Journal of Arts & Humanities

Volume 09, Issue 04, 2020: 42-52
Article Received: 16-03-2020
Accepted: 11-04-2020
Available Online: 24-04-2020
ISSN: 2167-9045 (Print), 2167-9053 (Online)
DOI: http://dx.doi.org/10.18533/journal.v9i4.1883

Use of Local Omani Clays with Low and Mid-Range Temperature Glazes for Art Educational Purposes: Possibilities and Limitations

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ABSTRACT

In this study, red clays, the main industrial material of the Alanwar Ceramic Tiles Plant (ACTP) in Oman, were investigated for use in making glazed ceramics in local educational institutions. Different low and mid-range temperature glazes, which contained various compositions and properties, were examined in the glazing lab at Sultan Qaboos University. The study's aims were to develop and test low- and mid-range temperature glazes to explore if they could fit the red clays used by ACTP, so that the surface could be adhesively bonded. The laboratory glazes were obtained following technical rules to confirm the possibility of using different types of glazes on ACTP clays in Omani schools and universities. This could help reduce the cost of importing clays from overseas to use in Omani education institutions.

Keywords: ACTP clays, Glazes, Ceramics, Oman.

1. Introduction

It is well known that commercial imported glazes are extremely expensive for individual ceramicists or potters, in spite of their widespread availability in Oman. Most students of ceramic art, at various levels of education, depend on imported rather than local materials, which has resulted in high production costs (Almamari, 2016). The most difficult challenge faced by students and artists is to what extent the Omani local earthenware clays can withstand high-temperature firing, especially when glazes are applied.

There is a growing body of literature that recognizes the importance of red clays as raw materials for ceramics and pottery in art education and fine art institutions. To understand the importance of the specific structures of any clay, including red earthenware clays, Hein et al. (2004) asserted that original chemical studies of prehistoric pottery were based on the hypothesis that ceramic produced from a specific clay would show a similar chemical composition and that its composition would be distinguished from that of pottery produced from a different clay. In fact, the

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clay properties that are of interest to the pottery industry are plasticity, which enables the shape of the body, chemistry, mineral composition, thermal properties, color, refractoriness, and mechanical strength after firing (El Idrissi et al., 2018).

In the current study, red clays gathered and manufactured by the Alanwar Ceramic Tiles Plant (ACTP) were produced from six different raw materials with various chemical compositions. The clay recipes produced by the ACTP were mixed as dry materials in different ratios, ranging from 10% to 28%, and a plastic clay was prepared. This mixture contained different types of sands and pure red clays gathered from various Omani environments. As at all ceramic plants, the raw material was first ground in a very large mill and then mixed homogenously in the main ball mill. The prepared clays were before forming stage in order to achieve proper plasticity. Finally, the clays were formed into ceramic tiles by using very advanced pressure machines. Table 1 shows the ACTP clay mixture recipes.

Table 1.

The ACTP clay mixture recipes

Raw Material	Percentage (Ratio)
General Sand	14%
Scrap (fired ceramic grogs)	10%
Wadi ghol Clay	18%
Mahadha Clay	28%
Lawa Sand	14%
Al Hamra Clay	16%

While some research has been carried out on general red earthenware clays, there is still very little scientific understanding of the quality of complicated composed clays in Oman, such as the ACTP clay mixture recipes. Also, data about the efficacy and safety of using local clays are limited. The purpose of this investigation was to explore the possibilities and limitations of using ACTP clay for educational purposes by testing low- and mid-range temperature glazes on this clay in electric kilns.

2. Laboratory tests

For sample preparation, raw materials were obtained from the ACTP in the Nizwa state of Oman. The raw materials displayed a rather mixed texture and a very wide particle size range. The factory gathered the raw materials from four Omani states, from the north to the middle of the country. As shown in Table 1, samples of raw materials were obtained from Nizwa, Al Hamra, Mahadha, and Lawa states. To determine the physical properties, including the weight, shrinkage, density, and water absorption, a series of tests were performed in the Sultan Qaboos University (SQU) ceramic laboratory. The mechanical properties, including the compressive strength of the test tiles, were used to check that the test tiles achieved basic ceramics standards. With dimensions of 8 X 8 cm each (Figure 1), the ceramic tiles used for the experiments were made of ACTP clay and bisquette-fired at a low temperature (1000°C) to guarantee the absorption of the glaze sample. In the SQU ceramic laboratory, all the glaze recipes were composed of different materials, which gave the ceramicist many subtle differences in textures and colors. The possibilities are endless with any glaze; the ceramicist just needs to focus on testing the glazes' ability fit with fired ceramics tiles according to the project's main objectives.

Figure 1. A fired ACTP test tile of 8 X 8 cm dimensions, used for testing glazes.

3. Technical and artistic evaluations

This research project set out to assess the quality of using the ACTP clay in developing low- and mid-range temperature glazes on ceramic bodies. A strong consistency and stability was observed between the glaze recipes on the test tiles made using the ACTP clay. The results indicated that different glaze recipes, ranging between low- (1000°C) and mid-range (1100°C) firing temperatures, mostly fitted consistently with ACTP clay (Figures 2 & 3). This section discusses the results in more detail by using a special rubric that concentrates on general appearance (Glossy or Matte), and common ceramic glaze defects (Shivering, Crawling, and Blisters).

Closer inspection of the test tiles, shown in Figures 2 and 3, proved the quality of the ACTP clay in terms of its durability and heat resistance. In the laboratory preparation processes, some dried glazes formed cracks, and this was considered a sign that the glazes had shrunk too much. These cracks provided an opportunity for the crawling to start. This explained the appearance of the crawling defect in the tests numbered 5, 7, 14, 15, 17, 18, 19, 20, and 31. This can be explained by the fact that ingredients with very fine particles, such as zinc, bone ash, and magnesium carbonate, usually contribute to an increase in shrinkage during drying, which causes crawling defects in glazes. However, sometimes in art education and fine art ceramic practices, these types of textures are required, and many artists take advantage of them to develop their artworks. Nevertheless, because this research aimed to examine the clay's quality, it is very important to confirm that this is a glaze defect and that the clay test tiles were not responsible for the crawling phenomenon.

In general, the applications and practical experiments in this research showed the positive quality of ACTP clay if it is used for educational purposes: all 32 tests proved its quality for glazing. Table 2 shows each test's quality factors or defects.

Figure 2. Test tiles showing the final applications of the glaze recipes 1–16 (Appendix 1) after firing the ACTP clay tiles at between 1000°C and 1100°C.

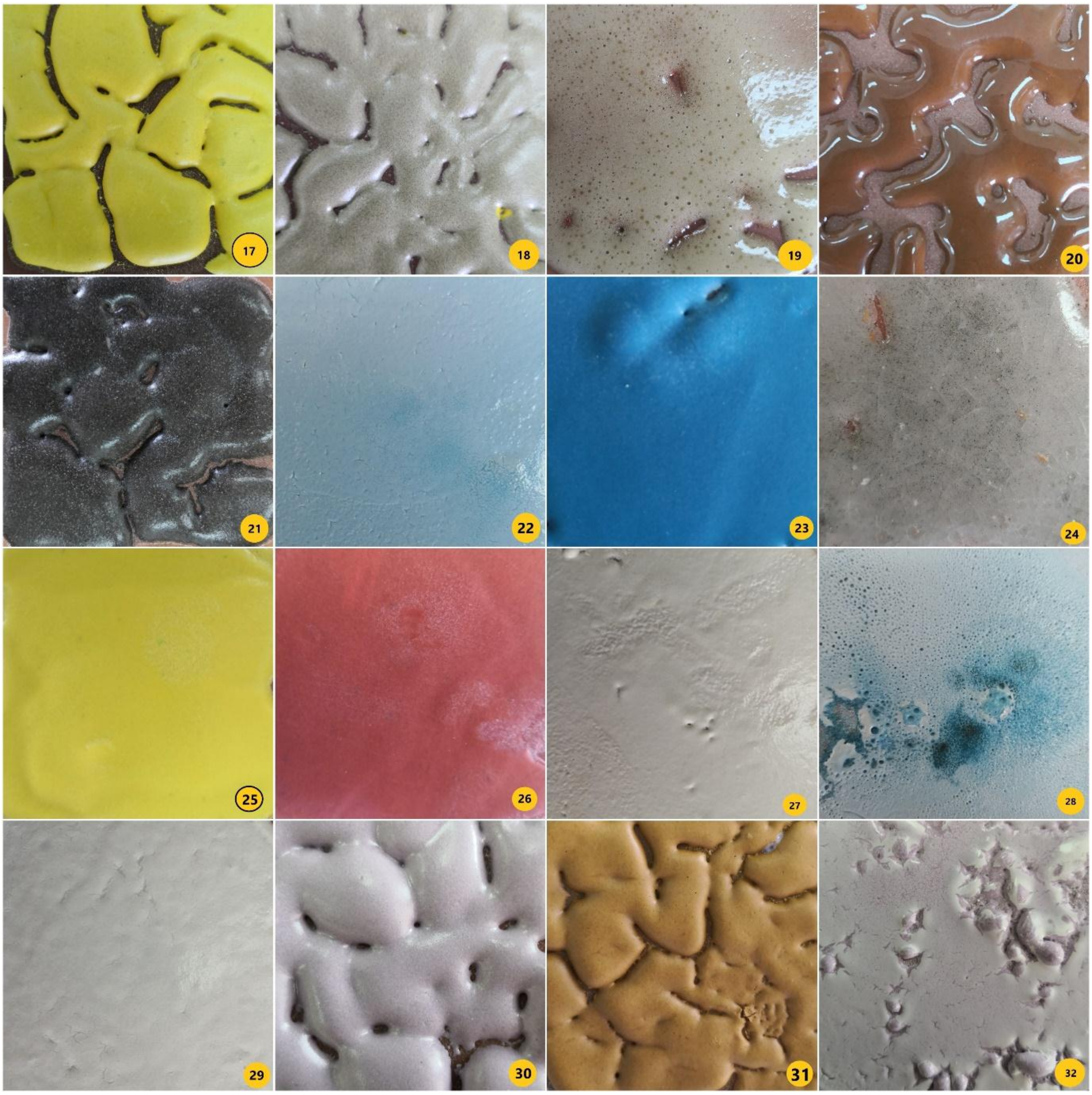

Figure 3. Test tiles showing the final applications of the glaze recipes 17–32 (Appendix 1) after firing the ACTP clay tiles at between 1000°C and 1100°C.

Table 2.

Overall test quality factors or/and defects.

Glaze Test No.	Fit With Clay	General		Glaze Defects		
		Matte	Glossy	Shivering	Crawling	Blisters
1	✓	✓				
2	✓		✓			
3	✓		✓			
4	✓	✓				
5	✓		✓		✓	
6	✓		✓			
7	✓		✓		✓	
8	✓		✓			
9	✓		✓			
10	✓	✓				
11	✓		✓			
12	✓		✓			
13	✓		✓			
14	✓		✓		✓	

15	✓		✓	✓
16	✓	✓		
17	✓	✓		✓
18	✓	✓		✓
19	✓		✓	✓
20	✓		✓	✓
21	✓	✓		✓
22	✓	✓		
23	✓	✓		
24	✓		✓	
25	✓	✓		
26	✓	✓		
27	✓	✓		
28	✓	✓		
29	✓	✓		
30	✓	✓		✓
31	✓	✓		✓
32	✓	✓		✓

4. Conclusion and recommendations

One of the more significant findings to emerge from this study is that the local clay gathered and composed by ACTP can fit with all low- and mid-range temperature glazes between 1000°C to 1100°C. This was proved by experimental research conducted in the SQU ceramic lab, where the researcher tested 32 different glaze recipes, as described in this article.

The findings of this study have important implications for future practice in Oman in crafts, ceramic art and ceramic education, including at schools and universities. Prior to this study, it was difficult to predict how ceramic artists or ceramics educators could use the clay recipe mentioned in Table 1 in their studios. Now, we can confirm that the ACTP clay is a practical clay for making artworks and not only ceramic tiles. For commercial purposes, the ACTP factory has the opportunity to invest in making ready-made clays for use in educational institutions instead of importing clays from overseas.

Further to what we achieved in this research, what is now needed is a cross-national study involving intensive research about Omani local clays, their durability, heating resistance, and glaze applications with different temperatures.

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Appendix (1): Tests Recipes

Test Recipe (1)

Chemical item	Percentage (%)
Lead Bisilicate	50
Feldspar	30
Tin Oxide	10
China Clay	6
Whiting	4
Blue PC. 4129.5	4
100%	

Test Recipe (2)

Chemical item	Percentage (%)
Lead Bisilicate	60
Cornish stone	30
China clay	5
whiting	5
Copper Carbonite	4
100%	

Test Recipe (3)

Chemical item	Percentage (%)
Lead Bisilicate	60
Cornish stone	30
China clay	5
whiting	5
Rad iron oxide	3
100%	

Test Recipe (4)

Chemical item	Percentage (%)
Lead Bisilicate	60
Cornish stone	30
China clay	5
whiting	5
P4138.5 green	4
100%	

Test Recipe (5)

Chemical item	Percentage (%)
Borax Frit	70
Ball Clay	20
Quartz	9
Rutile	1
Chrome Oxide	2
100%	

Test Recipe (6)

Chemical item	Percentage (%)
P3110 Frit	80
Ball Clay	10
Flint	5
Tin Oxide	2
Bentonite	3
Yellow/ P4148.5	3
100%	

Test Recipe (7)

Chemical item	Percentage (%)
P33110 Frit	80
Ball Clay	10
Flint	5

Tin Oxide	2
Bentonite	3
Brown 4142.5	4
100%	

Test Recipe (8)

Chemical item	Percentage (%)
Ferro 3110 frit	57
Soda fledspar	31
China clay	7
Whiting	5
Red glaze stain p4187.5	4g
100%	

Test Recipe (9)

Chemical item	Percentage (%)
Lead Bisilicate	60
Cornish stone	30
China clay	5
whiting	5
Yellow iron oxide	3
100%	

Test Recipe (10)

Chemical item	Percentage (%)
Lead Bisilicate	50
Potash Feldspar	30
Tin Oxide	10
China Clay	6
Whiting	4
Copper carbonite	3
100%	

Test Recipe (11)

Chemical item	Percentage (%)
Borax Frit	70
Ball Clay	20
Quartz	9
Rutile	1
Blue / P4129.5	3
100%	

Test Recipe (12)

Chemical item	Percentage (%)
Ferro 3110 frit	57
Soda fledspar	31
China clay	7
Whiting	5
Manga Dioxide	4g
100%	

Test Recipe (13)

Chemical item	Percentage (%)
P3110 Frit	80
Ball Clay	10
Flint	5
Tin Oxide	2
Bentonite	3
Iron oxide purple	3
100%	

Test Recipe (14)

Chemical item	Percentage (%)
Borax Frit	70
Ball Clay	20
Quartz	9
Rutile	1
Yellow p4189.5	2
Purple p4132.5	1
100%	

Test Recipe (15)

Chemical item	Percentage (%)
Borax Frit	70
Ball Clay	20
Quartz	9
Rutile	1
Iron Oxide Purple	3
100%	

Test Recipe (16)

Chemical item	Percentage (%)
Ferro 3110 frit	57
Soda fledspar	31
China clay	7
Whiting	5
Iron oxide purple	3g
100%	

Test Recipe (17)

Chemical item	Percentage (%)
Lead bisilicate	50
Feldspar soda	20
Chaina clay	10
whiting	10
Yellow stain	10
Yellow iron oxide	3g
100%	

Test Recipe (18)

Chemical item	Percentage (%)
Lead Bisilicate	50

Feldspar	30
Tin Oxide	10
China Clay	6
Whiting	4
Purple iron oxide	4
100%	

Test Recipe (19)

Chemical item	Percentage (%)
Borax Frit	70
Ball Clay	20
Quartz	9
Rutile	1
Lead Oxide	3
100%	

Test Recipe (20)

Chemical item	Percentage (%)
P3110 Frit	80
Ball Clay	10
Flint	5
Tin Oxide	2
Bentonite	3
Brown/ P4142.5	3
100%	

Test Recipe (21)

Chemical item	Percentage (%)
Ferro 3110 frit	57
Soda fledspar	31
China clay	7
Whiting	5
Nickle oxide black	3g
100%	

Test Recipe (22)

Chemical item	Percentage (%)
Ferro 3110 frit	53
Potash feldspar	27
Yellow stain	10
China clay	6
China clay	4
Blue P 4129.5	4g
100%	

Test Recipe (23)

Chemical item	Percentage (%)
Ferro 3110 frit	57
Soda fledspar	31
China clay	7
Whiting	5
Sky blue p4129.5	4g

100%

Test Recipe (24)

Chemical item	Percentage (%)
P3110 Frit	80
Ball Clay	10
Flint	5
Tin Oxide	2
Bentonite	3
Iron Oxide Spangles	2
Yellow Iron Qxide	2
100%	

Test Recipe (25)

Chemical item	Percentage (%)
Ferro 3110 frit	57
Soda fledspar	31
China clay	7
Whiting	5
Golden yellow stain p4140.5	4g
100%	

Test Recipe (26)

Chemical item	Percentage (%)
Ferro 3110 frit	57
Soda fledspar	31
China clay	7
Whiting	5
P4140.5 Golden yellow	2g
P4148.5 Manderin Yellow	2g
P4187.5 Red Glaze	2g
100%	

Test Recipe (27)

Chemical item	Percentage (%)
Ferro 3110 frit	53
Potash feldspar	27
Yellow stain	10
China clay	6
China clay	4
Red iron oxide	3 g
100%	

Test Recipe (28)

Chemical item	Percentage (%)
Ferro 3110 frit	53
Potash feldspar	27
Yellow stain	10
China clay	6
China clay	4
Capper oxide	3g

100%

Test Recipe (29)

Chemical item	Percentage (%)
Ferro 3110 frit	53
Potash feldspar	27
Yellow stain	10
China clay	6
China clay	4
Antimony oxide	3g
100%	

Test Recipe (30)

Chemical item	Percentage (%)
Lead Bisilicate	50
Feldspar	30
Tin Oxide	10
China Clay	6
Whiting	4
Purple P. 4182.5	4
100%	

Test Recipe (31)

Chemical item	Percentage (%)
Lead bisilicate	50
Feldspar soda	20
Chaina clay	10
whiting	10
Yellow stain	10
P4179.5 orange	4g
100%	

Test Recipe (32)

Chemical item	Percentage (%)
Ferro 3110 frit	53
Potash feldspar	27
Yellow stain	10
China clay	6
China clay	4
Purple p4182.5	4g
100%	