Petrography and Geochemistry of Kinta Valley Palaeozoic Carbonate Rock

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Abstract. Petrographical and geochemical analyses of carbonates rocks collected from four different quarries around the Simpang Pulai areas were studied to determine the provenance and hydrothermal setting of the source region. Geologically, the selective quarries are predominantly underlain by the Kinta Limestone Formation. Locally, limestone at the quarry site predominantly made up of massive and thin bedded varieties, greyish white and with black carbonaceous patches/spots, fined grained limestone, frequently and in places intercalated or associated with carbonaceous shale or phyllite. Massive, of about few centimetres to 4 m thick, cream to pinkish white coloured, fined grained dolomite have been encountered running across the central part of the quarry are in N-S direction adjoining most of quarries. The carbonate rocks were analysed by performing microscopic study, mineralogical analysis of XRD and chemical analysis of XRF. The colour present by the carbonate rocks (limestone, dolomite, and marble) depends on its composition. White, semi-white, light-grey and beige colours can be attributed either to pure calcite or dolomite. All carbonate samples exhibit limited existence of major elements except for Ca and Mg. The particular characteristics of each rock depend highly upon the type of minerals present, their composition, grain size, and their geochemistry. Moreover, the integration of petrographic and geochemistry studies can lead to much better understanding on different secondary processes, including dissolution, karstification and dolomitization.

1. Introduction

The Kinta Limestone Formation is part of Western Belt in the centre of Perak, and it is an area of interest for several reasons. The metamorphic and diagenetic alterations that have an impact on the stratigraphic complexity, the huge potential on the industrial usage of limestone, the stanniferous mineralization, and heritage values of caves are among the reasons, which raise the interest of researchers in the past [1]. The limestone is considered to be recrystallized due to metamorphism of granitic intrusions [2, 3] and other diagenesis phases [2, 4, 5] to change into marble and dolomite. Due to these alterations, attempts have been made to study and characterize further the Kinta Limestone Formation. For example, the Kinta Limestone Formation has been fully tested in detail for its geochemical characteristics to obtain supporting data for the paleontological dating via chemostratigraphy, except for a few oxide analysis carried out to optimize the industrial usage of Kinta Limestone [5].
In this paper, we had selected four quarries around the Kinta area to study their petrographic also geochemical data and to further correlate with the minerals present in the selected carbonate rocks that represent the quarries, the grain size of the samples as in photomicrograph, and the composition of oxides especially CaO and MgO that might influence the colour, strength that can also effect the fragmentation degree [6] and dissolution rate of carbonate rocks.

1.1 Geological setting

Kinta Valley is characterized by remnant limestone hills sandwiched by the Triassic granitic batholiths [7] of the Main Range in the east and the Kledang Range in the west (Figure 1). There are three main facies in Kinta Valley: carbonate facies, argillaceous facies and arenaceous facies [8]. The carbonate facies is known as Kinta Limestone Formation [4]. The Kinta Limestone is spanned from Silurian to Permian age in stratigraphy lexicon of Peninsular Malaysia [2, 9]. The Palaeozoic limestone was exposed for a very long period of time that only the limestone hills/karst are the remaining visible part [10]. Karst is a particular style of landscape that contain caves and underground water systems that develop specially on soluble rocks such as limestone, dolomite, marble, and gypsum. It is an open system which closely made up of two combined hydrological and geochemical subsystem [11].

At the selected quarry sites, the formation is predominantly made up of massive and thin bedded varieties, greyish white and with black carbonaceous patches/spots, fined grained limestone, frequently and in places intercalated or associated with carbonaceous shale or phyllite [12]. Massive, of about few centimetres to 4 m thick, cream to pinkish white coloured, fined grained dolomite (CaMg(CO$_3$)$_2$) have been encountered running across the central part of the quarry are in N - S direction adjoining most of quarries. Also, massive, medium to coarse grained and white to cream coloured marble.

2. Materials and methods

Samples of carbonate rock were taken from four different quarries around Simpang Pulai and Gopeng (Figure 1). The selected samples to undergo tests are varies from whitish to pinkish to dark grey. Petrographic thin section analysis was realized on 12 rock samples. Polarizing microscope Meiji model were used, under magnifications of 4x-40x and photomicrographs were taken by Canon camera. Nine carbonate samples were selected for geochemical study and these samples were powdered first in agate mortar. Nine carbonate samples were selected for geochemical study and these samples were powdered first in agate mortar. Major oxides composition were obtained by X-ray fluorescence (XRF) using an X-ray spectrometer Rigaku RIX 3000. Loss-on-Ignition (LOI) was measured by heating up the samples to 1000°C in porcelain crucibles. The powdered samples were also mineralogically characterized using X-ray diffraction (XRD). XRD spectra were acquired from 10° to 89° 2θ. All the method used were performed in School of Materials and Mineral Resources, USM Engineering Campus.
3. Results and discussion

3.1 Petrography

Petrographic studies were performed to identify the carbonate components in the samples. Three samples were studied from each of the quarries, where every thin section was selected beforehand so that it can show variant characteristics of the quarry. Figure 2 shows the photomicrograph of the prepared thin sections and it is expected to have the existence of calcite (most abundance) and dolomite minerals.

Based on the figure, we can see the grain size are varies from fine to coarse grain, from 200µm up to 1200µm for calcite and dolomite minerals. L1, L2 and L3 have the finest grain of all and the other minerals are hard to be distinguished except for calcite as its characteristics like cleavage can still be seen under the microscope. Calcite and dolomite are easily been recognized as they possessed euhedral to subhedral shaped with perfect cleavage and visible twinning. A very clear cleavage (red arrow) can be seen in samples H1, I2-I4, T3 and T4 while sample I4 show calcite with lamellae twinning (blue arrow). The cleavages also appeared under plain polarized light. The colour of minerals under the polarized microscope are colourless to light brown and as the minerals extinct, it turns to dark grey. There are calcite veins found in L3 that are coarser than the host minerals and microfracture filled by iron found in H1. T1 are found to have opaque mineral that have inclusion of calcite and dolomite.

3.2 Geochemistry

Table 1 shows the elemental data from XRF analysis of 9 selected samples. The elemental concentration includes CaO, MgO, and other major elements including SiO₂, Al₂O₃, Fe₂O₃, MnO, K₂O, P₂O₅, and SrO concentrations. These concentrations give clues of the composition of minerals in the samples that can help in justified the petrographic analysis and XRD analysis. Geochemical contents of carbonate rocks are important to study as it is involved in dissolution process which can also impact the underground water.
Figure 2. Photomicrograph of the carbonate rocks from the quarries in Kinta Valley under cross polarized light (XPL). H1, H2 & H3 shows calcite minerals with no real rhombohedral shape; calcite in I2, I3 & I4 appear to have a very clear cleavage and lamellae twinning; L1, L2 & L3 have fined visible grain. L3 has calcite vein (green arrow) that are coarser than the host; dolomite are clearly seen in T1, T3 & T4 together with calcite. Opaque mineral are found in T1. C: calcite; D: dolomite; Op: opaque mineral; Fe: iron

Based on the table, samples from Simpang Pulai and Gopeng reveal significant differences in their major compositions. CaO content dominate the concentration of each samples. It ranges from 35.48% to 68.55%, where the average is 56.84%. H2 has the highest amount of CaO while T1 has the lowest amount of CaO. T1 and T2 have the highest concentration of MgO, which are 18.19% and 18.64% respectively whilst for other samples, the concentration is less than 2.00%. As H2 has the highest content of CaO, the sample does not contain any MgO content and other major elements also contain no more than 1.00%, same goes for I4. It is noted that as MgO concentration increases, concentration of CaO decreases.

Al₂O₃ and Fe₂O₃ concentrations were significantly low (>1.00%) except for L1, where the concentrations are 2.11% and 1.12% respectively. L1 also contains high content of SiO₂ (6.78%) same goes to T2 with SiO₂ content of 1.32%. Besides of these major concentrations, there are also some other compositions existed in the samples like SO₃, NiO, CuO, Cl, Rb₂O, Y₂O₃, and ZrO₂ with concentration less than 1.00% that make the total of 100%. Loss-on-Ignition (LOI) of these carbonate rocks were dominantly high (range: 30.00–44.78%) due to the CO₃ content and the calcination process takes place during the heating process.

X-ray diffraction patterns that display peaks of possible mineral contents in the samples are shown in Figure 3. The patterns are between 2Theta (2θ) versus intensity (counts). The graph have the highest peak of calcite minerals for all samples except T1 and T2 at degree of about 29° and dolomite mineral for T1 and T2 with highest peak at about 31°. Based on the XRD pattern, it can be justified that the high MgO content of XRF in samples T1 and T2 and dolomite mineral in petrographic analysis. As for the other samples, the peaks of calcite justified the abundance of calcite grains in photomicrograph and the high content of CaO in XRF analysis.
Table 1. Some of the major elements composition of the selected Palaeozoic carbonate rocks of Kinta Valley

| Sample/Conc.(%) | SiO₂ | Al₂O₃ | Fe₂O₃ | MnO | MgO | CaO | K₂O | P₂O₅ | SrO | LOI | Total |
|----------------|------|-------|-------|-----|-----|-----|-----|------|-----|-----|-------|
| H1             | 0.3733 | 0.2603 | 0.1370 | 0.0178 | 0.5195 | 62.7831 | 0.0103 | 0.0051 | 0.0308 | 35.8400 | 99.9772 |
| H2             | 0.1055 | 0.0760 | 0.0417 | 0.0425 | 0.0000 | 68.5549 | 0.0108 | 0.0000 | 0.0298 | 31.1300 | 99.9912 |
| I2             | 0.0756 | 0.0274 | 0.0565 | 0.0000 | 1.9014 | 67.8691 | 0.0099 | 0.0056 | 0.0481 | 30.0000 | 99.9936 |
| I3             | 0.2489 | 0.1229 | 0.1908 | 0.0105 | 0.8018 | 63.1044 | 0.0433 | 0.0234 | 0.0380 | 35.4000 | 99.9840 |
| I4             | 0.1086 | 0.6682 | 0.2613 | 0.0295 | 0.0000 | 62.5467 | 0.0000 | 0.0396 | 0.0277 | 36.2800 | 99.9616 |
| L1             | 6.7842 | 2.1137 | 1.1272 | 0.1371 | 1.2841 | 50.5441 | 0.6450 | 0.0313 | 0.0278 | 37.2000 | 99.8945 |
| L3             | 0.3840 | 0.3315 | 0.0740 | 0.0122 | 0.4870 | 64.3695 | 0.0077 | 0.0000 | 0.0282 | 34.2900 | 99.9841 |
| T1             | 0.4018 | 0.2137 | 0.3327 | 0.4710 | 18.1953 | 35.4877 | 0.0035 | 0.0167 | 0.0095 | 44.7800 | 99.9119 |
| T2             | 1.3299 | 0.7718 | 0.2399 | 0.6075 | 18.6470 | 36.3077 | 0.0040 | 0.0616 | 0.0086 | 41.9400 | 99.9180 |

Figure 3. X-ray diffraction pattern of each selected carbonate rocks from quarries in Simpang Pulai and Gopeng. All samples showed a clearly highest peak that represent the most significant mineral in the sample. 20 showed are from 20-55° with varies of counts.
4. Conclusion

Carbonate rocks from selected quarries in Simpang Pulai and Gopeng have high content of calcite with low content of other minerals. Though, there are two samples that contains high concentration of MgO and it is proved by XRF analysis and XRD pattern graphs. This is good for industrial usage as they want the high quality of limestone and dolomite. Sample with the highest amount of Ca (calcite) is H2, the highest content of Mg (dolomite) is T2. The difference of mineral contents, grains size, and the compositions can help in justifying the particular characteristics of each of the carbonate rocks like colour, strength, and moisture content. The comprehensive of petrographic and geochemical of carbonate rocks in Kinta Valley can lead in understanding the secondary process including karstification, dolomization and dissolution processes. Petrographic, XRF and XRD are three analysis that compliment with each other. From photomicrograph, we can see the minerals and its characteristics that cannot be seen by naked eyes and the existence of the mineral were being approved by XRF and XRD analysis.

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