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comparing the performances of bricks made with natural clay and clay activated by calcination and addition of sodium silicate

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Abstract

- The mix between **4 M to 12 M NaOH solution and aluminosilicate** material forms a thick paste that can be compacted in a mold in order to manufacture bricks at relatively low temperatures (< 100°C). Starting materials available in Senegal consist of soils that primarily **contain kaolin**. In this study, we compare the performance of **clay from the Niemenike deposi**t and **clay pre-treated at 700°C**. The performance of the two clays depends on the temperature of curing and on the time of curing.

Senegal shows the geographical location of the Niemenike clay deposit used in the research.

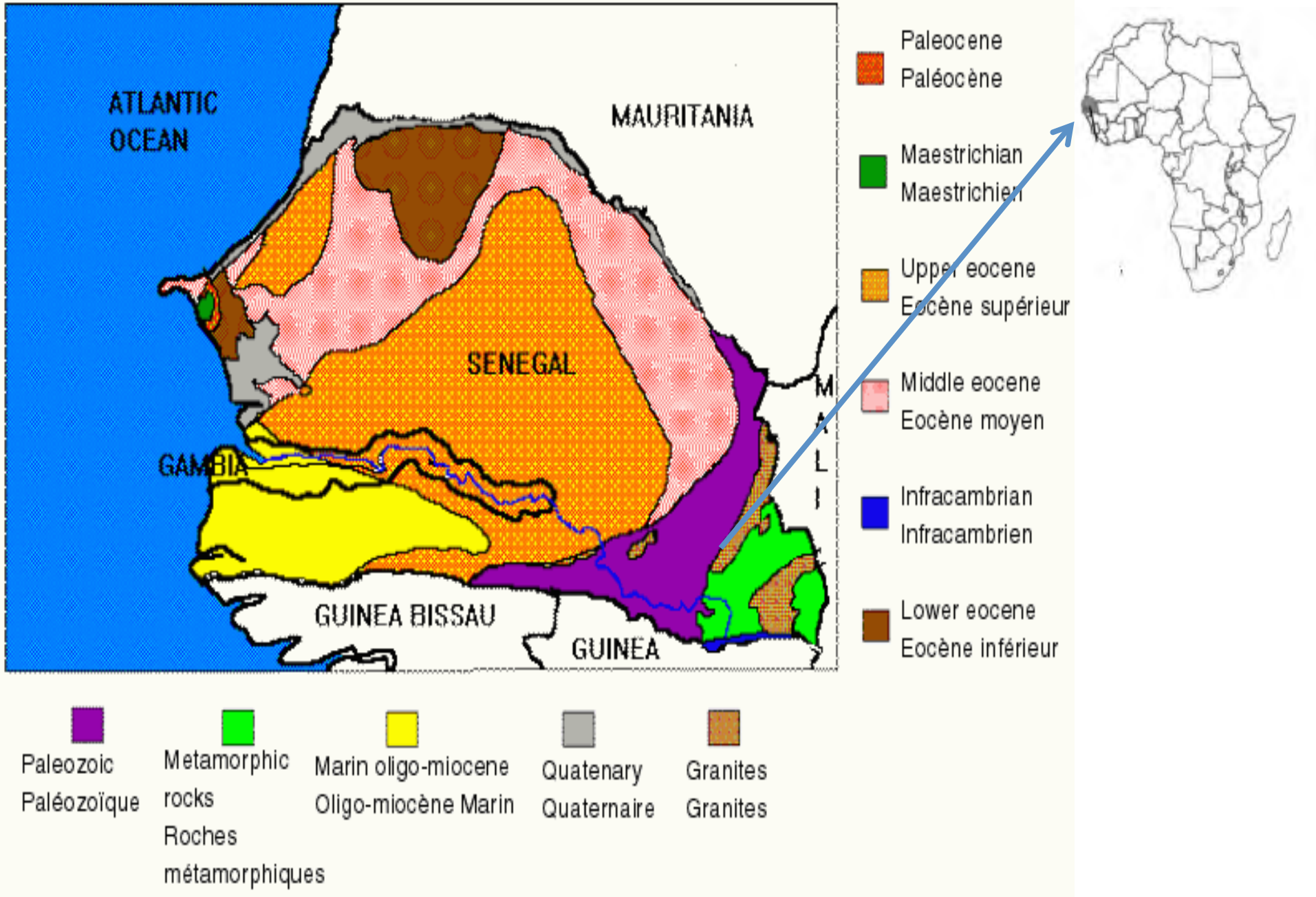
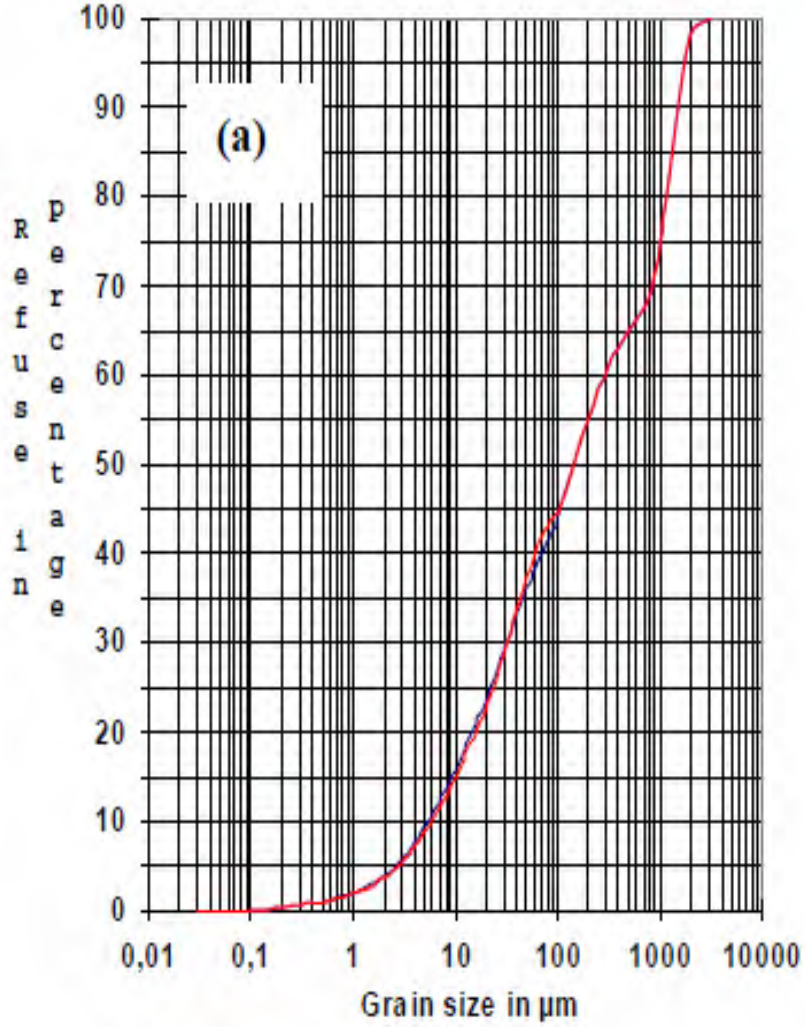


Table 1: Chemical composition of Niemenike clay (wt %)

SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5	LOI
57.0	0.08	25.6	4.78	0.12	0.8	0.02	0.48	0.03	0.03	11.01

Figure 2 (a) Particle size analysis suggests that natural sample and the ultrasonic treated sample are similar. View(a) and Positions of the Lam-Lam phosphate deposit on the SiO_2, Na_2O and Al_2O_3 triangle and the location of the zeolite domain View(b).



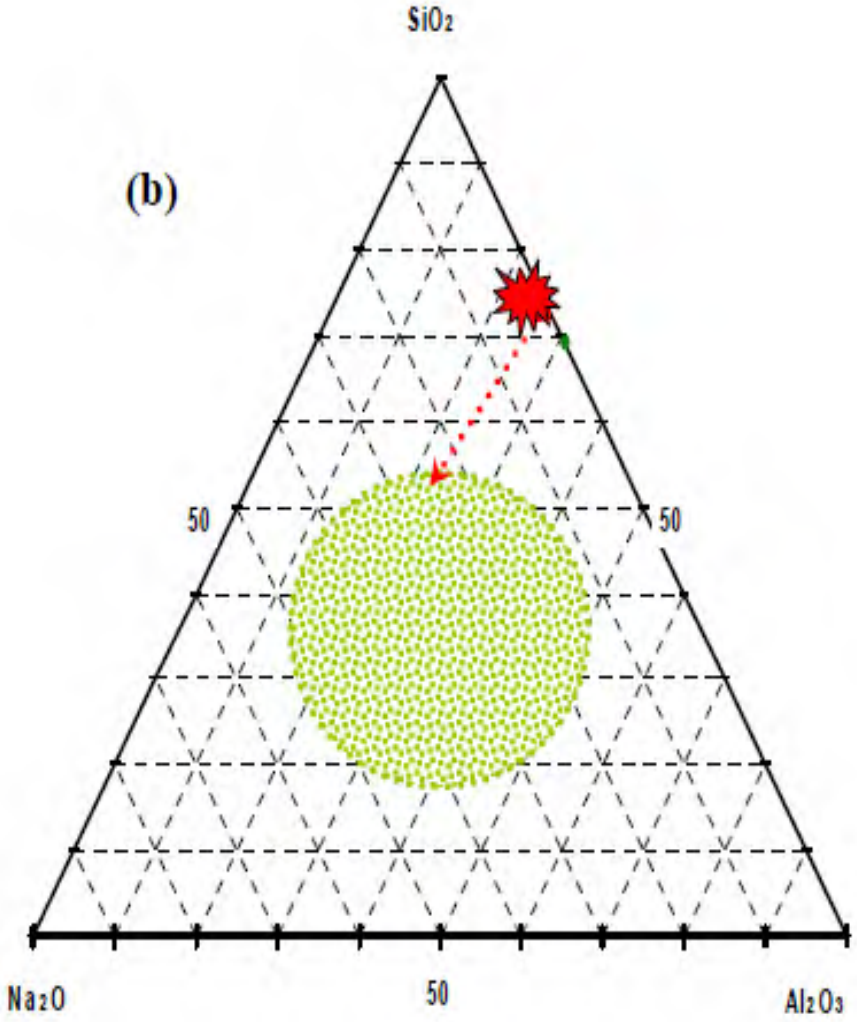
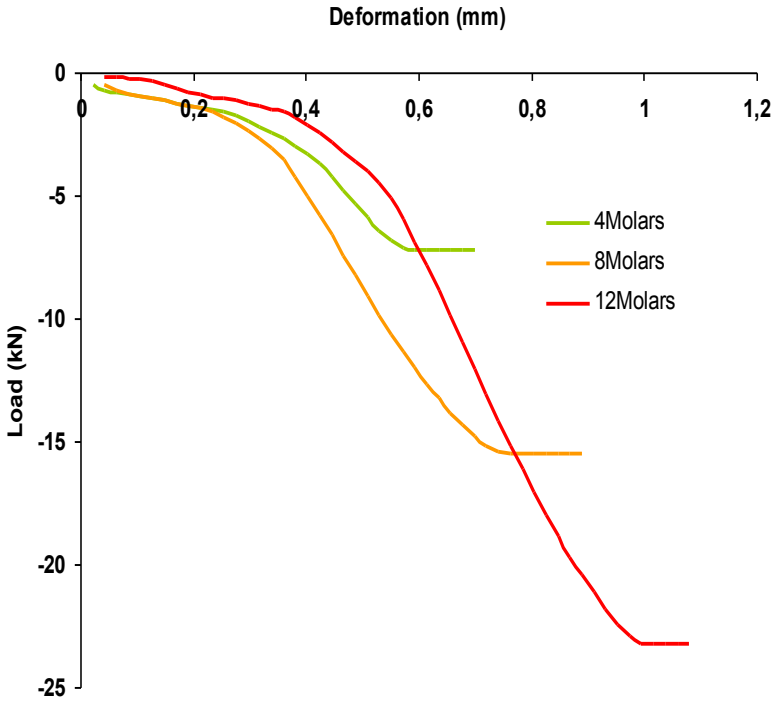


Table 2: Formulations studied

Sampl	Niemenike (wt%)	NaOH (wt%)	Cure temperature (°C)	Cure (days
1	80	4 molar	120	0.25
2		(20)		0.5
3				1
4	80	4 molar	40	7
5		(20)		14
6				28
7				60
8	80	8 molar	120	0.25
9		(20)		0.5
10				1
11	80	8 molar	40	6
12		(20)		12
13				24
14				60
15	80	12 molar	120	0.25
16		(20)		0.5
17				1
18	80	12 molar	40	7
19		(20)		14
20				28
21				60

Figure 3: Stress strain curves for the Niemenike clay samples cured at 40 °C/60%RH (**View a #s 7,14,21**) for 60 days and at 120 °C/0%RH (**View b #s 2, 9, 16**) for 12 hours. Each sample was made with 4, 8 and 12M NaOH solution as a thick paste and then cured.



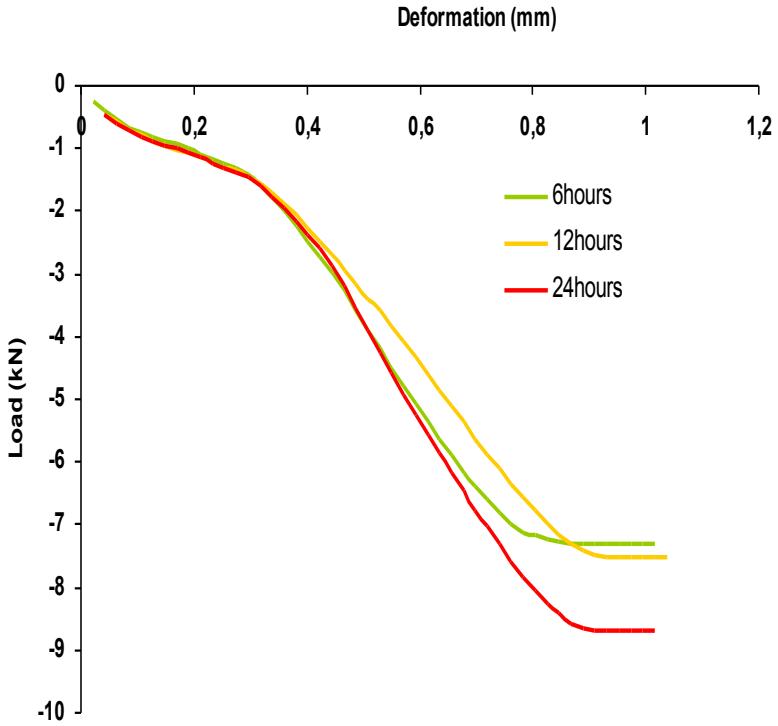


Figure 4: Summary of compressive strength of samples cured at 120 °C (left) and 40 °C (right).

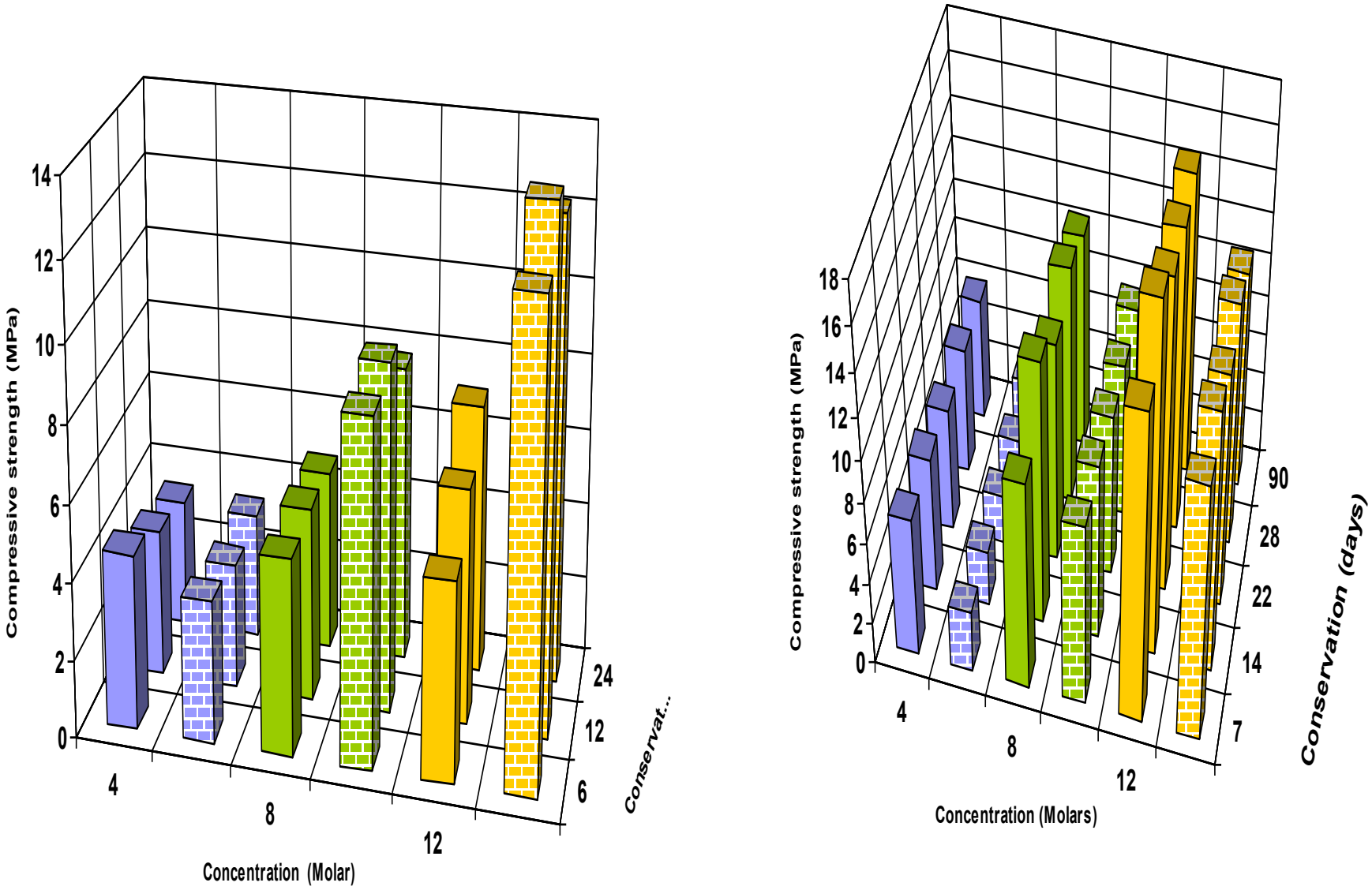


Figure 5: Electron micrographs. (a) typical microstructures of Niemenike clay: solid quartz (button center) and mainly books of kaolin (center left for example). (b) Brick samples made with 8 M NaOH solution and cured for 90 days at 40°C and 60 %RH. (c)

Brick samples made with 8 M NaOH solution and cured for 90 days at 60 %RH.

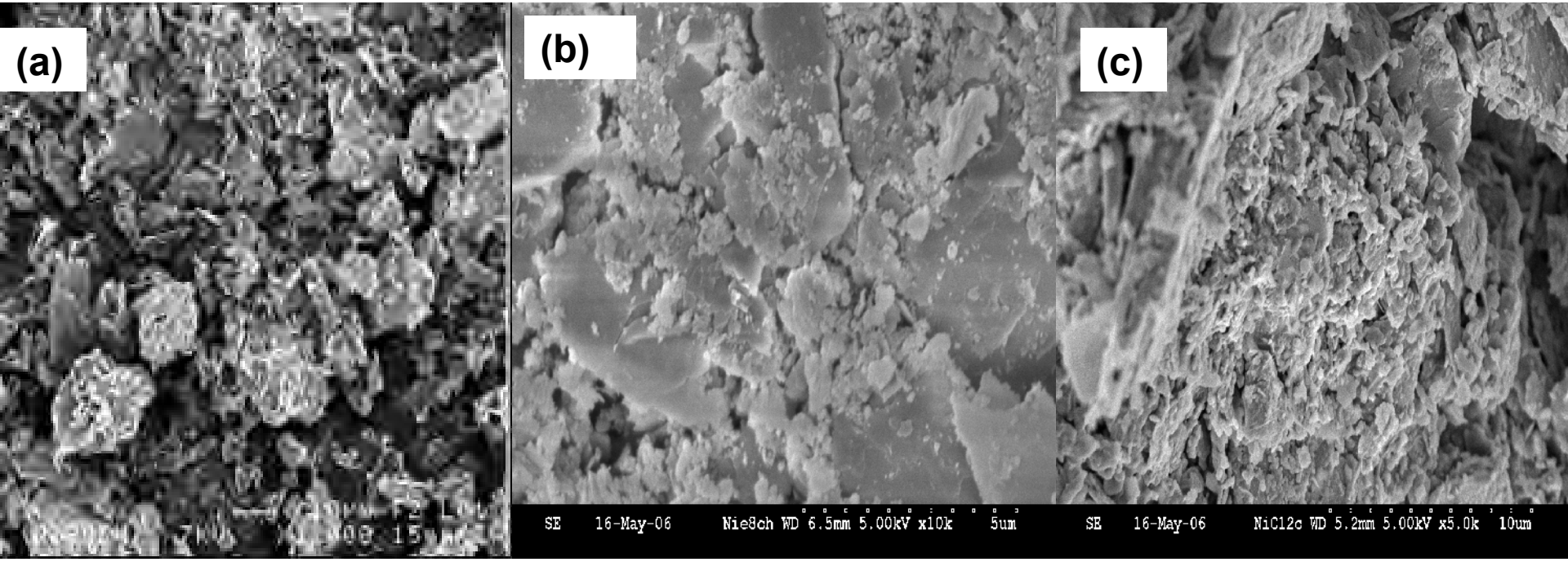


Figure 6: X-ray diffraction patterns. (a) Raw Niemenike clay: **quartz, nacrite, kaolinite and muscovite** can be identified. (b) Niemenike clay activated with 12 M concentration and cured at 120 °C for 7 days: kaolinite peaks are less intense**, sodalite**

can be identified and possibly **bucchulite** $Ca_2Al_2SiO_6(OH)_2$. .

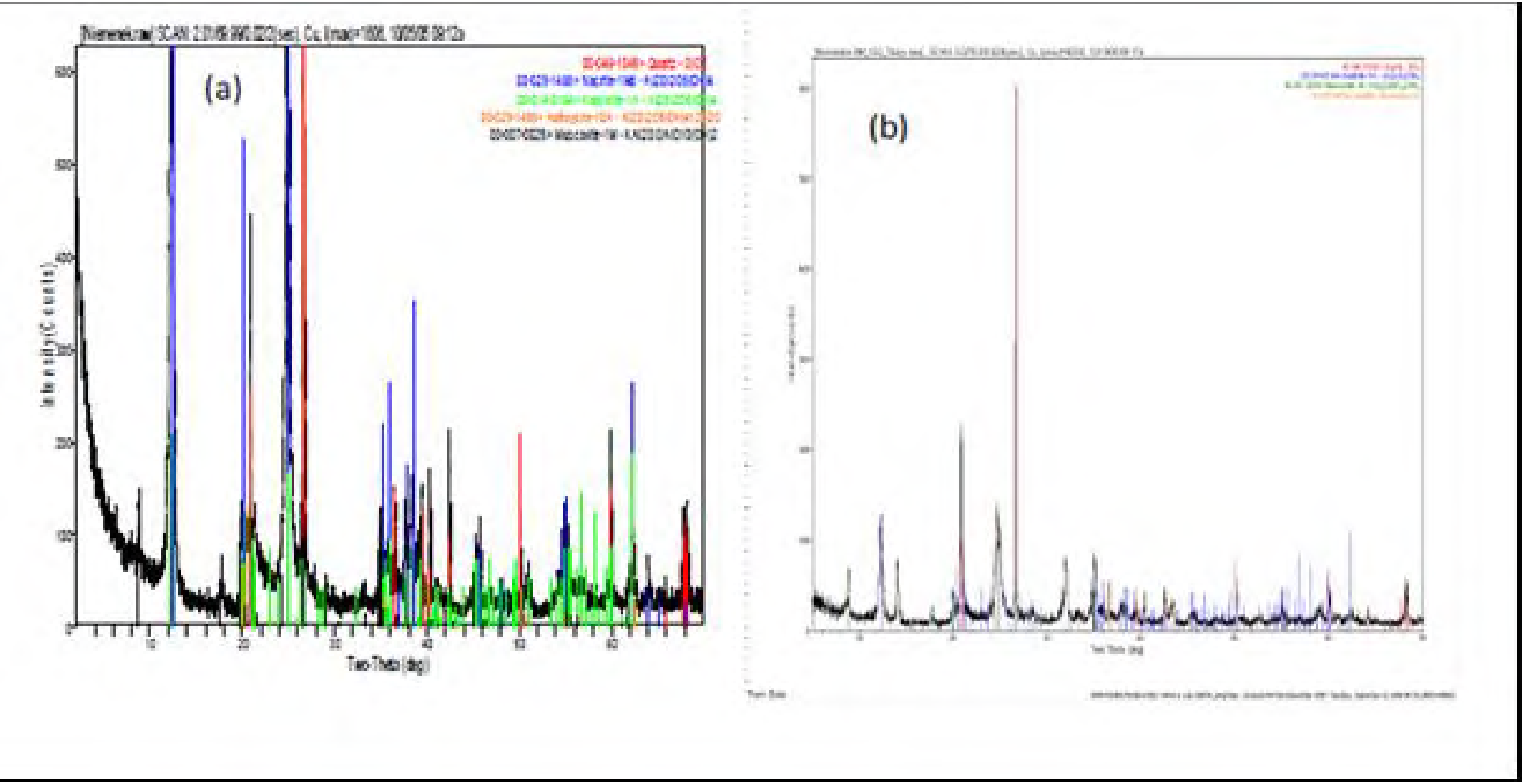


Table 3: Results of leaching test of bricks cured at 120 °C for 12 hours with 4, 8 and 12Molar of NaOH used.

Concentration (molar)	Measurement at 1 day		Measurement at 7 days	
	Conductivity (mS/cm)	pH	Conductivity (mS/cm)	pH
4	0.30	10	0.50	10
8	0.10	10	0.30	10
12	0.10	10	0.30	10

Conclusions

Strength development is dependent on temperature and length of curing, alkali concentration, fineness, crystallinity and composition of the raw materials.

For samples cured at 120°C for 12 h curing seems to impart the best mechanical properties to the samples regardless of the concentration of NaOH solution used to make the sample. It is also notable that the strength gained at any given time is directly proportional to the concentration of NaOH used to make the sample. **In short-term tests, for bricks kept at 120ºC**, calcination is interesting for concentrations greater than 4M. For 4M concentration, there are not enough NaOH as discussed previously and the effect of calcination is not visible. For concentration greater than 4M, the activated and calcined clay exhibits an increase of strength with concentration. The strength of calcined clay activated with 12M NaOH solution, cured 12 hours, reaches 13.4 MPa, which is twice the strength obtained with the natural clay (6.1 MPa).

For reactions carried out at lower temperatures, samples that were cured in the 40°C and 60% RH chamber attained highest strengths after two weeks for all concentrations. The reaction is much slower but the obtained strengths are similar. In a previous paper (Diop et al, 2008), the authors observed that the presence of moisture may allow hydration reactions to continue for a longer time. **In long-term tests, for bricks kept at 40°C/60% RH**, the calcination is **unfavorab**le to compressive strength, regardless the concentration.

The difference between bricks made with natural clay and calcined clay can be explained since in the latter all clay minerals are destroyed. Clay minerals react more slowly with alkaline solutions (Sazhin et al., 1967; Berg et al., 1965). For this principal reason, in short-term tests the mechanical strength of bricks made with thermally pre-treated clay is greater but in long-term tests the natural clay gives performance greater strength. So in general the idea that thermally pre-treated clays are more reactive is true only for the short term.

This very slow reaction can explain why, for Niemenike clay activated with sodium hydroxide, the kaolinite and halloysite peaks are evident after 7 days at 120ºC in the X-ray diffraction patterns, although sodalite and zeolite mineral was formed.

The low conductivity obtained for 8M and 12M samples suggests that the Na component of the 8 and 12 M brick reacts nearly completely. In contrast, the 4 M sample may not contain enough NaOH for reaction to proceed sufficiently. Thus the sodium silicate is still soluble and washes out, giving a higher conductivity.

Because the reaction of the clay with 8M or 12M NaOH will continue for a long time at 40°C, it seems probable that curing could take place under **a heavy tarp in the sun**, a situation available to villagers all over equatorial Africa, one that will provide and maintain both high humidity and temperature. It is also proposed that a simple manual press might be used to make full-sized bricks. The mixture is quite plastic much like ball clay and can be **also extruded** (Diop et al., 2005).

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