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SUSTAINABLE MINING OF THE CLAY RESOURCES IN PENINSULAR MALAYSIA

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Abstract: Sustainability in the mining of clay depends on the nature of the resource, its usage, extraction practices, and the reuse of land affected by mining. Although there are abundant clay resources in Peninsular Malaysia, much of the clay is common clay used in large volumes for simple structural products like bricks, pipes, roof tiles and flower pots. Other, less common clays have special properties that enable them to be used in higher value products. Sustainable extraction of our clay resources will depend on using the appropriate clay for a given application, avoiding the use of high value clays for the production of low value products, and avoiding excessive digging and ground disturbance during extraction. Most clay resources that have been identified occur in thin layers and at shallow depths (less than 10 metres). Mining is extensive rather than intensive. If large volumes of clay are extracted, land areas affected can be substantial. Mining without adequate knowledge of clay quality can result in ad-hoc digging and the excessive disturbance of large areas in the search for the right clay. With good knowledge of the deposit and proper planning, clay can be extracted with minimal disturbance to the land. Different types of clay can be identified and marketed reducing waste and increasing returns. The land can be properly landscaped and reused. Some extraction takes place in areas being developed, and the land is built on immediately after the clay is removed. Sometimes, development moves faster that the ability of industry to use the clays. Good clay should be properly stockpiled and conserved; otherwise it may go to waste or become inaccessible. Optimizing usage, minimizing the environmental impact of extraction, and the quick return of land to other productive uses contribute towards the sustainable development of the clay resources.

INTRODUCTION

To successfully develop a resource in a sustainable manner, many factors must be considered. The extraction of the resource will have an impact on the environment, and there will be social and economic benefits as well as costs. Although clay resources in Peninsular Malaysia are abundant, to exploit these resources in a sustainable manner, we will have to consider the nature of these reserves, their utilization, extraction practices, the environment, and the reuse of land after mining. Only then will we be able to utilize and manage our clay resources efficiently, to bring maximum economic returns and at the same time reduce waste, land disturbance and environmental impact. Sustainable development is usually studied on a global scale, but for the purpose of this paper I shall confine my views to the clay resources in Peninsular Malaysia.

SUSTAINABLE DEVELOPMENT OF MINERAL RESOURCES

At the Earth Summit, held in Rio de Janeiro in 1992, sustainable development was defined as a strategy to "meet the needs of the present world population without causing adverse effects on health and the environment, and without depleting or endangering the global resource base, hence without compromising the ability of future generations to meet their needs" (Selamat, 2002). At Rio, three pillars of sustainable development: economic, social and environment spheres were established. (IIED 2002) In relation to man and minerals, the contents of the different spheres include:

Economic Sphere

- Efficient use of Mineral resource, natural or otherwise, maximizing economic returns
- Proper Resource Inventory and Resource Management
- Maintain and enhance the condition for viable mineral enterprise

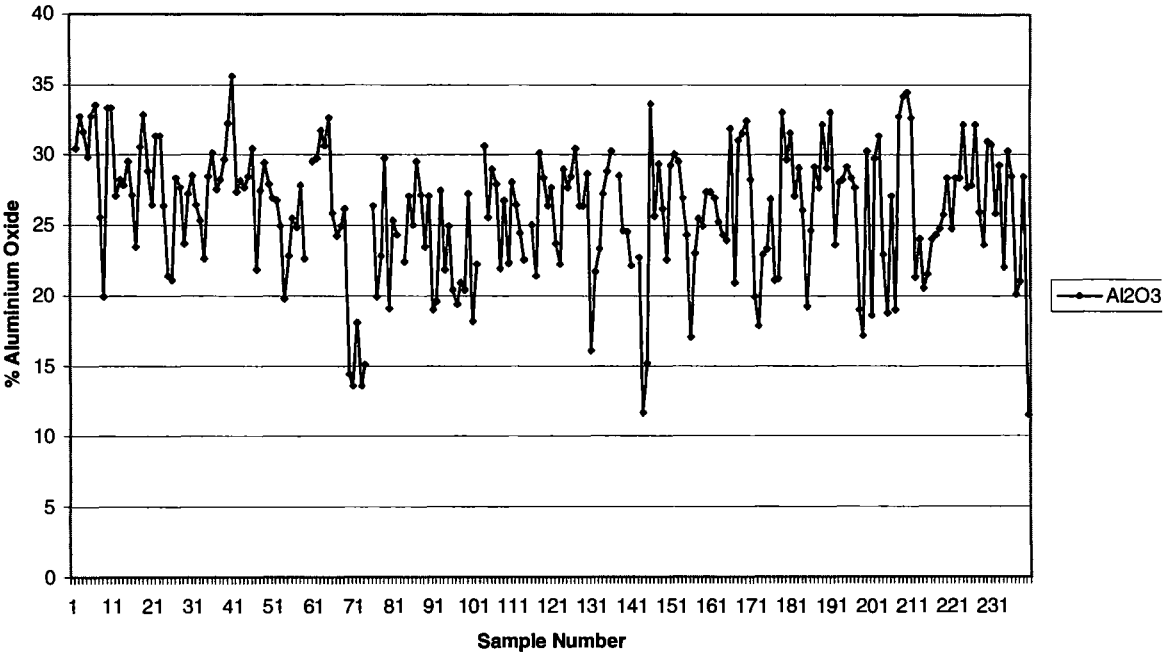
Social Sphere

- Ensure the depletion of natural mineral resource will not deprive future generations through intelligent conservation or replacement with other forms of capital
- Ensure health and safety of people in and around mining and related mineral operations and production always
- Seek to sustain improvement over time
- Ensure a fair distribution of the cost and benefits of mineral development for all

Environmental Sphere

- Minimize waste and environmental damage during mining and along the whole of the mineral supply chain
- Promote responsible stewardship of natural mineral resources and the environment
- Operate within ecological limits and protect critical natural capital
- Rehabilitate or reclaim the land as quickly as possible for the next land use.

Figure 2 : Variation of Al2O3 content in a ball clay deposit (Doll Said, IM17/95)



Clay Resource Utilization and Management

It has been reported (JMG Malaysian MineralsYearbook 2003) that Peninsular Malaysia has reserves of 112 million tonnes of kaolin, 559 million tonnes of ball clay and 228 million tonnes of mottle clay giving a total clay reserve of close to 900 million tonnes. The reported production in year 2003 of clay was about 9.1 million tonnes and kaolin about 426,000 tonnes. Production of earth material was 14.8 million tonnes (JMG Mineral Production Statistics 2003). Simple mathematics indicate that we have reserves to last us a century, so it seems we need not worry about sustainable development in the utilization of our clay reserves. In fact, our reserves of clay and clayey material may be greater than stated, since common clay and shale reserves have not been systematically evaluated. There were 138 clay and 1058 earth material producers operating in the year 2003 (JMG Mineral Production Statistics 2003).

To estimate the usage of our clay reserves, let us look at the current users of clay in the country. Clays are used, in terms of decreasing quantities, for making clay bricks, cement, floor and wall tiles, clay pipe and roofing tiles, pottery, sanitary ware, refractories, formers, tableware, decorative art ware and others. Sectors using, or producing, activated clay and advanced ceramics use imported clays.

The main bulk consumers of clay, namely the producers of brick, cement, rough pottery and structural clay products, use common clay or shale and do not use much of the above mentioned proven clay resources (except some mottle clay). As prices of these clays are low, proximity of clay pits and users are more important than clay specifications and quality. Clay is extracted from the nearest suitable and available source. Small, shifting clay pits provide the supply of common clay to the traditional small-scale ceramics industry. The pace of the construction industry, or local development, drives the demand for clay.

The floor and wall tile industry are the biggest users of ball clay and kaolin. I estimate the amount of clay used by the floor and wall tile industry at about 900,000 tonnes per annum. While the reported reserves are plentiful, not all are available or located close too the tile factories. The map in Figure 1 shows the location of current tile factories and clay pits. The tile factories are located in the Klang valley, Seremban, Kluang, Kulai and Pasir Gudang. The clay pits are located in Bidor, Batang Berjuntai, Puchong, Dengkil, Rompin, Kahang and Mersing. Clays have to be transported over considerable distances across the country because only clays of specific properties can be used for floor and wall tile manufacturing.

The manufacturers of refractories, sanitary ware, formers, tableware and decorative art ware require clay of even more specific qualities and properties. They use local clays in combination with imported clays for their products. In many cases, only imported, compounded clay is used. This is a high value potential market for Malaysian clays. An effort to study our clays in order to find some that are suitable for this use, as well as techniques for improving and blending existing clays would be very worthwhile as increased use of local clays in these industries would reduce imports, and increase the economic returns on our clay resources. Our clays have been exported raw overseas where they are blended and sold back to us at higher prices.

The production of 425,942 tonnes of kaolin in year 2003 comes mainly from Perak (182,011 tonnes) and Pahang (176,000 tonnes)(JMG Mineral Production Statistics 2003). Most of the kaolin produced in Perak is

processed into various grades for filler, ceramic, fibreglass and other industries. Some is used unprocessed for the fertilizer and white cement industry. Most of the kaolin from Pahang is sold unprocessed for the floor and wall tile industry, and exported. Other kaolin or kaolinitic clay is usually sold raw to local ceramic industries or exported. Kaolin has a wide variety of uses from ceramics, fillers, fibreglass, fertilizers, white cement, electrical porcelain, paper fillers and coatings, pesticides, adhesives, medical, pharmaceutical, cosmetics, refractories and catalysts. Although kaolin has been produced for many years in Malaysia, we should explore the possibility of its use in other high value industrial products. Producing such products will need new financial and technological input but it can bring high returns for the small volumes of kaolin reserves used.

Not all of our reported clay resources are accessible, available, mineable or suitable for industrial use. Non-suitability does not necessarily mean the clay is of low quality. It might be of higher quality than would be suitable for its intended use. Often clays with suitable and unsuitable properties are mixed together within a deposit, necessitating selective mining, thus creating waste. In order to optimize the usage of our clay resource and minimize environment impacts of clay extraction, we investigate the quality, characteristics, and properties of each clay resource, its suitability for one or several applications, its consistency, and the possibility of blending it with other clays to make it suitable for an application. Estimates should be developed of the amounts of clays suitable for each application.

Some clay reserves in Peninsular Malaysia are under threat of sterilization or wastage due to the rapid spread of development. The clays in Puchong, Selangor are very suitable for the manufacturing of tiles because of their good plastic properties. The area is undergoing very rapid development and lands with clay reserves are being dug up or built over. While some of the clay is being utilized by the ceramic industries, the pace of development is more rapid than clay utilization. Part of the clay reserves will be sterilized or thrown away (as clay is looked at as earth material and not an essential high valued industrial mineral). Stockpiling will assist to conserve some of the dug up clay for later use. However, much land is needy to maintain stockpiles. Starting a Greenfield site incurs financial, social and environment cost so we should optimize and conserve what that has being dug up already and reduce wastage.

MINING OF CLAY AND THE ENVIRONMENT

As clay is perceived as a common, low value earth material, little effort is spent on clay evaluation by the industry before starting a clay mine. Access to land, markets and permit to remove material seem to be of more concern than the quality and characteristics of the clay in the ground. Once the clay entrepreneurs get the land, they proceed to dig and sell, moving on if there are insufficient buyers for their clay or clay based products. This practice could work if one is looking for small amounts of common clay for making small quantities of bricks or pots. Many entrepreneurs of yesteryears made fortunes producing clay charcoal stoves and cooking pots in this manner.

While the traditional ceramic cottage industry continues to exist, current clay based industries use clays in huge automated plants costing millions of Ringgit, where materials must fulfill certain specifications, and variations can lead to the rejection of entire production runs. Quality products come from the control of the quality of raw materials. Controlled quality raw materials come from controlled digging, mining and blending processes. Controlled digging, mining and blending come from good knowledge of the properties and characteristics of the clay deposits, and variations, if any. Proper and detailed evaluation of clay deposits is necessary if they are to be used successfully in large clay based industries.

Clays for many small and medium scale ceramic industries are obtained from easily accessible deposits located in close proximity to the site of manufacturing. These small operations use common clays for the production of bricks, pipe, and rough pottery. The raw material is obtained by excavation, on an adhoc basis, usually by contractors, of any nearby accessible body of clay, without regard to environmental or rehabilitation concerns. In fast developing areas, the excavation pits will be rapidly reclaimed, but in other areas they are simply abandoned as the cost of remediation by backfilling would be high in comparison to the value of the clay extracted. This leaves behind pits, ponds and derelict landscapes. Nature often does, over time, take its course, and remediates the damage, but this does not happen immediately.

Large brick factories and cement manufacturers use large volumes of clay, shale or clay soil in their manufacturing process. They usually have their own land or rights to the land for long-term mining. Excavations are usually on hillsides or foothills with benches and haul roads such as is found in quarries. Large land areas are affected. Operations can have an impact on the landscape, cause soil erosion, dump sediment into waterways and result in landslides if not properly supervised and controlled. To achieve sustainable development, clay excavations should be planned properly, have operational controls, environmental management systems; and rehabilitation strategies after mining has ceased.

The manufacturers of floor and wall tile, sanitaryware, formers, artware and other higher value ceramic products require ball clays or plastic clay with specific properties, quality and consistency. Mining operations supplying these industries have to control the grade of material sent to the factory. While stockpile management and blending can help to even out inconsistencies, mine operators should have good knowledge of their clay deposits in order to control raw material quality and consistency.

Ball clays or plastic clays are sedimentary clays. Due to the transportation and sedimentation process, the clays can be quite variable. Figure 2 shows the variations of Al2O3 in clay samples collected at different points and depths in a sedimentary clay deposit. These variations in elemental and mineral content affect clay properties and behaviour within the manufacturing process. For example, variation in fired shrinkage will result in products which are distorted. Simply using the clay without due consideration for these variations will result in huge amount of rejected product, and poor product quality. This

wastage at the end of product line causes large losses, so it is cheaper to control the quality of raw material at the source. Operators try to control raw material quality by selective mining. Much of the resource is wasted in the selective mining process and more land needs to be opened up in the search for suitable clays. Better knowledge of the clay deposit leads to better quality product, reduced wastage and enhanced sustainability.

Ball or plastic clays usually occur as thin layers or lenses spread over present river valleys or flood plains. A typical profile is 1-2 metres of peat or overburden material, 2-10 metres of clay followed by sand layers. If it is consistent, it can be systematically mined by stripping off the overburden, extraction of clay in one or two benches and filling back the mined out areas. In this way, restoration can be progressive and land disturbance kept to the minimum. Restored areas can be replanted and shallow remnant pond can be used for aquaculture. The current usage of ball clay is relatively small and the land areas excavated are not large. Many clay pits are situated in small areas within large palm oil estates. Other clay pits are in areas of development, where both clay and sand are extracted at the same time, both commodities being needed for the development itself. Such pits are bigger and deeper and have to be properly restored after mining has ceased.

Kaolin deposits can be of hydrothermal, residual or sedimentary origin. As with ball clays, variations within the deposits must be understood in order that consistent and high quality kaolin can be obtained for local industries and for export.

SUSTAINABLE MINING OF OUR CLAY RESOURCES

I will now examine the mining and utilization of our clay resources in the context of the three pillars of sustainable development, namely the economic, social and environmental spheres.

Economic sphere

We have been using our clay resources in Malaysia since the Neolithic age but now in much larger and increasing volumes as the pace of development hastens. The bulk of clay, shale and earth material is used for bricks, pots, cement and pipe, low value but essential for national development. Some clays are used for products of higher value, ranging from floor and wall tiles to sanitaryware, artware, formers and tableware. Current research focuses on ways to use local clays for even higher value products such as advanced and technical ceramics. It is through these higher value products that we can increase the economic returns from our clay resources. Although some exploration and follow up investigations have been carried out, we need more detailed information about the quality and consistency of our clay deposits, their suitability for use by existing industries and deposits containing clays with special qualities for new and advanced applications. A detailed inventory of resources will be necessary if good resource planning and management is to be implemented on a national scale. Many clay enterprises are small, and start without good knowledge of their clay deposits. Some, while otherwise well managed, run into problems with the quality of their product due to problems with the quality of their raw material, causing them to become unviable and to shut down.

Social Sphere

Clay resources are abundant, so there will be plenty for use by future generations. However, land development continues apace, and many clay deposits are becoming inaccessible as a result. Others become unextractable due to environmental constraints. Proper resource management will be necessary to ensure adequate supplies for the present and for the future. Wastage of industrial clay can be minimized. Many clay mines are small and in isolated areas where there are little control over their operations. They are usually considered earth removal operations, and so are not subjected to mining and environmental controls. The industry is not quite transparent and is fragmented with few big operators and many small operators, so it is difficult to ascertain where costs and benefits of clay resource extraction go. With new policies and authorities, the industry can be better controlled.

Environmental Sphere

Unlike the mining of metals, where a few kilograms or grams is extracted from each tonne of ore, thereby creating a great deal of waste, the ideal clay mine utilizes everything dug out and no waste is created. However, if the operators do not have good information about the deposit, and have to dig many holes in order to find suitable material, much waste may be created and more land may be disturbed than is necessary. As industries increase their demand for clays of higher quality and consistency, operators widen their search and open up larger areas. Evaluation techniques of clay for industrial use should be improved to improve quality of raw material, reduce wastage and environmental disturbance. Many clay miners are small and short-term operators, so product stewardship can only come from the government, professionals and academics. At present, there are few requirements for the rehabilitation or reclamation of land after the clay has been extracted. In developing areas, buildings or other developments take over, but in isolated areas it is left for nature to take its course.

CONCLUSION

Although Malaysia has abundant clay resources, premium special application clays are not so abundant. We have to continue the search for premium grade clay with consistent quality, better characterize the deposits, and find new, higher value uses. While common clays and shale do have an important role in the low end clay industries essential to nation building, it is the premium clays that provide raw material for the higher end industries we wish to promote. Finding and exploiting deposits of these premium clays will reduce imports and increase economic returns from our clay resources. As the ceramic and clay based industries move up the manufacturing ladder towards more sophisticated products, the knowledge of, and the grade and consistency of our clay raw material should move up in tandem, otherwise, we will find ourselves importing expensive clays, while

exporting our own clays as cheap raw material. Our natural clay reserves are slowly depleting and we will get little economic return from it. To ensure the sustainable development of the clay resources in Malaysia, we will have to utilize and manage our clay resources efficiently to bring maximum economic return and at the same time reduce waste, land disturbance and environmental impacts. The environment has to be taken care off at all stages of clay extraction and utilization so the development of our clay resources can bring holistic benefits to the people and nation.

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