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# The economic potential of ultrabasic soils in the vicinity of Ranau, Sabah

## Potensi ekonomi tanah ultrabes di sekitar Ranau, Sabah

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**Abstract:** This paper investigates whether ultrabasic soils are profitable alternative resources of Cr, Co and Ni. A total of 55 holes have been bored through 3–20 metre thick in situ soils, at the pilot study area near Ranau, Sabah. The soil reserve of an approximately 1.1 $km^2$ area is 19.25 million tonne. X-ray diffraction study confirms the occurrence of goethite as the major constituent, with occurrence of lesser amounts of gibbsite, kaolinite and rutile. Quantitative X-ray fluorescence study on 300 bulk samples gives the following average, in wt%: Cr 1.90 (0.80–2.20), Co 0.06 (0.04–0.10), and Ni 0.64 (0.20–1.40). Cr and Ni, with reserves of 365,000 tonne and 122,000 tonne respectively are believed to be profitable, if efficient and cost-effective extraction techniques with 80% recovery are available.

**Abstrak:** Kertas ini cuba menyiasat sama ada tanah ultrabes boleh dijadikan sumber alternatif yang menguntungkan bagi Cr, Co dan Ni. Sejumlah 55 lubang telah digerudi menerusi tanah setempat berketebalan 3–20 meter, di kawasan kajian pemandu berhampiran Ranau, Sabah. Rezab tanah bagi kawasan seluas lebih kurang 1.1 $km^2$ itu ialah 19.25 juta tan metrik. Kajian belauan sinar-X mengesahkan kehadiran goetit sebagai juzuk utama tanah, dengan gibsit, kaolinit dan rutil wujud dalam jumlah yang lebih sedikit. Kajian kuantitatif pendarflour sinar-X terhadap 300 samapel pukal memberikan purata berikut dalam % berat: Cr 1.9 (0.8–2.2), Co 0.06 (0.04–0.10), dan Ni 0.64 (0.20–1.40). Cr dan Ni yang rezab masing-masing ialah 365,000 dan 122,000 tan matrik dipercayai menguntungkan, dengan syarat teknik ekstraksi yang efisyen dan murah dengan nilai boleh peroleh 80% dapat dibangunkan.

## INTRODUCTION

Weathering is the breakdown and alteration of rocks by physical and chemical processes to form soils. Depending mainly on the nature of the parent rock and several other chemical and physical factors, weathering may cause depletion of some elements as well as relative enrichment of some others. It has been fairly well documented that several metallic elements of economic importance, e.g. Cr, Co and Ni are enriched significantly in soils derived from weathering of ultrabasic rocks (see for example Eswaran and Sys, 1972; Baba Musta, 1995; Beukes *et al.*, 2002).

The sources of some metallic and semi-metallic elements are mined from parent ores and the general opinion is that the alternative resources are not profitable for large scale exploitation. However, some elements are so enriched in ultrabasic soils that their potential as alternative resources of these elements cannot be ignored. This is especially true in cases where the traditional ore deposits are exhausted. This paper attempts to investigate whether in situ ultrabasic soils from the tropical areas are profitable alternative resources of Cr, Co and Ni. Ranau, Sabah has been chosen to initiate the frontier study, due to widely distributed, rather thick ultrabasic soils at its vicinity, as well as its good accessibility.

## THE STUDY AREA

The study area is situated at km 5–6 east of the Ranau-Telupid road. The area covers approximately 1.1 $km^2$ of low lying undulating hills. Most of the area is covered by lalang and without permanent settlement. Further inward from the road is secondary jungle, being the eastern boundary of the study area.

## METHODOLOGY

### Detail topographic survey

By using the existing topographic maps (100 feet contour interval), a number of traceable benchmarks within and around the study area, a Theodolite and GPS, a specific land survey to produce a five meter interval contour map has been conducted for study area. The map, which depicts extreme details of the topographic features of the area was used for the correct placing of the 55 borehole sites.

## Drilling, sampling and sample processing

A total 1,258 disturbed samples, 1–2 kg each were taken every 0.3 m from the 55 air core drill holes. Rotary dry method was used in the drilling using 100 mm diameter tube. The samples were air-dried for several days prior to the standard preparation for geochemical analysis (Hutchison, 1973).

## X-ray diffraction technique

Due to the fine-grained nature of the soils, identification of the constituent minerals were performed by X-ray diffraction technique (XRD) on a fully automated Siemens D-5000 Diffractometer. The analyzing radiation is Cu K-alpha with wavelength of 1.5418A, the scanning range is 2–60 degree two-theta and scanning speed of 0.02 degree per second.

## X-ray fluorescence technique

The bulk concentrations of elements in the soil samples were determined by X-ray fluorescence technique (XRF) on a fully automated Philips PW 1480/20 Spectrometer. The excitation radiation is Rh K-alpha and the routine experimental conditions for the analysis of trace elements have been applied. Due to the lack of sufficient standard reference materials of ultrabasic soils, i.e. soils with high amount of iron oxides, the normal calibration technique was not applied. Instead, an internal standard method of analysis as described by Twaiq *et al.* (2002) has been utilized.

# RESULT AND DISCUSSION

## Topographic map

Figure 1 shows the surveyed 5 m contour interval topographic map of the study are. The map shows that the Ranau main road and the Poring junction near Kg. Tudangan in the west of the study area being the lowest point, whereas the highest point lies in the northeastern part–140 m difference in elevation. In the southern part, steep slops bound the study area from the low laying topography of the Crocker Formation.

## Ultrabasic soil reserve

By taking the average depth of soils of the 55 boreholes as 7 m (the range is 3–20 m), and the weight of one cubic metre of dry soil is 2.5 tonne, it is estimated the study area contains 19.25 million tonne of ultrabasic soils (Table 1).

## Mineralogical composition

Diffraction patterns of four samples from borehole no. 14, with increasing depth towards the top of the figure are shown in Figure 2. The patterns confirm that at least four minerals constitute the ultrabasic soils of interest. The minerals, arranged in the order of abundance are goethite,

**Table 1.** The ultrabasic soils reserve in the study area.

| | |
|---|---|
| Area | 1,100,000 $m^2$ |
| Range of thickness | 3-20 m |
| Average thickness | 7.0 m |
| Volume | 7,700,000 $m^3$ |
| Weight of soils ($1m^3$=2.5 tonne) | 19,250,000 metric tonne |

**Table 2.** Range of concentrations (in ppm) of some trace elements in the ultrabasic soils.

| | | | |
|---|---|---|---|
| Ba | Ce | La | U |
| 69-509 | 0-30 | 0-30 | - |
| Th | Ni | Cr | V |
| 0-131 | 2000-14000 | 8000-22000 | 300-6000 |
| Nd | Zr | Y | Sr |
| 50-100 | 50-100 | - | - |
| Rb | Pb | As | Ga |
| - | - | 0-10 | 10-20 |
| Zn | Cu | Hf | Co |
| 40-130 | 500-800 | 0-20 | 400-1000 |

**Table 3.** Cr, Co and Ni reserves in the study area.

| | Cr | Co | Ni |
|---|---|---|---|
| Range of concentration (ppm) | 8,000-22,000 | 400-1,000 | 2,000-14,000 |
| Average of concentration (ppm) | 18,964 | 620 | 6,387 |
| Total reserve (tonne) | 365,057 | 11,935 | 122,950 |
| Reserve (tonne, 80% recovery) | 292,046 | 9,548 | 98,360 |

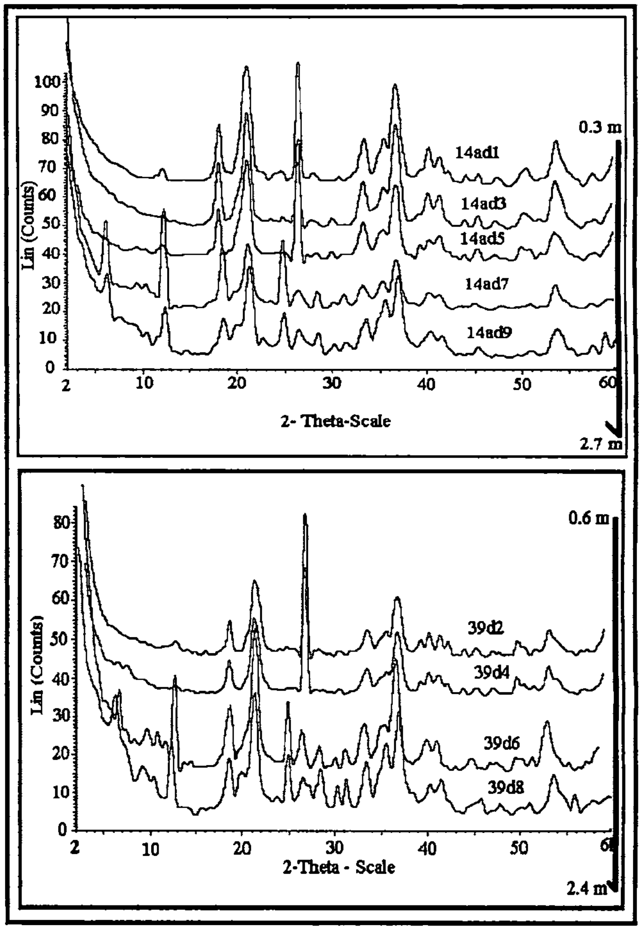


**Figure 2.** The X-ray diffraction patterns of 5 samples from bore holes no. 14 and 4 samples from bore hole no. 39 at different depth showing the occurrence of goethite, gibbsite, kaolinite and rutile.

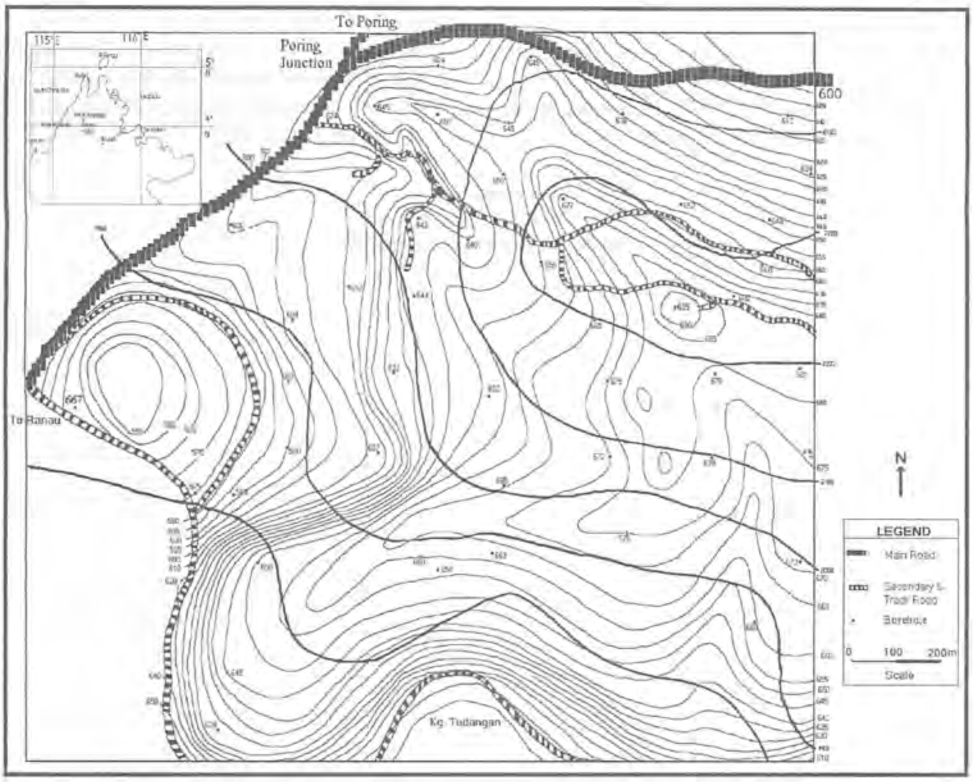


**Figure 1**. The five meter contour interval topographic map of the study area.

$Fe_2O_3.H_2O$; gibbsite, $Al(OH)_3$, kaolinite and rutile, $TiO_2$. Goethite is characterized by strong diffraction at two-theta angles of 21.2, 33.3 and 36.8. The characteristic diffraction angles for the other minerals are: gibbsite (18.4 and 26.5), kaolinite (12.4 and 24.8), and rutile (53.8).

### Chemical composition

Table 2 indicates the range of concentration of 20 trace elements analysed. These concentration figures have been used as general guide to indicate elements with significant high concentration. In short, Cr, Co and Ni are considered as elements of interest, due to their significantly high concentrations as well as the current market prices. By combining the calculated ultrabasic soil reserves of the study area (Table 1) and the average concentrations of each element, it is estimated that the total reserves of Cr, Co and Ni for the area are 365,057 tonne, 11,935 tonne and 122,950 tonne, respectively.

### The economic potential

The net reserves of Cr, Co and Ni for the study area, after allocating 80% recovery are 292,046 tonne, 9,548 tonne and 98,360 tonne, respectively (Table 3). Ni and Cr are more economically potential, as compared to Co. This early assumption is based on the current prices per tonne of the metals, i.e. USD 8,800 for Ni, USD 1,650 for Cr and USD 16,700 for Co.

## CONCLUSION

This study has shown that the ultrabasic soils at the vicinity of Ranau, Sabah are dominated by goethite, apart from gibbsite, kaolinite and rutile which occur in smaller quantity. The average concentrations of Cr, Co and Ni are 1.90%, 0.06% and 0.64% respectively. Based on the current prices of the metals, Cr and Ni are believed to be of economic potential, especially if efficient and cost effective extraction techniques are available.

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## REFERENCES

BABA MUSTA, 1995. *Perlakuan luluhawa batuan bes dan ultrabes di Malaysia: Tafsiran geokimia.* Tesis Sarjana Sains, Universiti Kebangsaan Malaysia.

BEUKES, J.P., GIESEKKE, E.W. AND ELLIOT, W., 2002. Nickel retention by goethite and hematite. *Mineral Engineering, 13(14-15)*, 1573–1579.

ESWARAN, H. AND SYS, C., 1972. *Clay mineralogy of soils on ultrabasic rocks from Sabah, Borneo.* Geological Institute, University of Ghent, Ghent.

HUTCHISON, C.S., 1973. *Laboratory handbook of petrographic techniques*. John Wiley & Sons, New York.

ROSE, A.W., HAWKES, H.E. AND WEBB, J.S., 1979. *Geochemistry in mineral exploration*. Academic Press, London.

TWAIQ, O.A., HAMZAH MOHAMAD, MOHAMAD MD TAN, ANIZAN ISAHAK AND BABA MUSTA, 2002. The determination of Cr, Co and Ni in ultrabasic soils by internal standard method of X-ray fluorescence spectrometry. *Abstrak Simposium Kimia Analisis Malaysia Ke-15*, 105.

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