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# Mineral contents in the soil clays of two pottery villages in Manipur

**L Premjit Singh, Sagolsem Lokhol Singh, M Premchand Singh and Y Sexona Singh**

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**Abstract**
The clays are among the most important soils of the world. The clay minerals are important for construction, pottery and ceramic items. As clays are materials originated from decomposition of rocks made up of clay minerals and non-clay minerals, their applicability depends on their chemical and mineralogical compositions. With an aim at studying the clay types and applicability of the clays of Manipur in general and that of Thongjao s/c village and Nongpok Sekmai village in particular, the study has been done. During the period of survey samples were collected from different sites in large scales from each of the villages in different depths. These clays have pH values ranging from 4.5 to 6.9 and are found to contain 0.67% to 3.547% organic carbon, 260 to 565 Kg per Hectare of Nitrogen and 22.4 to 78.5 Kg per Hectare of potassium. The clays were analysed using the Energy Dispersive X-Ray Spectroscopy (EDXS) after heating in order to remove moisture, Scanning Electron Microscope (SEM) and identified their chemical components.
The study may contribute valuable information in the practices leading towards sustainable development that may enhance and promote economic well-being of the community in the area.

**Keywords:** Energy dispersive x-ray spectroscopy (EDXS), scanning electron microscope (SEM)

## 1. Introduction
The word "clay" is derived from the middle English word 'cley', old English word 'claeg', Proto-West Germanic word 'klaij', Proto- Germanic word 'klajjaz', Proto-Indo-European word 'gley' - which means to glue, paste or stick together1. It refers to a naturally occurring material which is composed of fine-grained minerals. It is like a plastic when wet and it becomes hard when dried or fired. Clays have been used since Paleolithic clay times with the earliest known ceramics found at Dolní Věstonice (Czech Republic) dated at ca. 28,000 years old (*Vandiver et al.*, 1989) [13]. Clay study depends on the particle size. Geologists and soil scientists usually consider the size of the clay particle as 2 µm, sedimentologists use the particle size 4 µm and colloid chemists use 1 µm clay particle size2.

### 1.1 Clays are divided into two classes
**(A). Residual clay**
Residual clays are found in the place of origin and formed by surface weathering which give rise to clay in three ways:
i) Chemical decomposition of rocks, such as granite containing silica and alumina.
ii) Solution of rocks, such as limestone, containing clayey impurities, which, being insoluble, are deposited as clay.
iii) Disintegration and solution of shale.

**(B). Transported clay**
Transported clay is also known as sedimentary clay and it is removed from the place of origin by erosion and deposited in a new and possibly distant position3.
Clay can also be classified depending on the way that the tetrahedral and octahedral sheets are packed into layers. The major groups of clay minerals present in the soil environment include layer and chain silicates, sesquioxides, and other inorganic minerals.
Coil pottery, traditional way of making pottery items, has been practicing by the villagers of Thongjao s/c villages and Nongpok Sekmai village from time immemorial. Different types of pots with different colours and different names are made for different purposes. Pots occupied a part in Manipuri culture in religious ceremonies and domestic purposes, the demand for the

same continues to live on. Ancient art of making earthen-wares of Manipur is however, transformed now into new innovative designs and models to increase the volume of sale to potential buyers aside from regular consumers. Today's potters are creating items aside from the traditional pots, particularly models of turtles, penguins, candle stands and others. The finished pottery products of Thongjao are open edge than that of their counterparts at Nongpok Sekmai and nearby villages.

## 2. Experimental

### 2.1 Materials Collection

Clay samples were collected from the villages viz Thongjao Schedule caste village and Nongpok Sekmai village with a small spade from 0 - 30 cms depth at each sample location. The samples were thoroughly homogenized to form a composite sample, air dried, finely powdered and stored in air tight plastic containers for analysis.

### 2.2 Experimentation

The finely powdered samples were placed in the oven at 700C for 24 hours to remove the moisture completely. These clays have pH values ranging from 4.5 to 6.9 and are found to contain 0.67% to 3.547% organic Carbon, 260 to 565 Kg per hectare of Phosphorous and 22.4 to 78.5 Kg per hectare of Potassium. The clays were then subjected to Energy Dispersive X- ray Spectroscopy (EDXS) - Scanning Electron Microscope (SEM) (Carl Zeiss Sigma 300) at a magnification of 800, 1000 and 1004 under an emission current that changes with the accelerating voltage while pressure maintained at 10E-7 pascal for elemental mapping.

## 3. Result and discussion

### 3.1 Clays of Thongjao S/C village

#### 3.1.1 Area 1

This clay sample shows the back scattered grains Consisting of smooth grains as well as powdered aggregates and oxygen dominated elements.

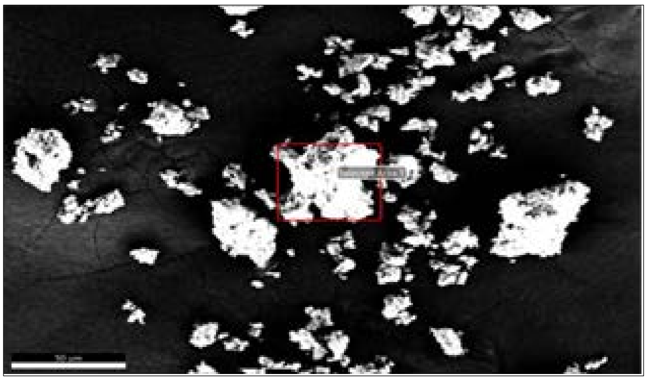
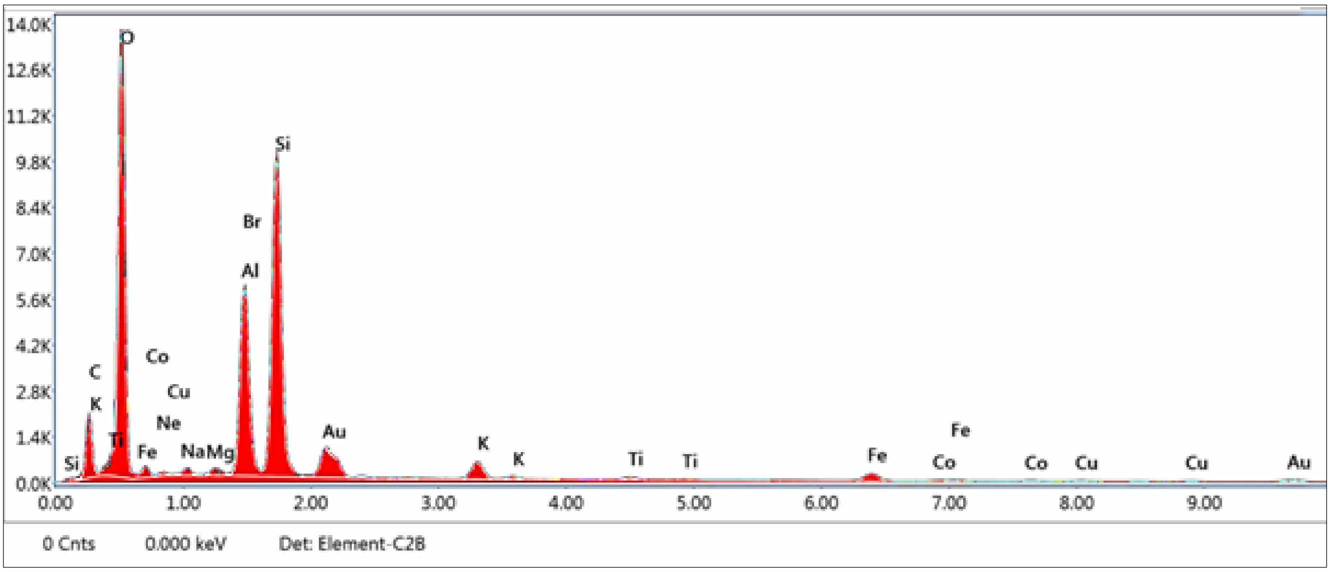


**Fig 1:** Back scattered image of Area 1 Sample 1

**Table 1:** EDXS - SEM **Smart Quant Results**

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| C K | 14.12 | 22.35 | 11.02 |
| O K | 48.74 | 57.9 | 9.06 |
| NeK | 0.22 | 0.21 | 40.7 |
| NaK | 0.66 | 0.54 | 18.76 |
| MgK | 0.35 | 0.27 | 14.38 |
| BrL | 4.18 | 1 | 4.09 |
| AlK | 6.55 | 4.61 | 6.11 |
| SiK | 15.96 | 10.8 | 5.55 |
| AuM | 4.3 | 0.42 | 8.81 |
| K K | 1.57 | 0.76 | 6.14 |
| TiK | 0.4 | 0.16 | 18.94 |
| FeK | 2.13 | 0.72 | 7.66 |
| CoK | 0.26 | 0.08 | 39.83 |
| CuK | 0.56 | 0.17 | 30.86 |




kV: 15 Mag: 1004 Takeoff: 23.6 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV) 128.6

**Fig 2:** EDXS - SEM Mapping of Area 1 Sample 1

**Area 1 Sample 2**

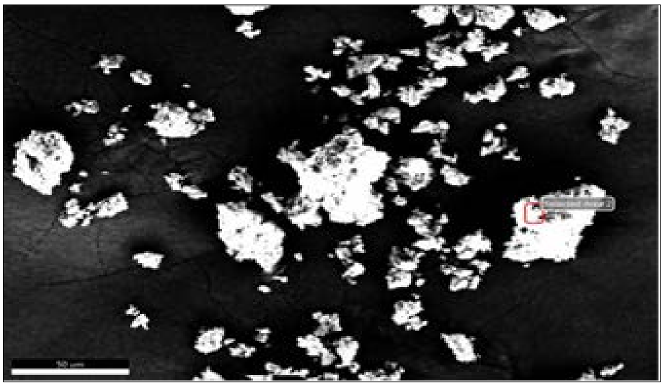
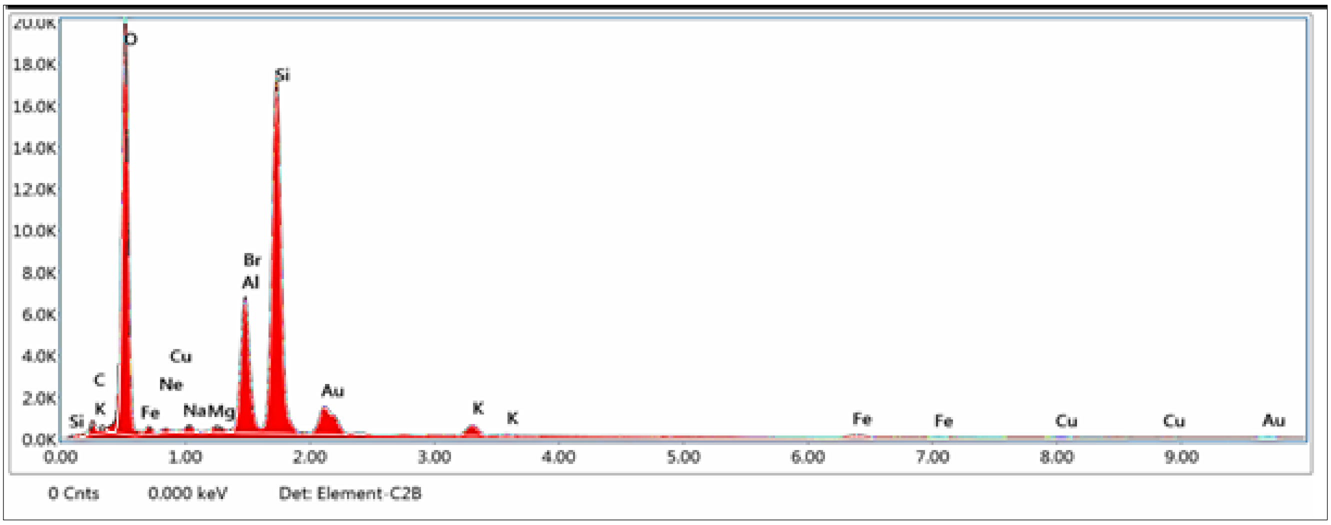


**Fig 3:** Back scattered image of Area 1 Sample 2

**Table 2:** EDXS - SEM Smart Quant Results

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| C K | 2.86 | 4.99 | 15.94 |
| O K | 51.56 | 67.54 | 8.52 |
| NeK | 0.39 | 0.41 | 24.38 |
| NaK | 0.92 | 0.84 | 14.72 |
| MgK | 0.45 | 0.39 | 13.66 |
| BrL | 4.67 | 1.23 | 3.95 |
| AlK | 6.04 | 4.69 | 6.17 |
| SiK | 24.07 | 17.97 | 5.45 |
| AuM | 6.08 | 0.65 | 6.63 |
| K K | 1.38 | 0.74 | 7.37 |
| FeK | 0.98 | 0.37 | 12.44 |
| CuK | 0.59 | 0.19 | 35.52 |




kV: 15 Mag: 1004 Takeoff: 23.6 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV) 128.6

**Fig 4:** EDXS - SEM Mapping of Area 1 Sample 2

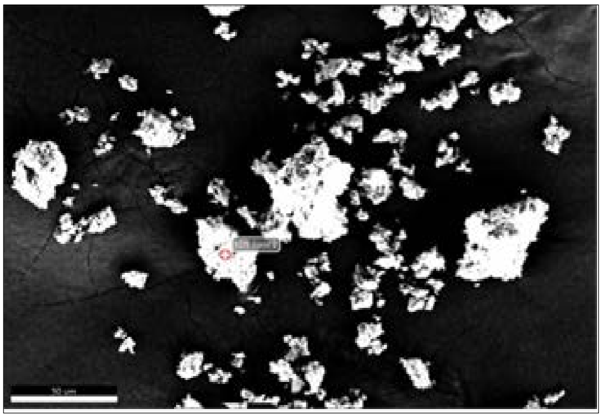
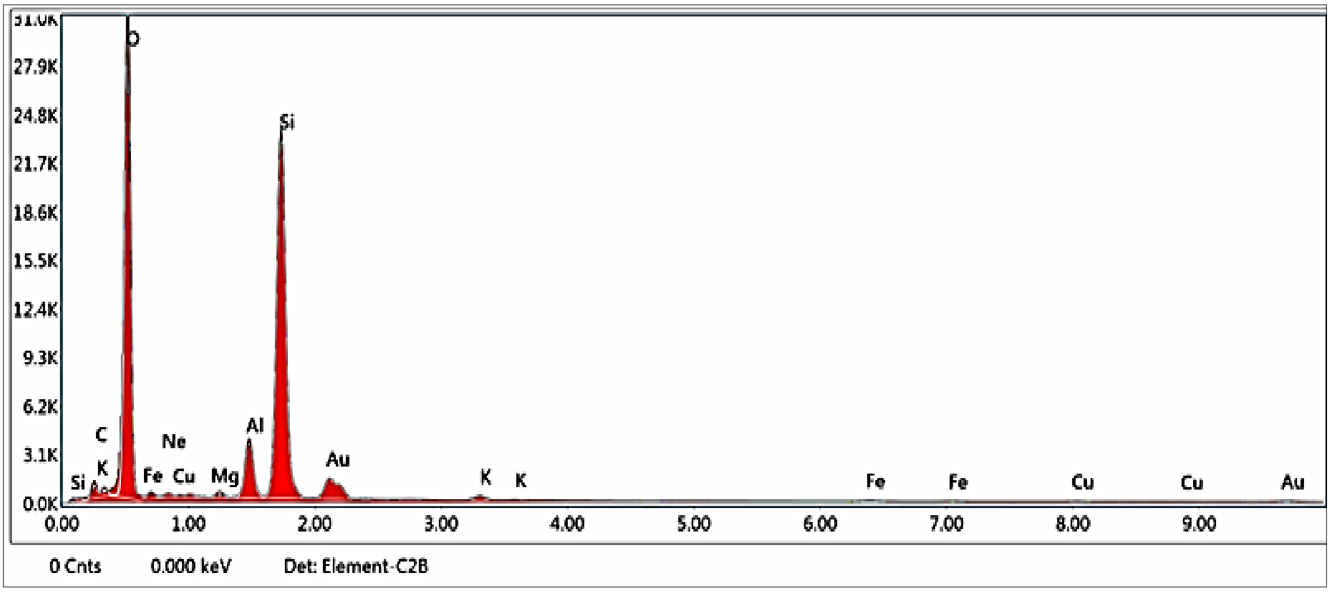


**Fig 5:** Back scattered image of Area 1 Sample 3

**Table 3:** Smar Quan Result

| Elemen | Weigh% | Atomi% | Erro % |
|---|---|---|---|
| C K | 5.02 | 8 | 12.91 |
| O K | 58.83 | 70.29 | 8.05 |
| NeK | 0.49 | 0.47 | 21.26 |
| MgK | 0.47 | 0.37 | 11.04 |
| AlK | 4.31 | 3.06 | 6.06 |
| SiK | 24.61 | 16.75 | 4.63 |
| AuM | 4.62 | 0.45 | 7.48 |
| K K | 0.57 | 0.28 | 10.96 |
| FeK | 0.53 | 0.18 | 17.71 |
| CuK | 0.53 | 0.16 | 34.63 |




kV: 15 Mag: 1004 Takeoff: 23.6 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV) 128.6

**Fig 6:** EDXS - SEM Mapping of Area 1 Sample 3

## Area 1

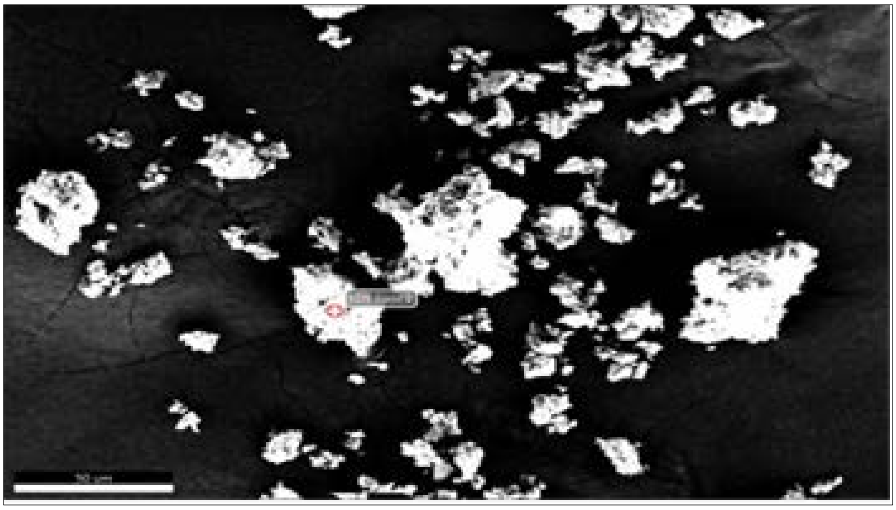
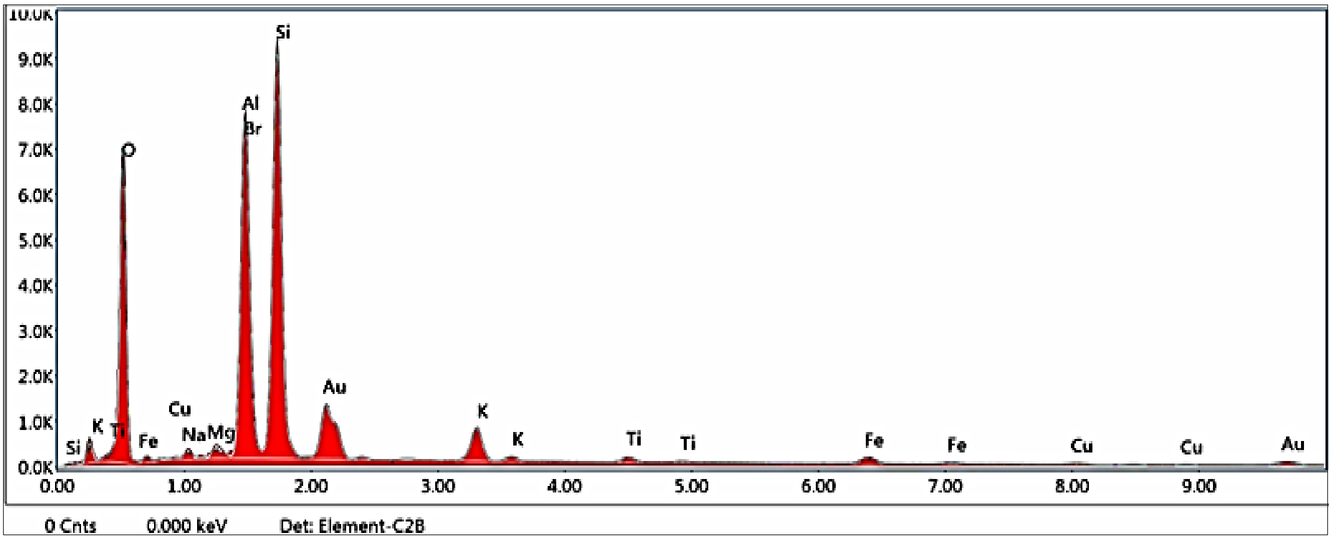


**Fig 7:** Back scattered image of Area 1 Sample 4

**Table 4:** EDXS - SEM Smart Quant Results

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| O K | 37.23 | 58.14 | 9.37 |
| NaK | 0.93 | 1.01 | 14.3 |
| MgK | 0.64 | 0.66 | 11.33 |
| BrL | 8.17 | 2.56 | 3.6 |
| AlK | 11.91 | 11.03 | 5.92 |
| SiK | 24.16 | 21.49 | 6.38 |
| AuM | 9.78 | 1.24 | 5.5 |
| K K | 3.42 | 2.19 | 6.68 |
| TiK | 0.75 | 0.39 | 16.84 |
| FeK | 2.13 | 0.95 | 9.71 |
| CuK | 0.88 | 0.35 | 31.77 |




kV: 15 Mag: 1004 Takeoff: 23.6 Live Time(s): 30Amp Time(μs): 3.84 Resolution:(eV) 128.6

**Fig 8:** EDXS-SEM Mapping of Area 1 Sample 4

**Table 5:** A comparative detailed data of the four samples of Area 1 is given in the table below:

| Element | Sample - 1 | | | Sample - 2 | | | Sample - 3 | | | Sample - 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wt. % | Atomic % | Error % | Wt. % | Atomic % | Error % | Wt. % | Atomic % | Error % | Wt. % | Atomic % | Error % |
| CK | 14.12 | 22.35 | 11.02 | 2.86 | 4.99 | 15.94 | 5.02 | 8 | 12.91 | 37.23 | 58.14 | 9.37 |
| OK | 48.74 | 59.9 | 9.06 | 51.56 | 67.54 | 8.52 | 58.83 | 70.29 | 8.05 | - | - | - |
| NeK | 0.22 | 0.21 | 40.7 | 0.39 | 0.41 | 24.38 | 0.49 | 0.47 | 21.26 | - | - | - |
| NaK | 0.66 | 0.54 | 18.76 | 0.92 | 0.84 | 14.72 | - | - | - | 0.93 | 1.01 | 14.3 |
| MgK | 0.35 | 0.27 | 14.38 | 0.45 | 0.39 | 13.66 | 0.47 | 0.37 | 11.04 | 0.64 | 0.66 | 11.33 |
| BrL | 4.18 | 1 | 4.09 | 4.67 | 1.23 | 3.95 | - | - | - | 8.17 | 2.56 | 3.6 |
| AlK | 6.55 | 4.61 | 6.11 | 6.04 | 4.69 | 6.17 | 4.31 | 3.06 | 6.06 | 11.91 | 11.03 | 5.92 |
| SiK | 15.96 | 10.8 | 5.55 | 24.07 | 17.97 | 5.45 | 24.61 | 16.75 | 4.63 | 24.16 | 21.49 | 6.38 |
| AuM | 4.3 | 0.42 | 8.81 | 6.08 | 0.65 | 6.63 | 4.62 | 0.45 | 7.48 | 9.78 | 1.24 | 5.5 |
| KK | 1.57 | 0.76 | 6.14 | 1.38 | 0.74 | 7.37 | 0.57 | 0.28 | 10.96 | 3.42 | 2.19 | 6.68 |
| TiK | 0.4 | 0.16 | 18.94 | - | - | - | - | - | - | 0.75 | 0.39 | 16.84 |
| FeK | 2.13 | 0.72 | 7.66 | 0.98 | 0.37 | 12.44 | 0.53 | 0.18 | 17.71 | 2.13 | 0.95 | 9.71 |
| CoK | 0.26 | 0.08 | 38.83 | - | - | - | - | - | - | - | - | - |
| CuK | 0.56 | 0.17 | 30.86 | 0.59 | 0.19 | 35.52 | 0.53 | 0.16 | 34.63 | 0.08 | 0.35 | 31.77 |

The above data show that sample 1 of area 1 Thongjao is anoxygen rich silicon with other elements like Potassium, aluminium, Iron, Sodium, Gold, Cobalt, Copper, Titanium, Magnesium, etc. (Figs. 1 & 2); sample 2 is also an oxygen dominated silicon with other elements like Potassium, aluminium, Iron, Sodium, Gold, Magnesium, Copper, etc. (Figs. 3 & 4); sample No. 3 is silicon dominated clay with other elements like Potassium, aluminium, Iron, Gold, Copper, Sodium, Magnesium, Titanium and oxygen (Figs. 5 & 6) while sample No. 4 gives a bulk spectrum dominated by silicon containing other elements like aluminium, gold, potassium, iron, sodium, magnesium, titanium from moderate to mild traces (Figs. 7 & 8).

### 3.1.2 Thongjao Area 2

The clay samples show the backscatter image and it is seen that the particles are powdered and aggregate with a few larger particles.

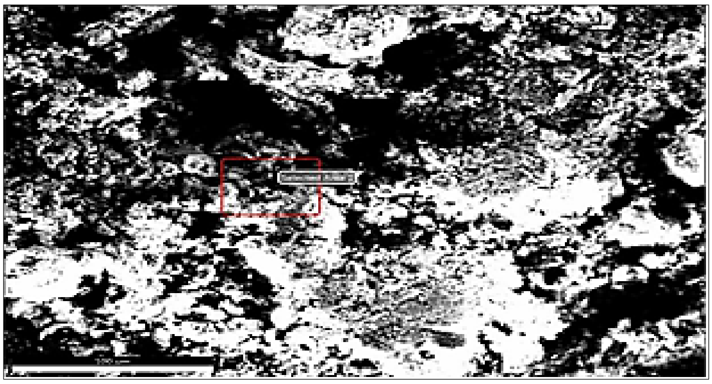
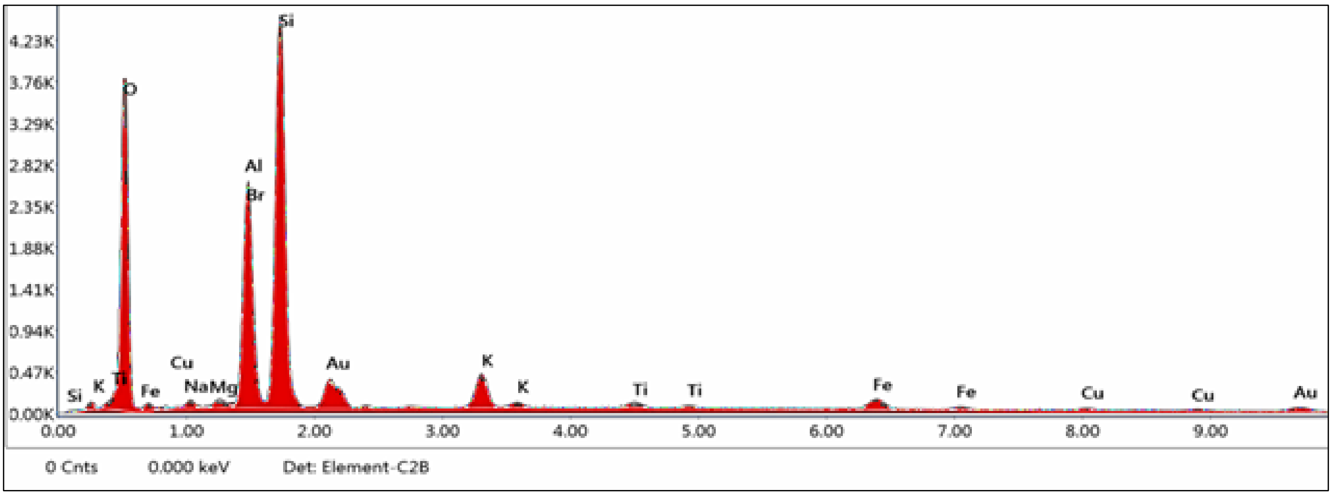


**Fig 9:** Back scattered image of Thongjao Area 2 Sample 1

**Table 6:** Smart Quant Results

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| O K | 42.06 | 62.17 | 9.37 |
| Na K | 0.87 | 0.9 | 20.34 |
| Mg K | 0.47 | 0.45 | 18.35 |
| B K | 7.05 | 2.09 | 4.83 |
| Al K | 8.75 | 7.07 | 6.69 |
| Si K | 24.88 | 20.95 | 6.28 |
| Au M | 5.46 | 0.66 | 10.21 |
| K K | 3.91 | 2.37 | 6.97 |
| Ti K | 1.94 | 0.87 | 10.91 |
| Fe K | 3.7 | 1.57 | 11.05 |
| Cu K | 1.86 | 0.69 | 28.32 |




kV: 15 Mag: 800 Takeoff: 23.6 Live Time(s): 30 Amp Time(μs): 3.84Resolution:(eV) 128.6

**Fig 10:** EDXS - SEM Mapping of Area 2 Sample 1

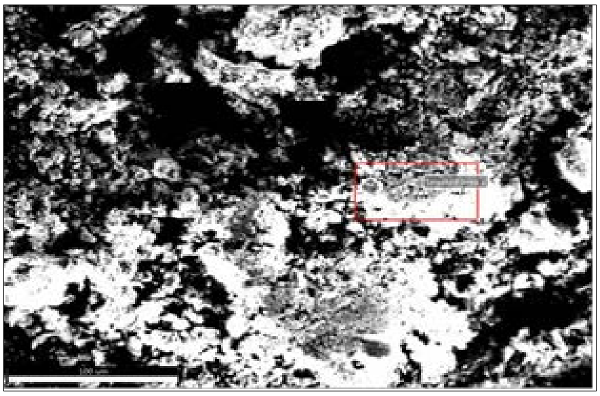
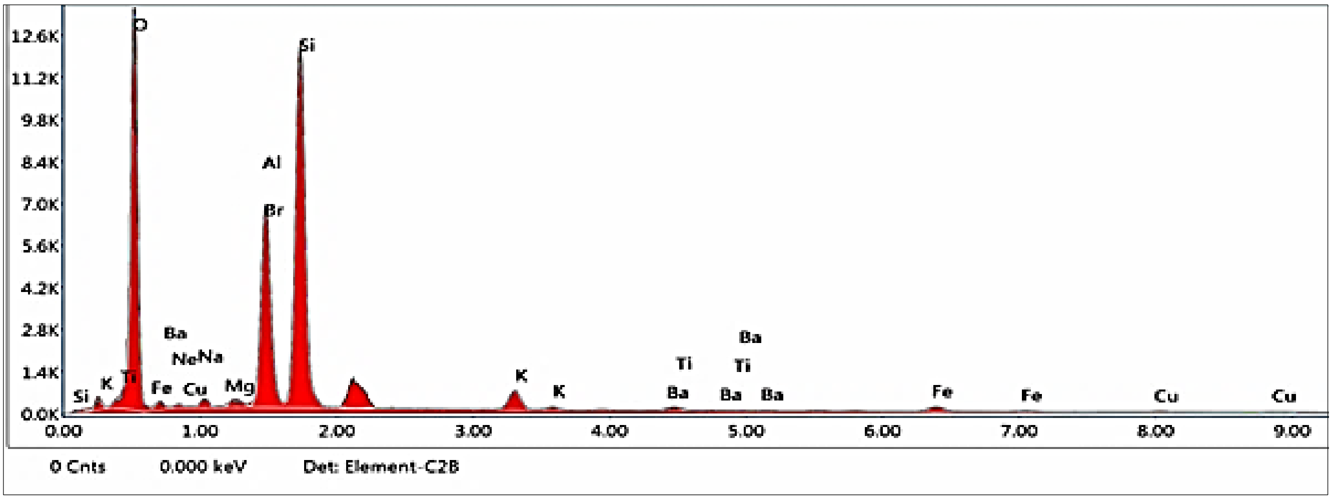


**Fig 11:** Back scattered image of Thongjao Area 2 sample 2

**Table 7:** Smart Quant Results

| Element | Value 1 | Value 2 | Value 3 |
|---|---|---|---|
| O K | 49.62 | 66.83 | 8.57 |
| NeK | 0.33 | 0.35 | 29.03 |
| NaK | 1.07 | 1.01 | 14.54 |
| MgK | 0.51 | 0.45 | 13.95 |
| BrL | 7.42 | 2.00 | 3.56 |
| AlK | 8.43 | 6.73 | 6.05 |
| SiK | 26.08 | 20.01 | 5.90 |
| K K | 2.36 | 1.30 | 6.12 |
| BaL | 1.21 | 0.19 | 39.34 |
| TiK | 0.33 | 0.15 | 26.28 |
| FeK | 1.91 | 0.74 | 9.80 |
| CuK | 0.74 | 0.25 | 28.59 |




kV: 15 Mag: 800 Takeoff: 23.6 Live Time(s): 30 Amp Time(μs): 3.84 Resolution:(eV) 128.6

**Fig 12:** EDXS - SEM Mapping of Area 2 Sample 2

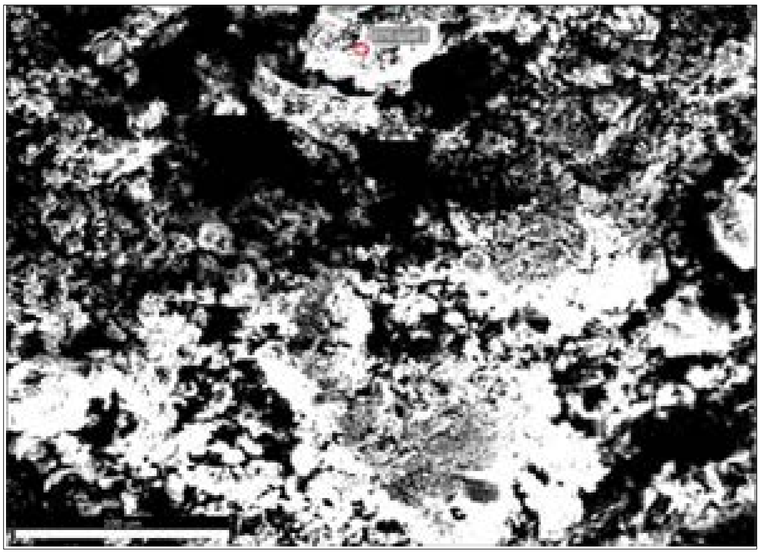
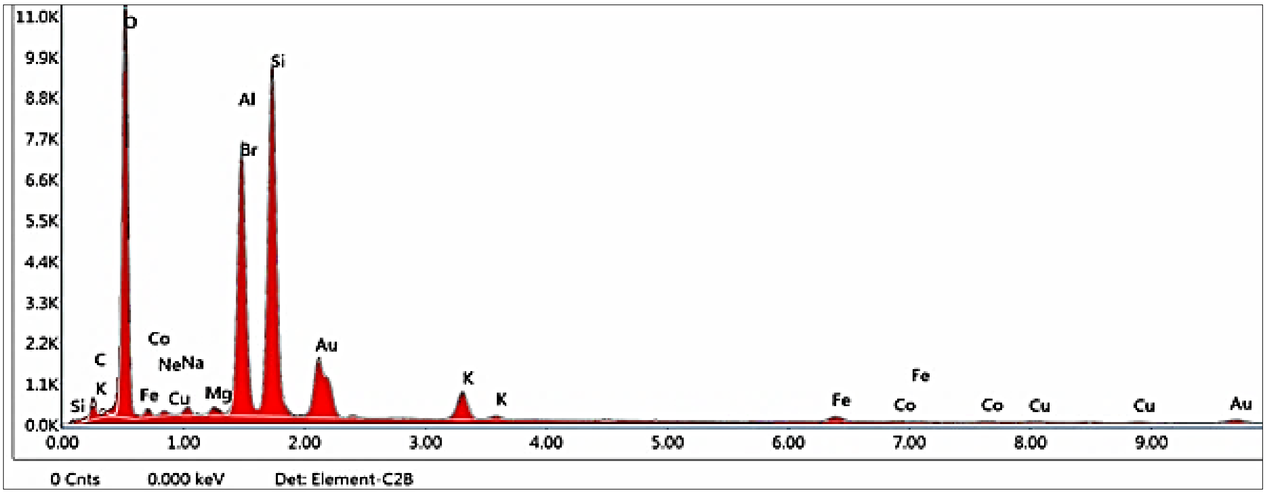


**Fig 13:** Back scattered image of Area 2 sample 3

**Table 8:** Smart Quant Results

| Element | Value 1 | Value 2 | Value 3 |
|---|---|---|---|
| C K | 1.7 | 3.26 | 24.16 |
| O K | 44.2 | 63.57 | 8.92 |
| NeK | 0.35 | 0.4 | 27.39 |
| NaK | 0.79 | 0.79 | 18.12 |
| MgK | 0.38 | 0.36 | 14.6 |
| BrL | 5.06 | 1.46 | 4.54 |
| AlK | 11.12 | 9.48 | 6.02 |
| SiK | 20.25 | 16.59 | 6.09 |
| AuM | 10.28 | 1.2 | 5.38 |
| K K | 2.89 | 1.7 | 6.33 |
| FeK | 1.75 | 0.72 | 11.34 |
| CoK | 0.36 | 0.14 | 38.95 |
| CuK | 0.86 | 0.31 | 37.29 |




kV: 15 Mag: 800 Takeoff: 23.6 Live Time(s): 30 Amp Time(μs): 3.84 Resolution:(eV) 128.6

**Fig 14:** EDXS - SEM Mapping of Thongjao Area 2 Sample 3

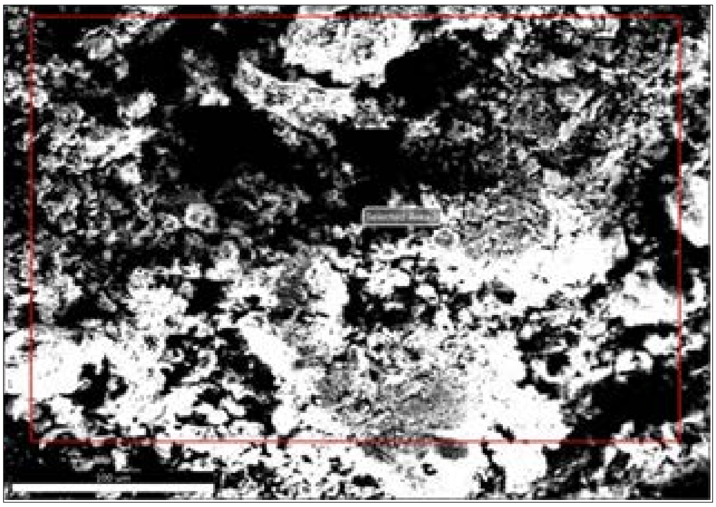
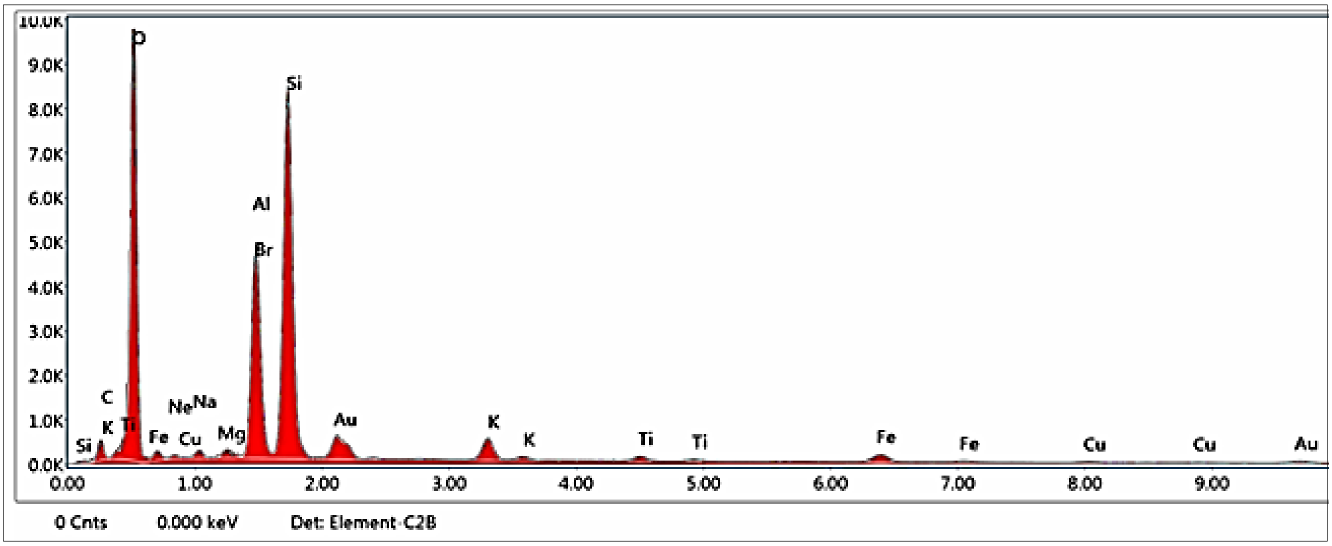


**Fig 15:** Back scattered image of Area 2 sample 4

**Table 9:** Smart Quant Results

| Element | Value 1 | Value 2 | Value 3 |
|---|---|---|---|
| C K | 3.46 | 6.14 | 16.72 |
| O K | 48.49 | 64.58 | 8.86 |
| NeK | 0.28 | 0.29 | 36.21 |
| NaK | 0.85 | 0.79 | 17.47 |
| MgK | 0.47 | 0.41 | 14.56 |
| BrL | 5.79 | 1.54 | 4.24 |
| AlK | 7.89 | 6.23 | 6.30 |
| SiK | 21.91 | 16.62 | 5.86 |
| AuM | 4.20 | 0.45 | 9.82 |
| K K | 2.37 | 1.29 | 6.60 |
| TiK | 0.74 | 0.33 | 12.57 |
| FeK | 2.71 | 1.03 | 8.85 |
| CuK | 0.85 | 0.28 | 39.97 |




kV: 15 Mag: 800 Takeoff: 23.6 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV) 128.6

**Fig 16:** EDXS - SEM Mapping of Area 2 Sample 4

The EDXS - SEM data of area 2 (Figures from 9 to 16) shows that the clay samples are oxygen dominated silicon with other elements like aluminium, Gold (excepting in sample 2), potassium, copper, magnesium, Titanium (excepting in sample 3) iron, Sodium, Neon (excepting in sample 1), etc.

### 3.2.1 Nongpok Sekmai

**Nongpok Sekmai Area 1 Sample1**

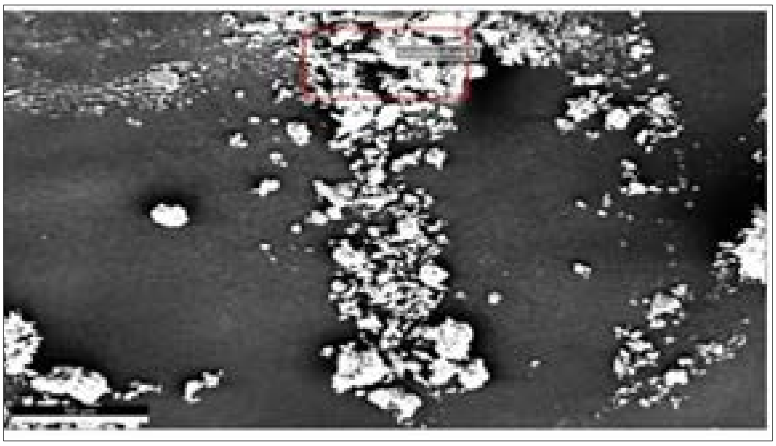
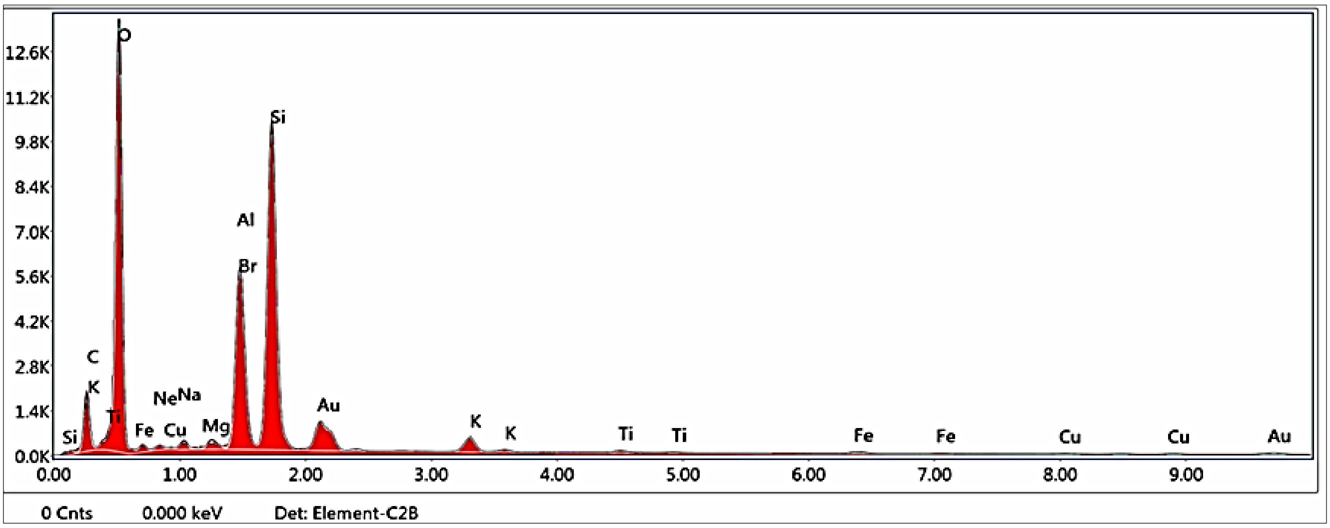


**Fig 17:** Back scattered image of Nongpok Sekmai Area 1 sample 1

**Table 10:** Smart Quant Results

| Element | Wt % | Atomic % | Error % |
|---|---|---|---|
| C K | 14.1 | 22.4 | 11.05 |
| O K | 47.86 | 57.1 | 8.94 |
| Ni K | 0.32 | 0.31 | 27.68 |
| Na K | 0.81 | 0.67 | 14.57 |
| Mg K | 0.47 | 0.37 | 12.12 |
| Bd L | 4.96 | 1.18 | 3.53 |
| Al K | 6.16 | 4.36 | 5.79 |
| Si K | 17.42 | 11.84 | 5.19 |
| Au M | 4.68 | 0.45 | 7.85 |
| K K | 1.48 | 0.72 | 6.4 |
| Ti K | 0.37 | 0.15 | 24.45 |
| Fe K | 0.68 | 0.23 | 19.65 |
| Cu K | 0.67 | 0.20 | 24.11 |




kV: 15 Mag: 1000 Takeoff: 23.6 Live Time(s): 30 Amp Time(μs): 3.84 Resolution:(eV) 128.6

**Fig 18:** EDXS - SEM Mapping of Nongpok Sekmai Area 1 Sample 1

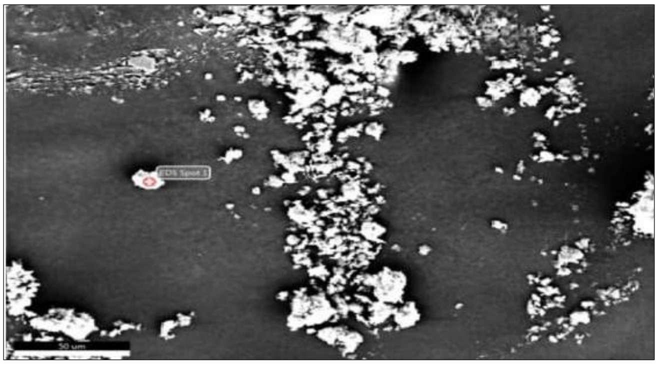
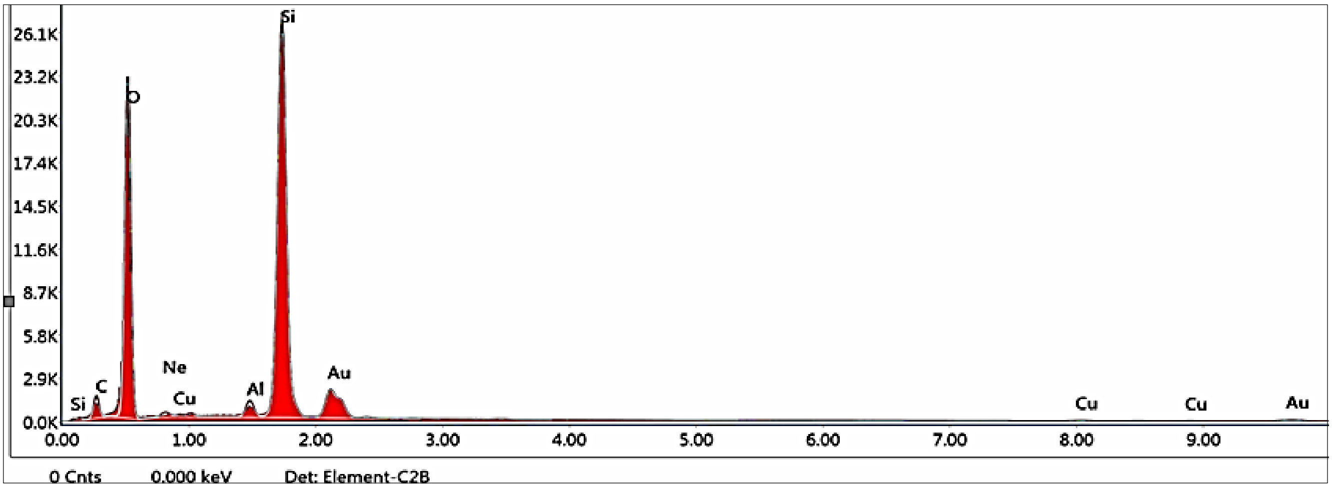


**Fig 19:** Back scattered image of Nongpok Sekmai Area 1 sample 2

**Table 11:** Smart Quant Result

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| C K | 9.90 | 15.95 | 11.59 |
| O K | 51.22 | 61.96 | 8.48 |
| Ne K | 0.32 | 0.31 | 26.71 |
| Al K | 1.29 | 0.93 | 7.05 |
| Si K | 28.84 | 19.88 | 3.89 |
| Au M | 7.71 | 0.76 | 6.06 |
| Cu K | 0.72 | 0.22 | 28.47 |




kV: 15 Mag: 1000 Takeoff: 23.6 Live Time(s): 30 Amp Time(μs): 3.84 Resolution:(eV) 128.6

**Fig 20:** EDXS - SEM Mapping of Nongpok Sekmai Area 1 sample

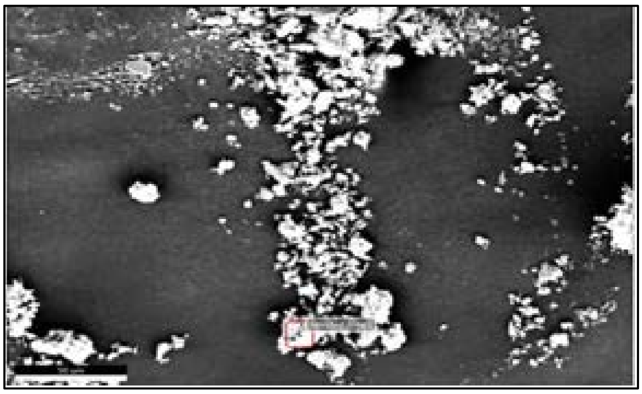
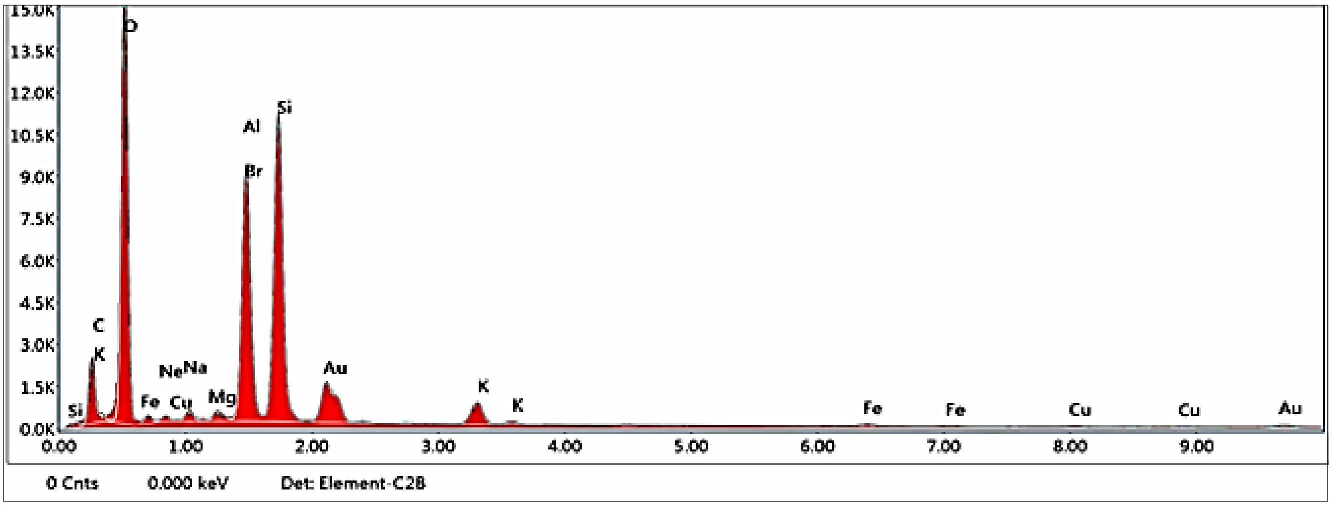


**Fig 21:** Back scattered image of Nongpok Sekmai Area 1 sample 3

**Table 11:** Smart Quant Result

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| C K | 14.01 | 22.87 | 11.01 |
| O K | 44.65 | 54.7 | 9.02 |
| Ne K | 0.35 | 0.34 | 20.22 |
| Na K | 0.92 | 0.79 | 13.34 |
| Mg K | 0.43 | 0.35 | 11.95 |
| Br L | 4.99 | 1.22 | 3.45 |
| Al K | 8.99 | 6.53 | 5.44 |
| Si K | 15.78 | 11.01 | 5.42 |
| Au M | 6.21 | 0.62 | 6.52 |
| K K | 2.14 | 1.07 | 5.56 |
| Fe K | 0.78 | 0.27 | 16.2 |
| Cu K | 0.74 | 0.23 | 25.02 |




kV: 15 Mag: 1000 Takeoff: 23.6 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV) 128.6

**Fig 22:** EDXS - SEM Mapping of Nongpok Sekmai Area 1 Sample 3

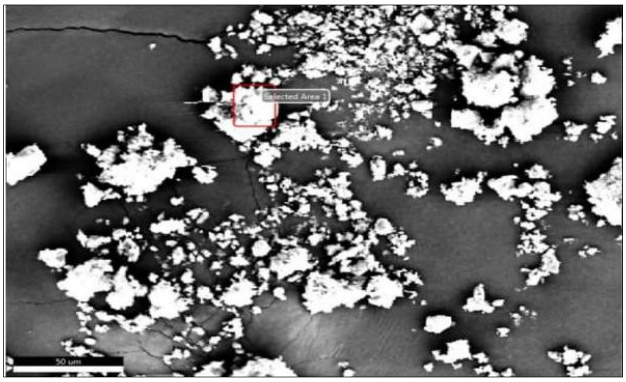
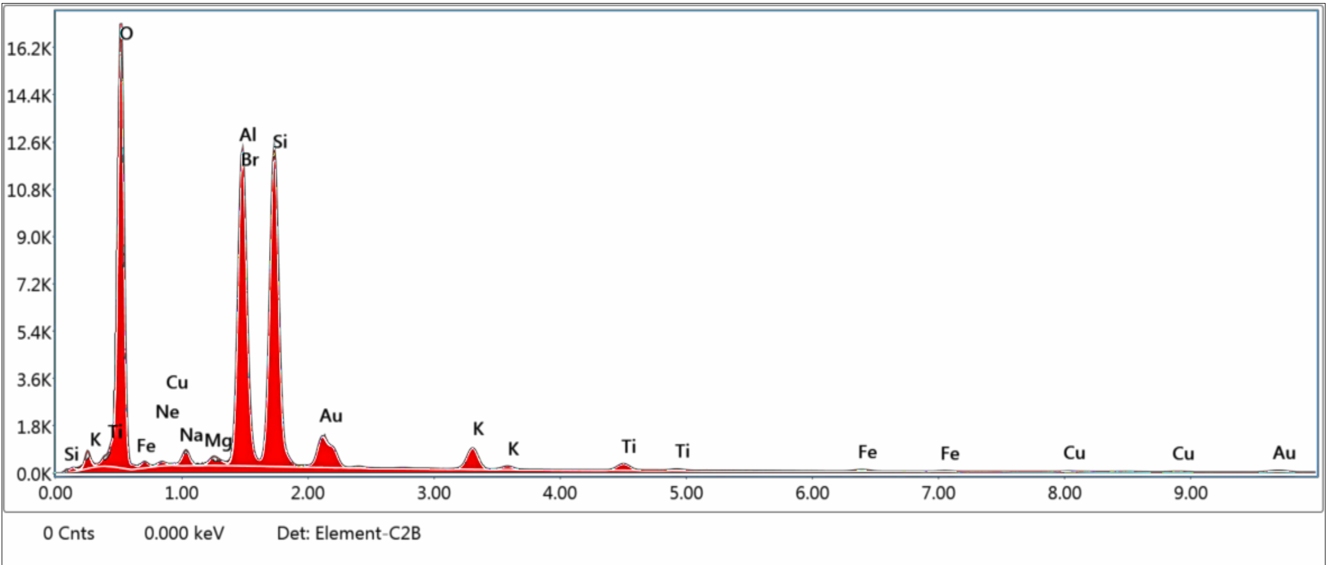


**Fig 23:** Back scattered image of Nongpok Sekmai Area 1 sample




kV: 15 Mag: 1000 Takeoff: 23.6 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV) 128.6

**Fig 24:** EDXS - SEM Mapping of Nongpok Sekmai Area 1 Sample 4

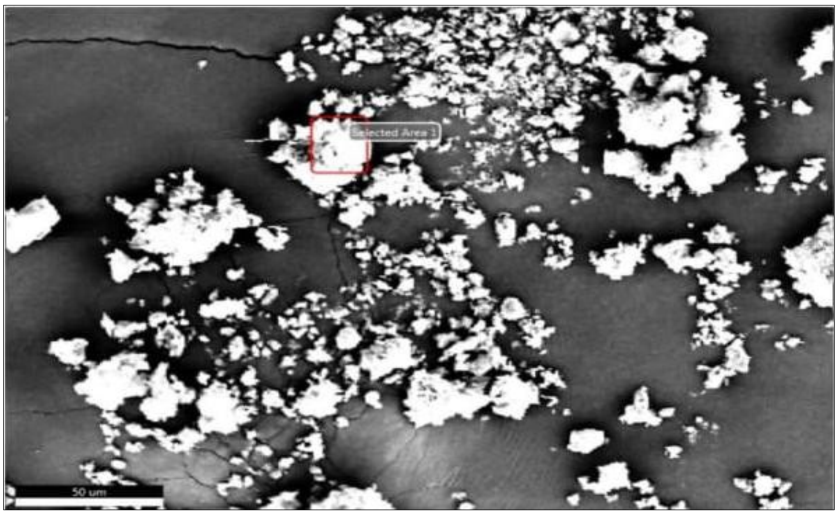
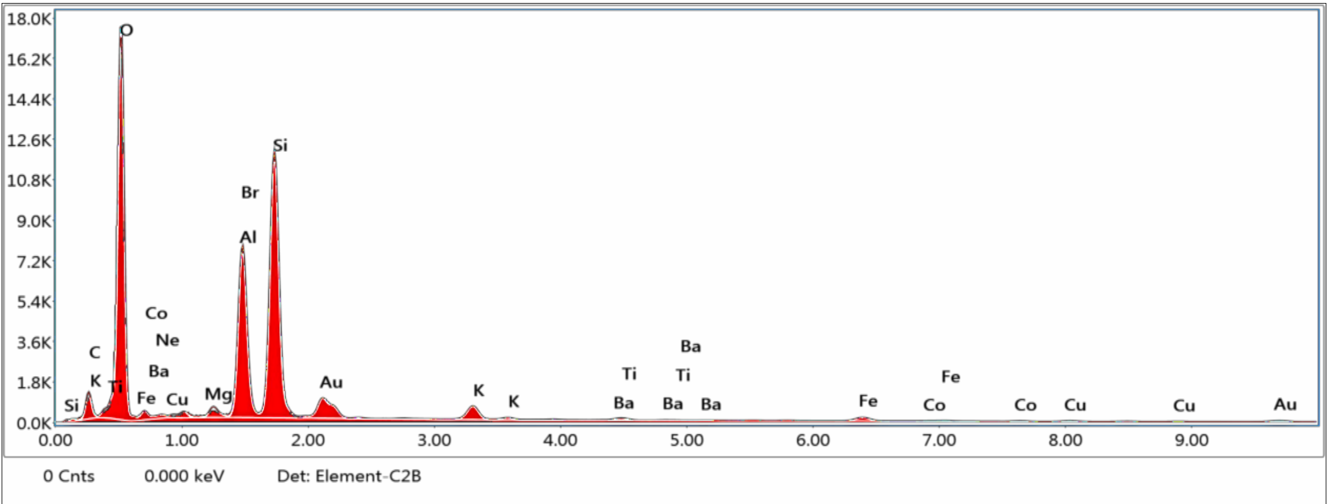



**Fig 25:** Back scattered image of Nongpok Sekmai Area 2 sample 1

**Table 12:** Smart Quant Result

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| C K | 6.93 | 11.86 | 12.27 |
| O K | 49.12 | 63.13 | 8.51 |
| Ne K | 0.27 | 0.27 | 33.3 |
| Mg K | 0.71 | 0.6 | 10.24 |
| Br L | 5.95 | 1.53 | 3.6 |
| Al K | 7.67 | 5.85 | 5.62 |
| Si K | 19.29 | 14.12 | 5.32 |
| Au M | 4.45 | 0.46 | 8.47 |
| K K | 1.91 | 1 | 6.2 |
| Ba L | 0.78 | 0.12 | 41.99 |
| Ti K | 0.27 | 0.14 | 24.63 |
| Fe K | 1.74 | 0.64 | 10.53 |
| Co K | 0.19 | 0.07 | 40.32 |
| Cu K | 0.74 | 0.24 | 32.77 |




kV: 15 Mag: 1000 Takeoff: 18.4 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV) 128.6

**Fig 26:** EDXS - SEM Mapping of Nongpok Sekmai Area 2 Sample 1

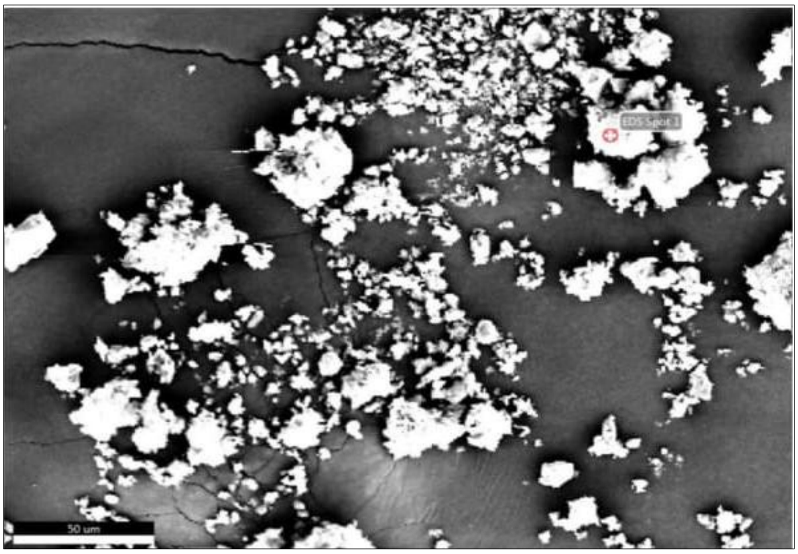
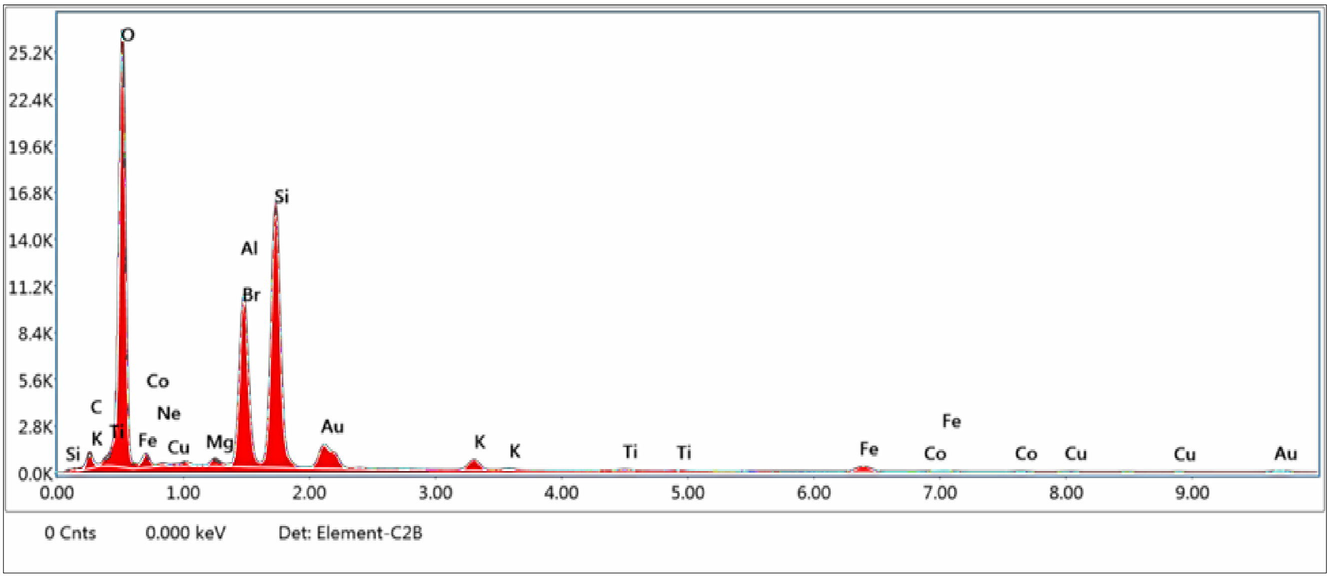


**Fig 27:** Back scattered image of Nongpok Sekmai Area 2 sample 2

**Table 13:** Smart Quant Result

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| C K | 2.91 | 5.13 | 15.29 |
| O K | 51.49 | 67.99 | 8.16 |
| Ne K | 0.25 | 0.26 | 29.38 |
| Mg K | 0.55 | 0.47 | 10.35 |
| Br L | 5.18 | 1.37 | 3.75 |
| Al K | 8.86 | 6.94 | 5.49 |
| Si K | 19.99 | 15.04 | 5.29 |
| Au M | 5.58 | 0.6 | 6.66 |
| K K | 1.32 | 0.63 | 6.18 |
| Ti K | 0.23 | 0.14 | 19.64 |
| Fe K | 2.63 | 0.99 | 6.61 |
| Co K | 0.27 | 0.1 | 32.97 |
| Cu K | 0.45 | 0.15 | 33.29 |




kV: 15 Mag: 1000 Takeoff: 18.4 Live Time(s): 30 Amp Time(μs): 3.84 Resolution:(eV) 128.6

**Fig 28:** EDXS - SEM Mapping of Nongpok Sekmai Area 2 Sample 2

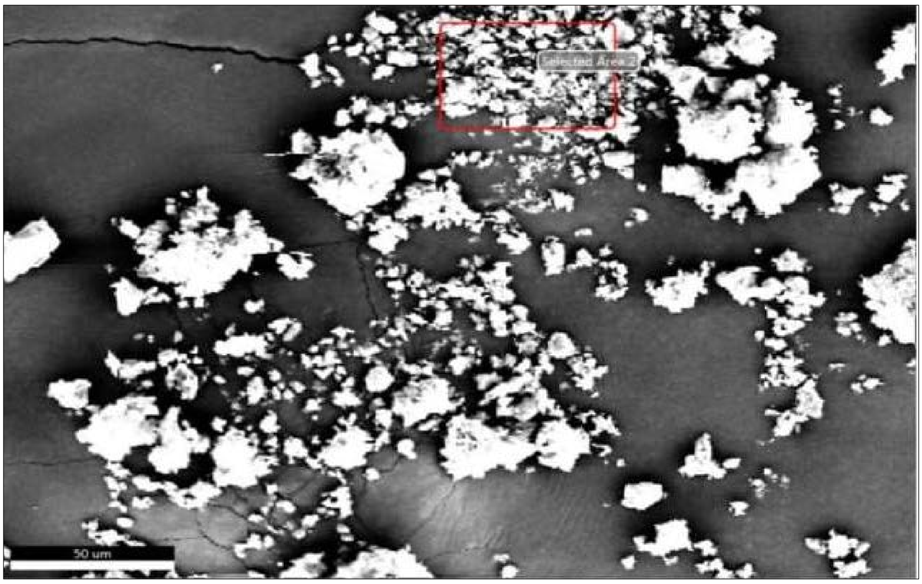
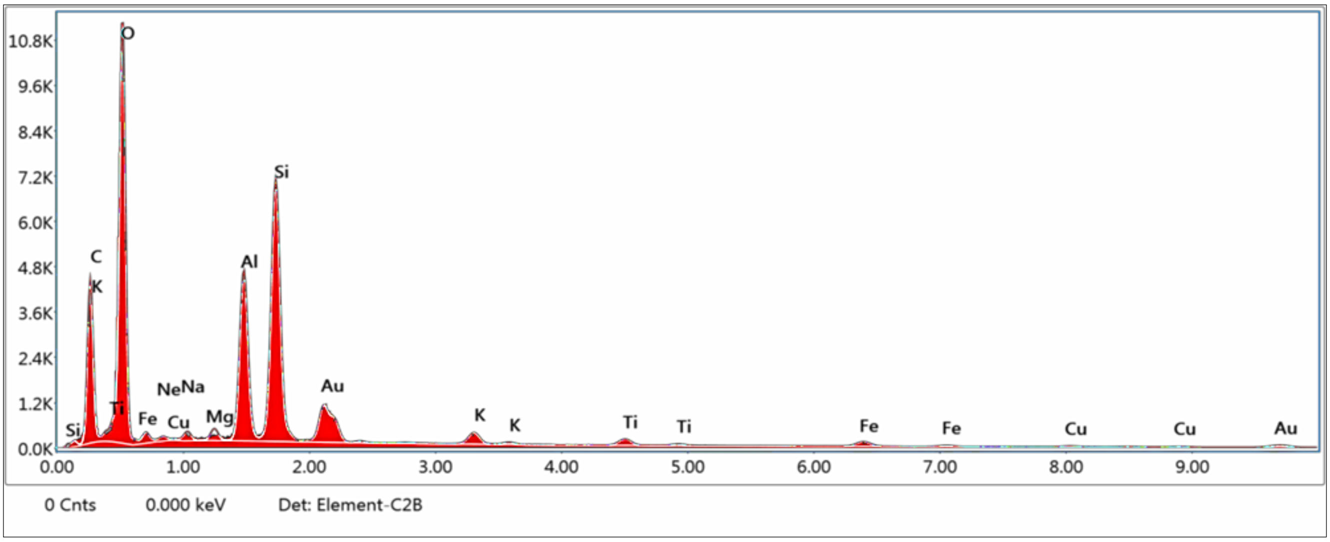


**Fig 29:** Back scattered image of Nongpok Sekmai Area 2 sample 3

**Table 14:** Smart Quant Result

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| C K | 27.11 | 38.61 | 9.77 |
| O K | 43.85 | 46.89 | 9.27 |
| Ne K | 0.28 | 0.24 | 29.49 |
| Na K | 0.69 | 0.52 | 16.06 |
| Mg K | 0.58 | 0.41 | 10.47 |
| Al K | 7.48 | 4.74 | 5.3 |
| Si K | 11.18 | 6.81 | 4.69 |
| Au M | 4.86 | 0.42 | 8.45 |
| K K | 1.02 | 0.44 | 8.38 |
| Ti K | 0.88 | 0.31 | 9.55 |
| Fe K | 1.47 | 0.45 | 11.38 |
| Cu K | 0.6 | 0.16 | 38.25 |




kV: 15 Mag: 1000 Takeoff: 18.4 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV)12

**Fig 30:** EDXS - SEM Mapping of Nongpok Sekmai Area 2 Sample 3

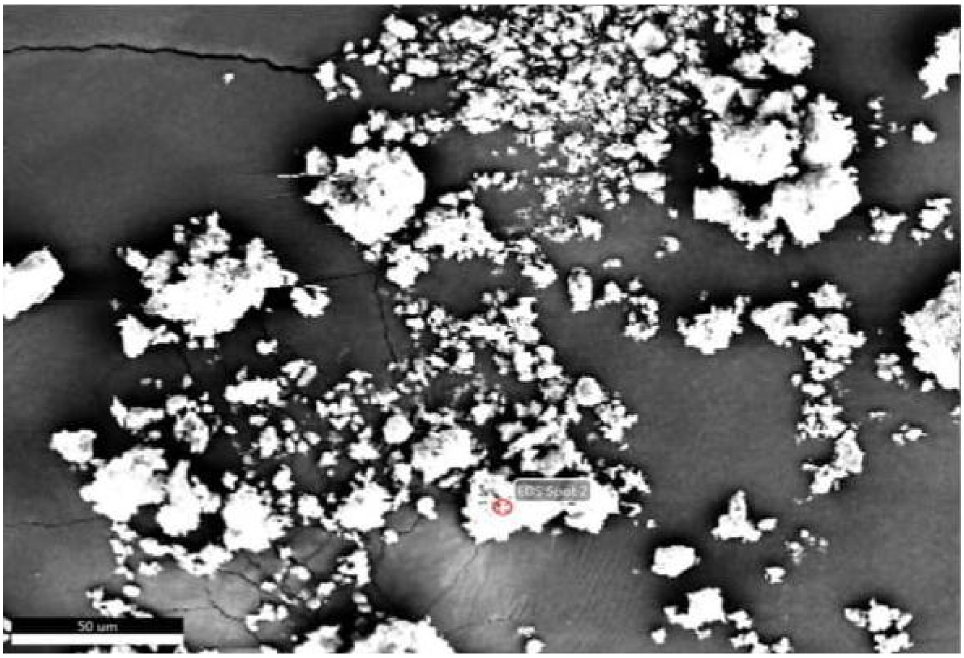
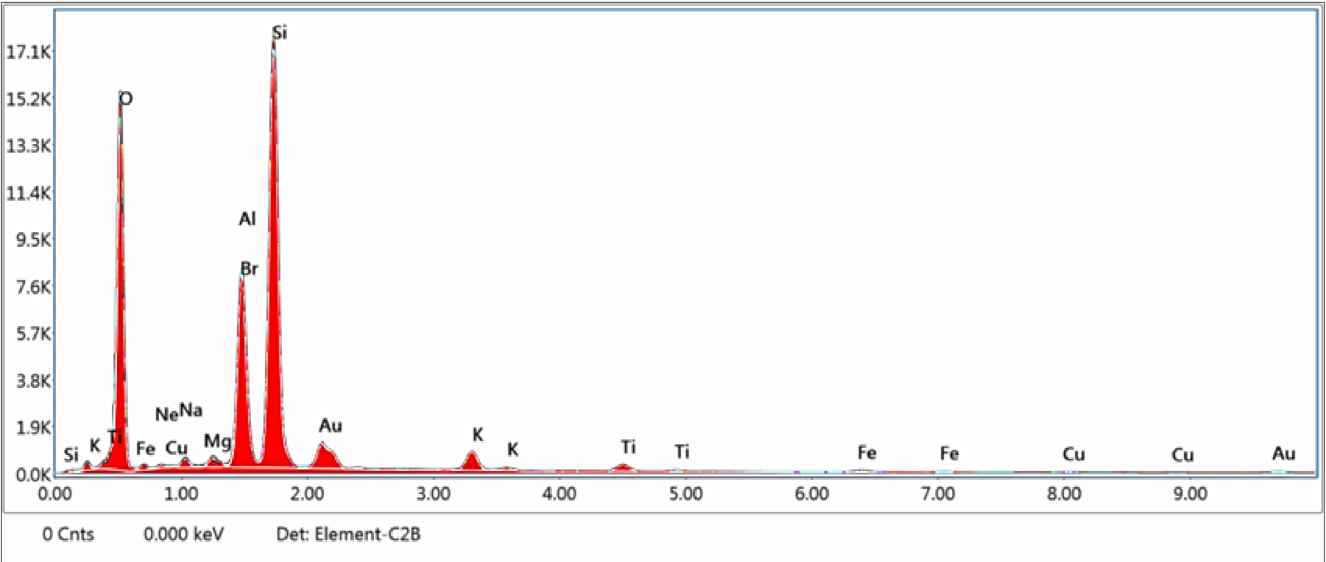



**Fig 31:** Back scattered image of Nongpok Sekmai Area 2 sample 4

**Table 15:** Smart Quant Results

| Element | Weight % | Atomic % | Error % |
|---|---|---|---|
| O K | 44.6 | 63.38 | 8.66 |
| Ne K | 0.24 | 0.28 | 27.25 |
| Na K | 1.04 | 1.03 | 12.99 |
| Mg K | 0.62 | 0.58 | 10.21 |
| Br L | 6.36 | 1.81 | 3.29 |
| Al K | 7.98 | 6.72 | 5.41 |
| Si K | 28.27 | 22.89 | 5.19 |
| Au M | 5.5 | 0.63 | 6.83 |
| K K | 2.5 | 1.45 | 6.07 |
| Ti K | 1.36 | 0.65 | 7.63 |
| Fe K | 0.91 | 0.37 | 16.1 |
| Cu K | 0.63 | 0.23 | 38.69 |




kV: 15 Mag: 1000 Takeoff: 18.4 Live Time(s): 30 Amp Time(µs): 3.84 Resolution:(eV) 128.6

**Fig 32:** EDXS - SEM Mapping of Nongpok Sekmai Area 2 Sample 4

The EDXS - SEM data of both the areas 1 & 2 (Figures from 17 to 32) shows that the clay samples are oxygen dominated silicon with other elements like aluminium, Gold, potassium, copper, magnesium, Titanium, iron, Sodium, Neon (excepting in sample 2 Area and Barium in sample 1 of area 2, etc.

## 4. Conclusion

The clays from Thongjao Scheduled Caste village under Kakching District, and Nongpok Sekmai under Thoubal district of Manipur, both pottery villages, are suitable for making different varieties of pottery products. Pottery is the primary occupation of these villagers since time immemorial. The clays of both the villages contain smooth grains as well as powdered aggregates. On examination in the Energy Dispersive X-Ray Spectroscopy - Scanning Electron Microscope (EDXS-SEM), oxygen and Silicon are found to be the main elements present with other elements like Aluminium, Potassium, Magnesium, Iron, copper, gold, titanium, etc. As oxygen is present in abundance the pottery products may give more beautiful on glazing as addition of oxygen to metals and minerals changes their appearance thus, will often give glazes bright colour. However, a detailed technical study will be needed to bring the coil pottery cottage industry a successful one.

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