The mineralogical constituents were determined by rational analysis from ultimate chemical analysis according to the Norm method illustrated by Andrews[29].

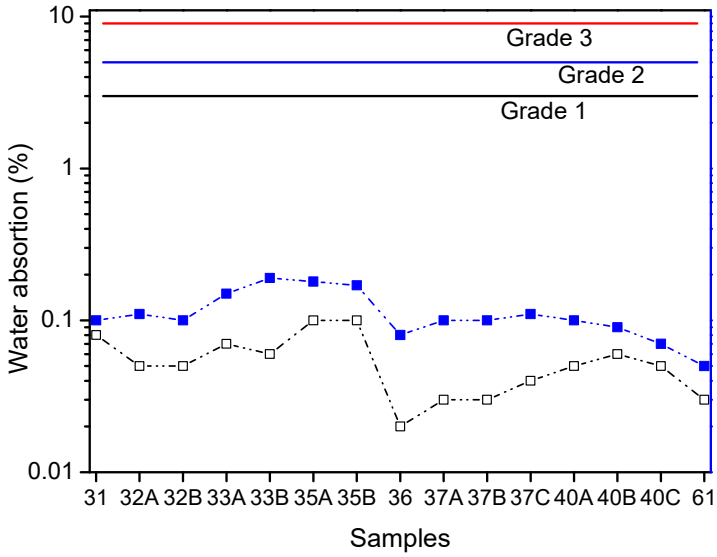

Fig. S2 — Water absorption (WA) against 15 clay samples collected with the empty symbols representing raw and filled symbols as washed clay data. The horizontal lines indicate the clay grades.

Table S2 — Chemical analysis of raw Clay Samples

Samples	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	LOI (%)
31	1.04	0.86	0.58	**2.97**	**6.01**
32A	0.35	4.57	**0.67**	0.15	5.09
32B	0.30	**4.86**	0.58	**0.11**	5.01
33A	0.35	1.80	0.42	0.19	5.47
33B	0.32	1.67	0.44	0.15	5.75
35A	0.07	1.94	0.27	1.95	5.88
35B	**0.02**	1.96	0.35	1.97	5.89
36	0.34	0.59	0.34	0.20	**2.07**
37A	0.70	1.75	0.23	0.89	3.39
37B	0.62	1.77	0.26	0.83	3.60
37C	0.52	0.49	0.58	1.56	4.18
40A	**1.74**	**0.08**	0.33	1.10	4.88
40B	0.41	0.29	0.20	0.71	4.92
40C	0.67	0.40	**0.21**	0.48	4.89
61	0.22	0.62	0.31	0.19	2.55

Presence of calcareous nodules was noted in the clay samples of locations 31, 32A and 32B. These nodules are white-buff coloured, rich in calcium carbonate and 0.5–1 cm in diameter. The major components are SiO_2,

Al_2O_3, and LOI, with minor quantities of Na_2O, and K_2O and the combination conform to kaolinitic clays. Impurities are Fe_2O_3, TiO_2 and MgO in clays and with abundant free SiO_2. High content of CaO to the tune of 16.54-17.22% with high LOI (Table S3) indicate that they are mostly rich in calcium carbonates (Panel B in Fig. 5). These nodules are not just calcium carbonates but also contained clayey material.

Table S3 — Chemical analysis of Calcareous Nodules

	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	TiO_2 (%)	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	LOI (%)
Nodule 1	43.18	5.91	3.73	0.91	**16.54**	0.81	8.2	3.8	16.83
Nodule 2	44.15	6.41	2.96	0.82	**17.22**	0.73	7.2	2.91	17.56
Nodule 3	43.98	6.12	3.11	0.73	17.08	0.79	7.3	3.1	17.71

Table S4 — Chemical Analysis of Clay Samples after beneficiation

Samples	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	LOI (%)
31	1.12	0.92	0.72	**3.19**	6.56
32A	0.45	5.83	0.75	0.69	6.71
32B	**0.38**	**6.21**	0.74	0.44	6.72
33A	0.45	2.29	0.64	0.54	7.29
33B	0.41	2.15	0.70	**0.44**	**7.69**
35A	0.08	2.08	0.59	2.09	6.33
35B	0.02	2.09	0.57	2.19	6.36
36	0.76	1.32	0.86	0.65	**5.77**
37A	1.23	3.06	0.81	1.86	6.46
37B	1.10	3.14	0.66	1.74	7.19
37C	0.77	0.73	**0.95**	2.41	6.77
40A	**2.32**	**0.11**	0.64	1.56	6.51
40B	0.54	0.38	**0.26**	1.10	6.46
40C	0.96	0.57	0.43	0.75	7.08
61	0.54	1.53	0.75	0.47	6.41