# Study on slope stability of Maolin area in Kaohsiung (Taiwan) using mineralogical and microstructural techniques

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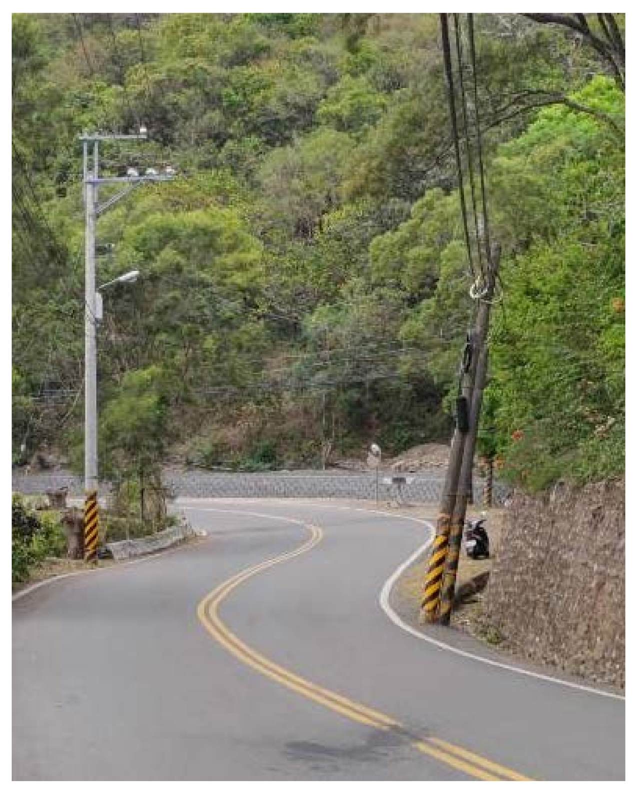
## Introduction

The Wanshan tribe is in the Maolin district of Kaohsiung City in Taiwan. This area belongs to the Chaochou Formation within the Lushan Slate Belt. Its terrain is hillslope and stream terrace with slate and argillite rock-composition. The geological features of this area include slope angle greater than 30 degrees, colluvium, and serious erosion, which had a debris flow during the Morakot typhoon (2009). The area is currently classified as a massive potential landslide region and is still in a slow slip (creeping).

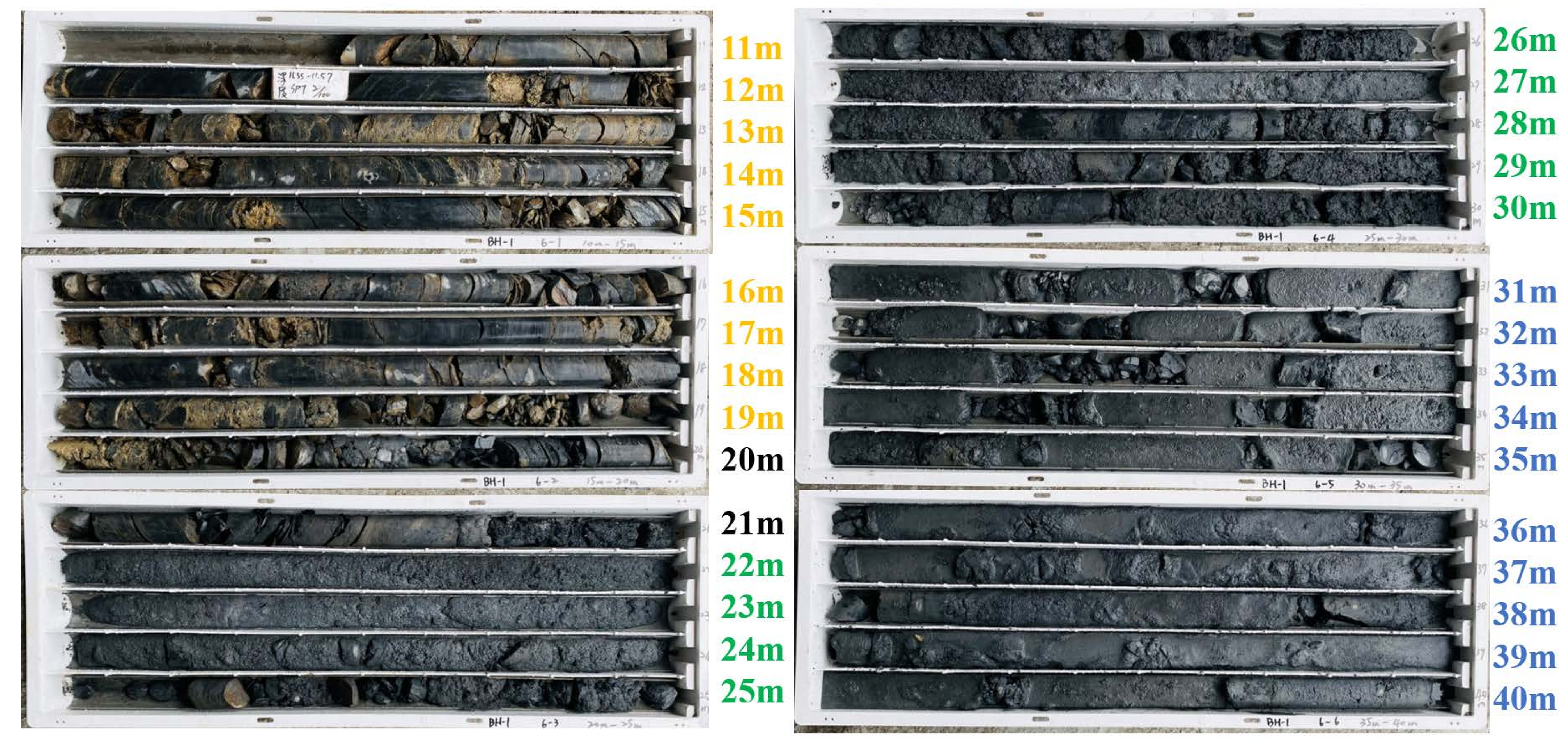
In this study, mineralogical and microstructural techniques were applied to investigate the slope stability of this area, e.g. X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), optical microscope (OM), scanning electron microscopy (SEM), and microcomputer tomography (micro-CT). A 40 m-depth rock-core was drilled at the field site and the core samples were prepared for related measurements and experiments. The rock-core composed of fresh slates and weathered slates.



## Materials and Methods

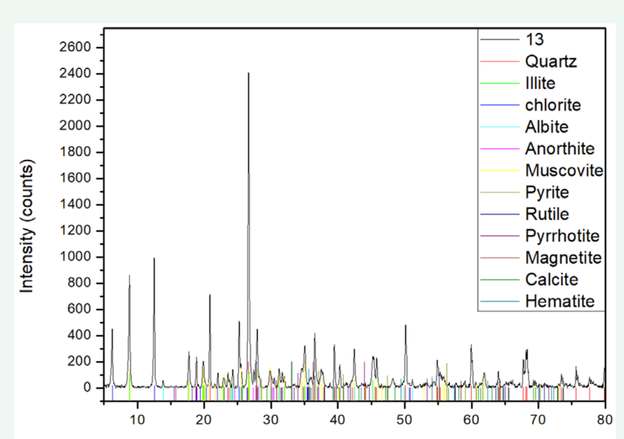
In this study, mineralogical and microstructural techniques were applied to investigate the slope stability of this area, e.g. X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), optical microscope (OM), scanning electron microscopy (SEM), and microcomputer tomography (micro-CT). A 40 m-depth rock-core was drilled at the field site and the core samples were prepared for related measurements and experiments. The rock-core composed of fresh slates and weathered slates.

Weathered slate Fresh slate Slate debris Slate debris in ground water




## Results

### XRD

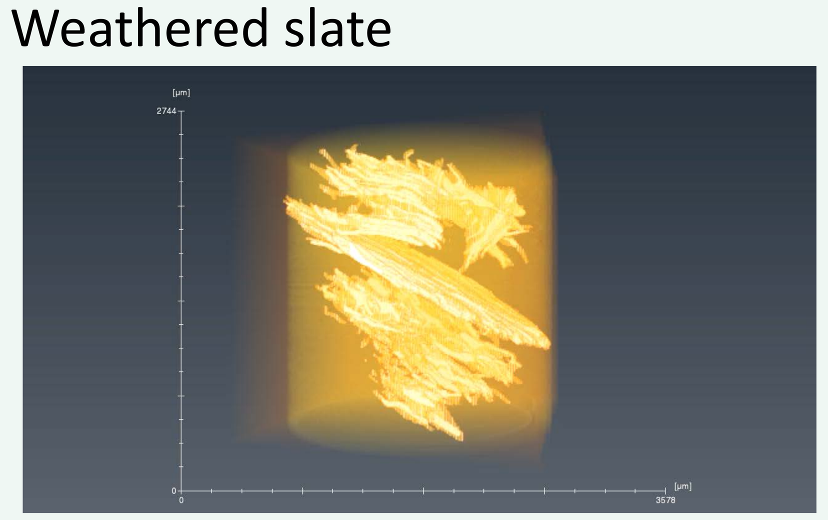



| | Quartz | Chlorite | Illite | Muscovite | Pyrite | Albite | Anorthite | Rutile | Pyrrhotite | Calcite | Magnetite | Hematite | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 m | 45.35% | 19.4% | 14.47% | 7.76% | 0.12% | 5.46% | 0.64% | 0.49% | 3.78% | 1.32% | 0.14% | 1.07% | 100% |
| 17 m | 41.21% | 15.79% | 22.53% | 6.78% | 0.08% | 7.08% | 0.54% | 0.44% | 0.15% | 0.66% | 2.91% | 1.83% | 100% |
| 20 m | 48.76% | 17.67% | 12.84% | 11.78% | 0.2% | 5.1% | 1.25% | 0.52% | 0.24% | 1.3% | 0.3% | 0.04% | 100% |
| 21 m | 38.98% | 24.36% | 14.47% | 9.37% | 0.09% | 4.85% | 2.09% | 0.45% | 0.67% | 1.22% | 2.84% | 0.61% | 100% |
| 31 m | 45.81% | 17.54% | 15.98% | 7.77% | 0.13% | 7.84% | 0.51% | 0.15% | 0.17% | 0.99% | 2.16% | 0.95% | 100% |
| 35 m | 46.21% | 19.76% | 15.46% | 9.55% | 0.06% | 3.22% | 0.33% | 1.03% | 0.44% | 1.22% | 2.44% | 0.28% | 100% |
| 40 m | 45.41% | 19.4% | 14.47% | 7.76% | 0.09% | 5.46% | 0.64% | 0.49% | 3.78% | 1.32% | 0.11% | 1.07% | 100% |

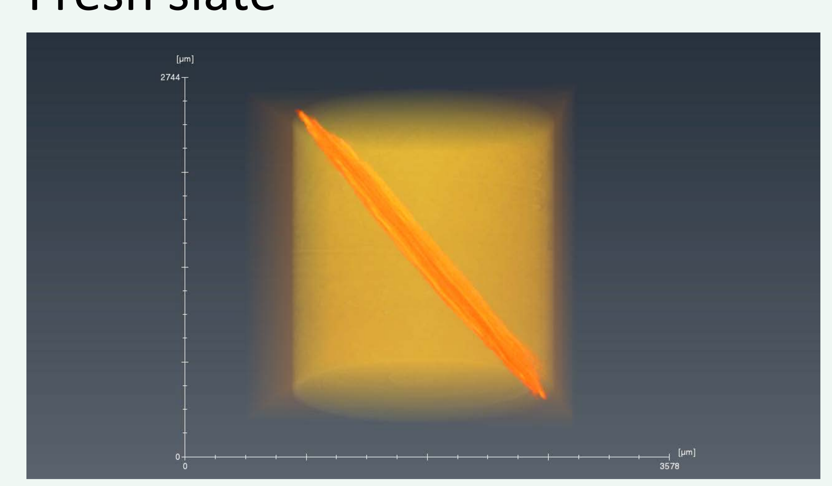
Weathered slate Fresh slate Slate debris Fresh slate in debris Slate debris in ground water

### Micro CT

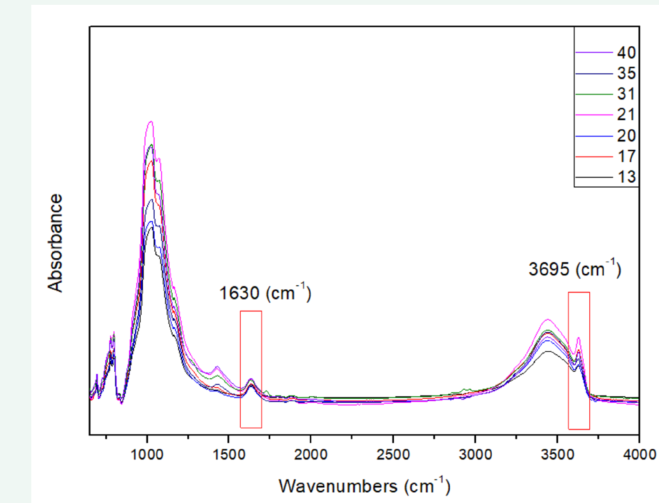
Weathered slate



Fresh slate



### FTIR



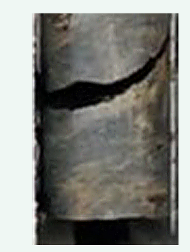

| 3627 (cm-1) | 13 m | 17 m | 20 m | 21 m | 31 m | 35 m | 40 m |
|---|---|---|---|---|---|---|---|
| %Area | 0.94% | 1.13% | 0.89% | 1.31% | 0.99% | 0.87% | 1.18% |
| Normalized | 71.57% | 86.17% | 68.01% | 100% | 75.68% | 66.33% | 90.27% |

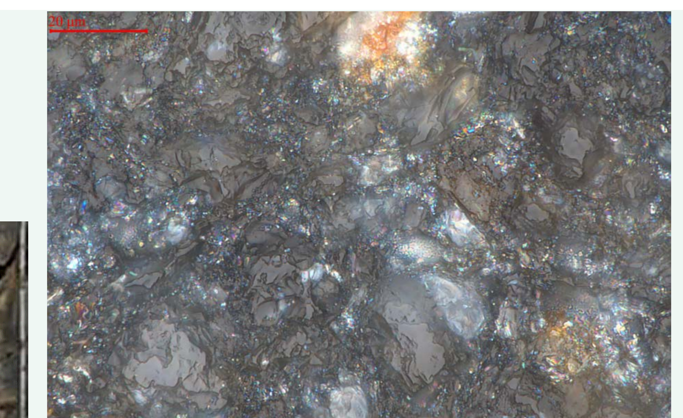
| 1630 (cm-1) | 13 m | 17 m | 20 m | 21 m | 31 m | 35 m | 40 m |
|---|---|---|---|---|---|---|---|
| %Area | 1.89% | 2.15% | 1.35% | 2.19% | 1.74% | 1.22% | 2.04% |
| Normalized | 86.29% | 98.11% | 61.82% | 100% | 79.36% | 55.99% | 93.52% |

Weathered slate Fresh slate Slate debris
Fresh slate in debris Slate debris in ground water

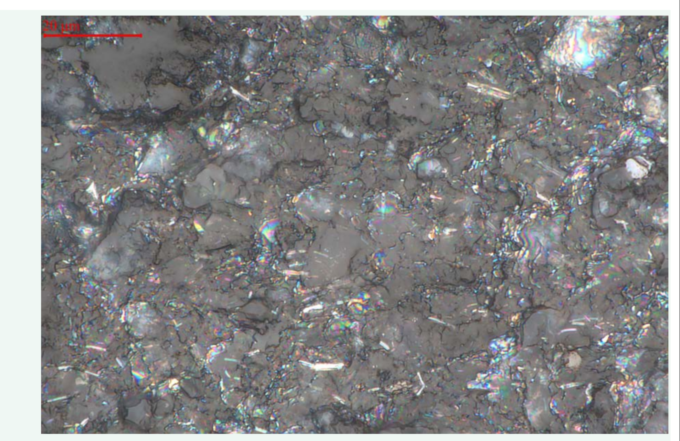
Based on XRD and OM analyses, the mineral phases in this area included quartz, illite, chlorite, muscovite and feldspar. The weathered core-sample had a more content ratio of clay minerals compared to that in the fresh slate core-sample. The FTIR results exhibited that the weathered core-samples had a higher water content than that in the fresh slate samples. With the help of SEM and micro-CT, it can be observed that the weathered core-sample had many longitudinal fractures, however, the fresh slate core-sample just had the slate cleavage.

### OM



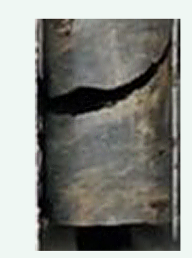


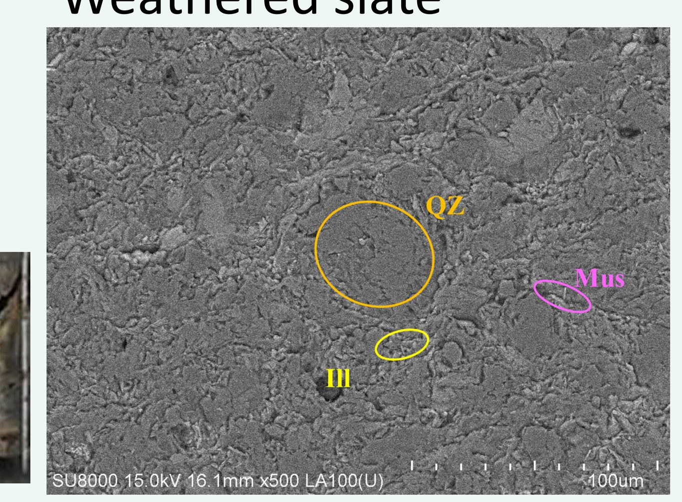
Weathered slate

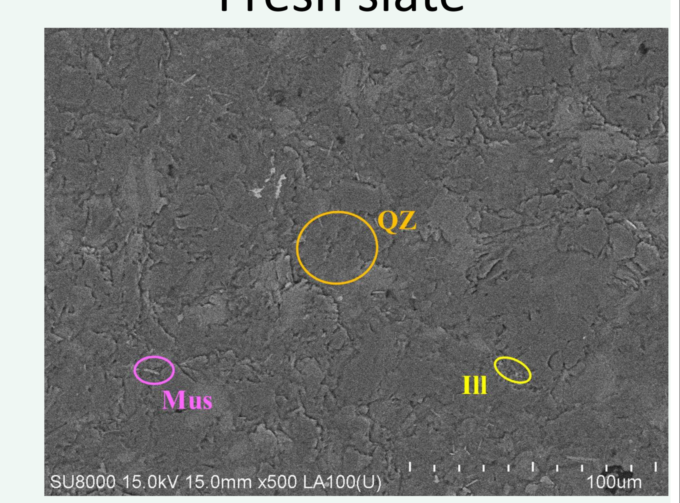


Fresh slate

### SEM






## conclusion

It is so interesting that the lithology of rock-core changed into a dense fresh slate at the depth of 20 m; it suggested that this rock-layer is more impermeable to water. The weathered rock is favorable for water infiltration and then induced rock weathering, which could weaken the mechanical strength of this rock-layer. It is known that the lithology variation/change of rock-layers preferred to accumulate water, and it was easy to become a weak interface-layer. Therefore, we should pay attention to the fluctuation of groundwater level in this area and the drainage system needs to be well done.