DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2010/107

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Centre for Sustainable Artisanal and Small-Scale Mining (SASMIN), Geocenter Danmark

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Foreword

This study on agrominerals in Tanzania was undertaken by Centre for Sustainable Artisanal and Small Scale Mining (SASMIN), involving a multidisciplinary team of geographers from the University of Copenhagen, Institute of Geography and Geology (IGG), one geologist from the Geological Survey of Denmark and Greenland (GEUS) – in collaboration with one geologist from the University of Dar es Salaam. SASMIN is an interdisciplinary research and consultancy unit pertaining to sustainable small-scale mining in developing countries, drawing on researchers from both GEUS and IGG.

Field investigations for this study were undertaken in the period from the 1 -15 March 2010 in various locations around the Mbeya area, Tanzania, which is known to be endowed with agrominerals.

The project was funded by Geocenter Denmark. Fieldwork for the research was made possible through a research clearance kindly granted by the Tanzania Commission for Science and Technology (COSTECH).

LIST OF CONTENT

Abbreviations and Acronyms

AFSP:	Accelerated Food Security Project
ASDP:	Agricultural Sector Development Programme
COSTECH:	Commission for Science and Technology
FAO:	Food and Agriculture Organization of the United Nations
GEUS:	Geological Survey of Denmark and Greenland
HH:	Household
HP:	Horse Power
NAIVS:	National Agricultural Input Voucher Scheme
PML:	Primary Mining License
PPL:	Primary Prospecting License
SASMIN:	Centre for Sustainable Artisanal and Small-Scale Mining
STAMICO:	State Mining Corporation
TASAF II:	Second Tanzanian Social Action Fund
TNBC:	Tanzania National Business Council
TSh:	Tanzania shillings
URT:	United Republic of Tanzania

Exchange rate

As per 4 November, 2010, 1 Euro was equivalent to 2100 TSh.

Executive summary

Poor soils are a major cause for poverty in Sub-Saharan Africa and restoration of soil fertility is a significant challenge for development efforts. Some of the main resources – phosphate and lime – are present in many African countries and may potentially be used in relatively unprocessed form as alternative, inexpensive fertilizers by smallholder farmers in the vicinity of the resources. It is estimated that only about 60% of farmers in the Mbeya Region, SW Tanzania use fertilizers due to income constraints and a large number of farming communities struggle with soil fertility problems. This is the rationale for the present appraisal study on the agromineral potential of the Mbeya Region.

Exploration and exploitation of agrominerals in Tanzania are governed by the New Mining Act 2009-10. Presently the majority of the Mbeya Region is covered by various types of mineral licenses but presumably some of them are only taken for financial speculation. Thus, concerted efforts to boost small-scale mining of agrominerals are facing considerable institutional complexity, not least caused by opaque relationship between agricultural and mining regulatory policies.

The practical challenges and the potential benefits of using rock phosphate are widely discussed in the literature. However, the general view is that use of rock phosphate for local agricultural use is justified, provided the addition of rock phosphate is managed in accordance with the type of crop and the conditions of the soil. A pilot study was carried out to learn from farmers in the village of Muvwa, adjacent to Songwe Scarp carbonatite about their cultivation practices and views regarding demand and constraints for the use of locally produced agrominerals with phosphate. The survey shows that the general pattern is marked by a strong reliance of fertilizer for maize production, moderate use of fertilizer for cash crops like coffee and tomatoes whereas beans and some of the alternative cash crops are produced with very little – if any – fertilizer. All farmers interviewed are interested in participating in limited experiments and use of alternatives to commercial fertilizer, i.e. local rock phosphate.

Very few farmers in the Mbeya Region use agricultural lime as they are unaware of its effects and as it is often locally unavailable and/or too expensive. If agricultural lime could be made locally available at an affordable price then it would give farmers an opportunity to improve their crop yields. The carbonaceous sedimentary rocks – travertine – of Songwe Valley are being mined for (i) dimension stone, (ii) calcinated carbonate, and as (iii) raw material for cement; no agro-lime is presently being produced.

A feasibility study including the Songwe Scarp carbonatite phosphate and the Songwe Valley travertine lime as potential agro-mineral resources is warranted. The study should address the accessibility of the agro-mineral resources as well as organisational and institutional issues related to their exploitation.

1.Introduction

Most soils in sub-Saharan Africa are losing nutrients necessary for sustainable agriculture - as a result of intensive farming and inadequate compensation of nutrients lost due to precipitation and soil erosion - and vast areas in the region experience moderate to acute phosphorous deficiency (Vanlauwe & Giller 2006). Consequently, the poor soils are one of the roots causing poverty in Africa. Thus maintaining and restoring soil fertility is a significant challenge in many sub-Saharan countries and warrants the need for affordable technology and implements addressing the sustainability of the agricultural activities for million of farmers.

The aim of this report is to focus on the concept of using locally available geological materials – agrominerals - as inexpensive alternatives to commercial fertilizers among smallholder farmers in the vicinity of such resources. It is the authors' postulate that numerous untapped agromineral deposits exists in the sub-Saharan Africa and should be considered as potential nutrient sources for farming communities.

Phosphate rocks and lime deposits have been identified in many African countries, but are either untapped or used as raw material for the manufacture of commercial fertilizer; small-scale production of agrominerals for local use is rare. The Mbeya Region, situated in the South western highlands of Tanzania, is characterised by intensive smallholder farming and it is endowed with several potential agromineral resources like carbonatitic phosphate rocks and limestone. These resources have previously been examined within the framework of the Tanzania-Canada Agrogeology Project in the early 1990s, encompassing studies on the phosphate resources of the carbonatites complexes in the Mbeya region, including the Panda Hill, the Mbalizi and the Songwe Scarp carbonatites, as well as applied agro-technical studies on the rock phosphates (Chesworth *et al.* 1988; Chesworth *et al.* 1989). However, no follow-up activities have addressed the technical, economic and social aspects and challenges involved in a possible implementation of small-scale operated production of agrominerals.

This appraisal study aims to outline a basis for a future feasibility study that has as its objective to examine the possibilities for starting small-scale mining, distribution and testing of agrominerals for local use. The area under study is situated west of Mbeya town including parts of Songwe Scarp and Songwe Valley; in administrative terms it includes parts of Mbeya Rural District and Mbozi District. This area is relative richly endowed with the specific natural resources (phosphate and lime) and there is an urgent and substantial need for fertilizers both among the poorer smallholders and more well-of cash crop producers of e.g. coffee or sunflowers. The project is deliberately limited to the local scale as the main ambition is to enhance local sustainability and self-reliance in areas where the resources are available. A further advantage of the Mbeya area is that it hosts a number of NGOs working with agricultural development. Finally, the town of Mbeya and its surroundings are rapidly expanding thus offering a bustling market that is linked to other regional centres with adequate infrastructure, including the Tanzania Zambia Railway and highways linking Tanzania with Zambia and Malawi (see Fig. 1). These characteristics made the Mbeya area ideal for this agromineral appraisal study.

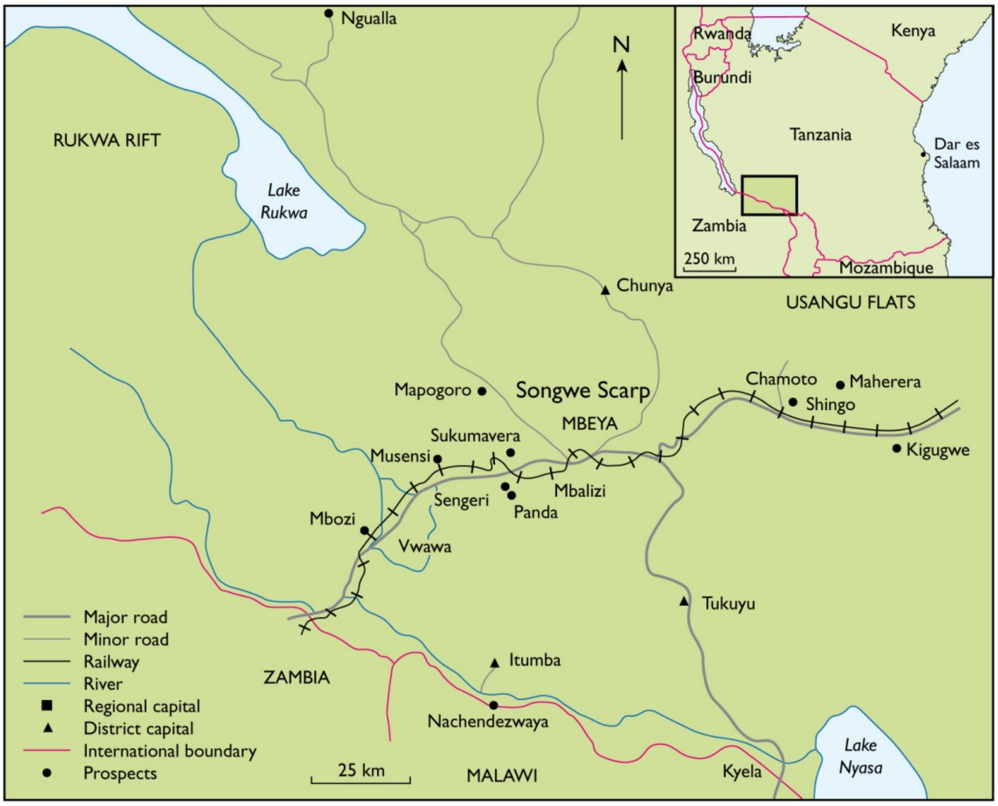

Fig. 1. *Infrastructure of the research area. The prospects shown are known carbonatite occurrences considered by previous studies as potential phosphate resources.*

2. Institutional setting

2.1 The regulation of fertilizer supply

From state subsidy to liberalisation – and back. Fertilizer policy in Tanzania has traversed a somewhat cyclical development since the Arusha Declaration in 1967 when the agricultural marketing system was nationalized. During the early couples of decades, imports and distribution of fertilizer were carried out by a state monopoly that sold fertilizer at highly subsidized prices. Shortages of supply were frequent and delays in deliveries reduced efficiency. As a consequence of the economic crisis in the mid-1980s and the implementation of structural adjustment policies, liberalization of the economy implied a dismantling of the agricultural marketing system, including the end of the state monopoly on fertilizer supplies and the phasing out of the subsidies during the early 1990s. Input markets were liberalized and private fertilizer imports and distribution were legalized (Minot 2009).

The removal of price subsidies resulted in a dramatic decline of fertilizer application in the late 1990s, reaching an all time low rate of less than 1 kg of nutrients per hectare (of arable land and permanent crops, FAO data) in the first years after the turn of the century. The resulting decline in food production and land productivity increased pressure for policy changes and in 2003 limited fertilizer subsidies were re-introduced, this time in the form of financial means to reduce transport costs from ports to inland farmers in selected regions, particularly for the benefit of farmers in remote areas. However, the Southern Highlands (i.e. the regions of Iringa, Mbeya, Ruvuma, and Rukwa) known as the country's 'grain basket' was also included. The system operated with fixed prices and margins determined by the government, and the physical flows of fertilizer were organised by a state institution. The involvement of the government in the distribution was not without problems as allocation priorities of state finances were intensely politically debated which often transferred into delayed funding and deliveries of fertilizer to farmers in the planting seasons. In addition, it was difficult to implement and monitor price controls all the way to the farm level (Minot 2009).

However, as a result of the new policy, the use of fertilizer increased rapidly, quickly reaching a higher level than during the previous decades. Regionally, the highest rates of fertilizer application takes place in the South-western part of the country, notably in Mbeya Region, where fertilizer is applied on more than 60% of farms (figures from 2002, volume not specified; see Minot 2009). Typically, farmers buy fertilizers at local markets or stores with money earned from sales of own farm products or other income sources, while credit is rarely used most likely due to very restricted availability. The most common reason for not using fertilizer is the price, which is found prohibitive but also the sheer lack of available volumes for sale (due to a variety of reasons) is an important cause (Minot 2009).

Introducing the voucher concept. In 2008, the subsidies for transportation of fertilizer was ended and gradually replaced by the National Agricultural Input Voucher Scheme (NAIVS), initially with two 'pilot' districts but planned to be substantially expanded in 2008 to include 53 districts - although lack of financial resources from the government in the 2008/09 season resulted in only 30% of eligible households (HHs) being reached (World Bank 2009a). Compared to the previous form of subsidy, the scheme was directed towards a different group of beneficiaries by targeting high-potential agricultural areas. The objective was to increase production by stimulating the use of fertilizer (at a lower price) in order to reduce rising food prices (this was the time of the start of the so-called global food crisis when high prices of food and fertilizer focused attention on food production and access to inputs). In addition, the scheme aimed to strengthen the private distributing companies in the supply chain by including them as the crucial link between importers and farmers. As such, the scheme supported the private sector by stimulating the consolidation and expansion of private distribution networks.

The vouchers are distributed to farmers in selected districts according to the production potential of their location, primarily in regions where the rainfall is reasonably reliable and dependence on irrigation is fairly low. The scheme is directed towards maize and rice farmers, the producers of Tanzania's main staple crops. Moreover, the scheme is targeting the poorest farmers - interpreted as full-time farmers with not more than one hectare of maize and/or rice under cultivation. Priority is given to female-headed HHs and farmers who are not regular users of improved seeds and fertilizer.

According to the World Bank 'Potential beneficiaries will be selected through participatory approaches at the village level. Simple, transparent criteria for eligibility will be published in the local media and broadcast on the radio' (World Bank 2009b). The selected farmers are given three input vouchers, two for different kinds of fertilizers: one 50 kg bag of urea (carbamide – $(NH_2)_2CO$; typically 46% nitrogen) and one 50 kg bag of DAP (diammonium phosphate) or Minjingu (see below) and one voucher for 10 kg of seed. Recipients should be able to co-finance the purchase through the vouchers that are worth 50% of the price. The vouchers are handled by certified dealers (both private and public dealers in fertilizers) and redeemed by National Microfinance Bank which has the largest branch network in the country (World Bank 2009a).

As such, the NAIVS is similar to what is termed 'a market-smart subsidy' in donor jargon, i.e. a subsidy that is targeting the poor in combination with support to the private distribution networks for fertilizers. This made the scheme eligible for financial support from the World Bank who in mid-2009 decided to start the Accelerated Food Security Project (AFSP) through an Emergency Recovery Loan under the theme 'Global food crisis response'. In essence, the project consists of a substantial co-financing of the NAIVS (160 million US$) over the period 2009-2012; the aim is to expand the subsidy to 57 districts and reaching about 1.5-2.0 million beneficiaries in total, which is considered to be equivalent to about 75% of poor smallholder HHs in high-potential food production areas, especially the Southern and Northern Highlands. At the same time, the private segment of the input supply chain is expected to be considerably improved and consolidated (World Bank 2009c).

In addition to the expansion of NAIVS, the AFSP includes continued support to specific components in two other programs, namely the Agricultural Sector Development Programme (ASDP) and the Second Tanzanian Social Action Fund (TASAF II). The former program offers financing for rehabilitation of economically and environmentally viable small-scale irrigation schemes as well as research and extension services related to improved soil fertility in the priority areas of the NAIVS. The latter offers financial support to public works programs for 'Able-Bodied Food-Insecure beneficiaries' with a priority to projects that conserve and restore natural resources essential to food production and local livelihoods and projects that offers direct support to vulnerable groups. The financial support for these programs covers the same period as the NAIVS (2009-12) and amounts to 30 million US$ for each program (World Bank 2009a).

The expectation is that the concentration of support to the high-potential agricultural areas in Tanzania will in the short term contribute to an increased production of food so that overall inflation is significantly reduced (increasing food prices have been the major cause for high inflation rates during recent years). In the longer term, considerably increased production of food from these areas may cover growing demand in neighbouring countries both for humanitarian assistance to food-insecure regions and for the commercial markets.

A new framework for agricultural policy – The Kilimo Kwanza Resolution. Despite the renewed interest of incorporating subsidies in fertilizer policy, the AFSP indicates a significant re-orientation of not only regulatory measures directed to a component of major importance in the agricultural input supply chain. It also reflects a new way of planning for agricultural development as expressed in the 'Kilimo Kwanza Resolution' (‘kilimo kwanza’ is Swahili and can be translated into ‘farming first’ or ‘agriculture first’) adopted in early June 2009 by the Tanzania National Business Council (TNBC) under the chairmanship of Tanzania’s President. The resolution establishes that Tanzania's agricultural sector has to be transformed into a modern and commercial sector by mobilizing financial resources from the private sector and international donors while adjusting public institutions to provide an adequate regulatory and managerial framework for invigoration of the agricultural sector (TNBC 2009a). Critics of the Kilimo Kwanza Resolution have pointed out that the policy favour large-scale commercial farming at the expense of smallholder farmers. Especially the landless among the smallholders are bound to be negatively affected by the policy, as they will find it difficult to access credit (Kanyabwoya & Kimboy 2010).

The resolution comprise ten actionable pillars which are spelled out in the action program (TNBC 2009b), including numerous activities to promote financing, implement strategic planning, secure land allocations for private investments, increase utilization of science and technology, improve physical infrastructure and mobilize popular support. Of particular importance in this context is 'Pillar 7: Industrialization for Kilimo Kwanza'. A number of backward and forward linkages from the agricultural sector are envisaged to be strengthened, among other things the availability of fertilizers via increased production (more than 300,000 tonnes per year) in existing facilities (phosphate and NPK from Minjingu) and exploration of possibilities for large-scale production of nitrogen-based fertilizers on the basis of natural gas deposits.

2.2 The regulation of mining

Mining legislation of the late 1990s. In 1994 the World Bank approved a US$ 14.5 million Mineral Sector Development Technical Assistance Project in order to establish a legal framework conducive to private investments in the mineral sector (Butler 2004). The project included a restructuring of the Ministry of Energy and Minerals and the writing of relevant investment and mining legislation including the Investment Act of 1997, the Mineral Policy of 1997, the Mining Act of 1998 and the subsidiary Mining Regulations of 1999. The 1998 act contained the key elements required to attract foreign investments: transferable and mortgageable mining licenses, no import duty or value added tax on mining equipment, periodic income and tax holidays, 3% royalty rates on minerals, and unlimited forward loss clauses. Moreover, the act allowed for 100% foreign ownership of mines, total repatriation of earnings and capital, and guarantees against nationalizations (URT 1998) and it did not include any local content requirements for foreign investors (Emel & Huber 2008). Accordingly, since the late 1990s, investments in large-scale mining have risen to more than US$ 2.5 billion (Roe & Essex 2009).

The 1998 Mining Act has been criticized for its limited impact on Tanzania's national development strategies including the country's efforts to reduce poverty levels (e.g. Emel & Huber 2008; Chachage 2005; Lange 2006; Curtis & Lissu 2008). The critique has emphasized the limited revenues that the Tanzanian state has received from minerals, especially gold, exported by large-scale mining companies; the sometimes insensitive evictions of small-scale miners and farmers brought about by the same companies; and the fact that the legislation has benefited the large-scale mining sector at the expense of small-scale miners (Lange 2008). The legislation of the late 1990s was based on 'first come, first served' terms. However, the restricted capacity of mining authorities to timely disseminate legislative information on license acquisition to small-scale mining operators unintentionally favoured large-scale mining companies, medium-scale exploration companies, and speculators. These used their legislative knowledge to secure licenses in mineral-rich areas before the vast majority of small-scale miners became aware of the opportunity (Mwaipopo *et al.* 2004; Jønsson & Fold 2009; Carstens & Hilson 2009).

In order to address the criticism coming from various stakeholders (Maganga & Mhinda 2009), President of Tanzania, Jakaya Mrisho Kikwete, in 2007 selected a Presidential Mining Review Committee in order to provide the government with an overview of the mining sector. The committee was chaired by former Attorney General Mark Bomani (Tanzanian Affairs 2008). Their recommendations, presented in what is often referred to as the Bomani report, essentially emphasized (1) an enhancement of the state's share of the production from large-scale mining through increased taxation and royalties and equity share ownership with the Tanzanian government and (2) improved working conditions for small-scale miners (URT 2008). An immediate consequence of the report was a planned revision and reform of the mining legislation.

The new mining legislation. The result, in the form of a new mineral policy and a new mining act, came in 2009-2010. In July 2009, Tanzania passed a new Mineral Policy; a statement of intent, to replace the Mineral Policy of 1997 (URT 1997). The policy promotes increased integration between the mining sector and other sectors of the economy in order to improve mining's contribution to the national economy. The policy also prescribes the development and increased formalization of the small-scale mining sector in order to facilitate sustainable development (URT 2009). In April 2010, Tanzania's parliament passed the 2010 Mining Act (URT 2010) to replace the 1998 Mining Act.

The 2010 Mining Act contains some changes from the legislative framework of the late 1990s. Although it is still largely based on 'first come, first served' terms, key changes include designation of more areas exclusively for small-scale mining purposes and royalties on metals up from 3% to 4% and based on 'gross revenue' instead of on 'net back-value'. Large-scale mining companies will be required to list on the Dar es Salaam Stock Exchange, and the government will have the possibility to acquire stakes in all future mining projects. The most comprehensive change in the act is arguably with regards to gemstones. Foreigners will not be able to hold gemstone mining licences without agreeing to a minority stake partnership with Tanzanian citizens. Also, gemstones are to be cut in Tanzania prior to their export in order to add value to the mining sector.

Besides the explicit mentioning of more areas designated for small-scale mining, something the Ministry of Energy and Minerals have already initiated in the previous decade (Maganga & Mhinda 2009), the legislation pertaining to small-scale mining seems to be quite identical to the 1998 Mining Act. Small-scale miners have the opportunity to acquire a Primary Prospecting License (PPL) and Primary Mining License (PML). A PPL is granted for a period of one year, can be renewed, and authorizes the owner to prospect for minerals within one of Tanzania's eight mining zones. A PPL is purchased through payment of application and preparation fees of 10,000 Tanzanian shillings (TSh) each.

A PML is granted for five years and gives the owner the right to exploit an area of up to ten hectares for five years. It can be mortgaged, renewed or transferred to others, although foreign firms cannot hold a majority share of a gemstone license (URT 2010). A PML gives the holder the right, subject to compliance with safety and environmental regulations, to carry out mining activities in the area. PML owners need to adhere to a set of basic social and environmental regulations. These are intended to prevent child labour, health and safety hazards, and environmental degradation. A PML is acquired subject to payment of application and preparation fees of TSh 10,000 each plus an annual rent of TSh 100,000. The procedures for acquiring a PML within an area designated exclusively for small-scale mining differ from the normal procedures, as it typically involves a tender process, where interested parties may apply (URT 2010).

2.3 Administrative overlaps and land-use conflicts

Administrative division of regulatory spheres. The legal and institutional framework of Tanzania places the responsibility of dealing with mining including small-scale mining with the central government in the form of the Ministry of Energy and Minerals. The ministry is represented by eight zonal mines offices spread across the country with an additional twelve district-based resident mines offices in the districts with significant mineral extraction. Traditionally, mining offices in areas with small-scale mining have focussed on technological issues of small-scale mining and surveying of claim applications. They have been less occupied with the administrative set-up and socioeconomic development within small-scale mining communities including the cooperation with other administrative units at the local level (Mwaipopo *et al.* 2004).

Whereas mining falls under the central government, most other administrative sectors (e.g. agriculture, community development, education, health, land, and water) fall under the local government at the village, ward and district levels. Thus, a key problem facing local mining authorities has been the lack of coordination and cooperation with other sectors of the state apparatus, most of which have undergone processes of decentralization during the last decade. This has taken place under the Local Government Reform Programme initiated in 2000, the aim of which was to improve the service delivery at the local level through increased coordination and improved capacity within district administrations and district councils (Mwaipopo *et al.* 2004).

This has had implications for the administrative support offered to small-scale miners by the local government, which do not gain any significant revenues from mining activities taking place in their area. As a consequence, there seems to be an attitude among many local government officials that the mining sector is outside their jurisdiction, wherefore they do not consider small-scale mining settlements in terms of health and education services, and infrastructural and sanitary facilities. The losers are both people living in small-scale mining settlements, who are often neglected in terms of service facilities, and the local government, which do not receive any revenues from the mining activities (Fisher 2008).

Contested mining claims. Another outcome of the contrasting administrative set-ups occurs when miners register their mining claims on the land of local residents; farm as well as grazing land. The 2010 Mining Act overrules the 1999 Village Land Act in terms of access to land, and whereas mining issues are dealt with at the zonal or ministry level, land issues are mainly managed at the village and district levels. Thus, miners commonly have the right on their side in land disputes. Initially, farmers and pastoralists will complain to the local government, though without effect, as the local government has no jurisdiction over mineral rights. If a case ends up in court, the compensations (if any) paid to farmers or pastoralists are limited and do not consider customary land histories, and the investments in cultivation of permanent crops (Jønsson & Fold 2009; Lange 2008). The inadequate compensations to resettled/evicted small-scale miners and/or farmers in connection to the commencement of mining activities, was one of the things put forward in the Bomani report as highly problematic (URT 2008).

The mining legislation in Tanzania erodes customary land-use systems, which until recently prevailed as the dominant way of dividing land. This has forced rural residents to adhere to a legislated environment with which they are not familiar. As a result, the mineral rights end up in the hands of people who have the capability to timely acquire available mineral rich land, often at the expense of the locals. Consequently, speculators that do not prospect or mine may sit on large tracts of land and continue to renew their licenses. As exploration and prospecting licences are supposed to relinquish fifty percent of the license area, the holder may remain control over the relinquished part through other companies or by working with middlemen. It is common practise to hold on to the licences, as many license holders anticipate a future profitable resale if large deposits of precious minerals are discovered.

Both the 1998 and the 2010 mining acts stipulate that licence owners need to engage in active prospecting, exploration, or mining. However, with regards to prospecting and exploration, licences are only rarely relinquished, as the monitoring of the large areas in question require resources, which presently do not seem to be available. These kinds of areas are often worked by small-scale miners, who consequently are forced to operate informally. Often their activities are silently accepted by the mining authorities. However, if the rightful licence owner claims the land, the small-scale miners, who may have operated in the area for decades, are evicted; something that may easily turn into conflicts (Fisher 2007; Carstens & Hilson 2009).

Among the small-scale miners, conflicts do also arise; both between PML owners and between PML owners and the so-called pit holders, who commonly are the ones responsible for the mining activities. They sub-contract an area within the PML area, which they are responsible for. The pit holders and the mine workers who they employ are, however, without any legal rights to the mining pit. If the PML owner decides to sell his licence, they may be evicted within days although some pit holders invest thousands of US$ in their operations. This has resulted in numerous conflicts in Tanzania, where some PML owners choose to sell their claims to larger exploration and mining companies without consulting the people working more or less independently on their claims (Carstens & Hilson 2009; Mwaipopo *et al.* 2004; Jønsson & Fold 2009).

3. Agrominerals – opportunities and constraints

Agrominerals are all such minerals carrying the potential of improving agricultural production by slow release of essential nutrient elements to the soil and/or by improving the soil texture. Common agrominerals/-rocks are phosphate, lime, K-rich minerals, clay, zeolite, and mica.

Agrogeology - broadly defined as 'geology in the service of agriculture' (Jack 2010) - is a trans-discipline using rocks and minerals as low-cost, locally available geological nutrient resources, finely ground and chemically unprocessed for agricultural development.

Fertilizer is any substance that is added to soil to boost plant growth and yield. Natural fertilizers are formed in nature and are used in the raw form, like the organic fertilizers (manure, leaf litter, sludge) or inorganic substances, i.e. rock fertilizers like marl, rock phosphate, volcanic rocks, and mica as opposed to artificial fertilizers which are easy soluble and contain guaranteed total active nutrient concentrations.

The benefit of using rock phosphate as an alternative to commercial fertilizer has been widely debated. The advantages of using rock fertilizers, in particular rock phosphates, in tropical climate are widely reported; a thorough review is published by van Straaten (2002). It is documented, however, that a successful use of direct application of rock phosphate requires a comprehensive knowledge on the actual rock phosphate being applied, the quality of the soil, the crop requirements, and knowledge on fertilizer management. Such awareness is not common among smallholder farmers and the potential of inexpensive, locally available and environmentally sound fertilizers therefore remains untapped.

3.1 Phosphate minerals

Some of the factors important for a successful use of rock phosphate are outlined below. Van Straaten (2002) has extracted the major findings in this field and the following paragraphs are primarily based on this report:

Soil acidity with associated Al toxicity, as well as P and Ca deficiencies, are common growth/limiting factors in highly leached tropical soils. To overcome the specific P nutrient deficiency in soils, various forms of P are applied. In organic P sources applied to the soils range from processed phosphate rocks (P-fertilizers) to ground phosphate rocks and slightly modified forms of phosphate rocks. Among the cost-effective alternative P-sources are local phosphate rock resources – though the solubility of phosphate rocks differ widely as a response to their mineralogy and chemistry. Hence not all phosphate rock resources are effective while applied directly to the soil.

Types of phosphate rocks. Phosphate minerals have diverse origins and chemical and physical properties. The principal phosphate minerals in phosphate rocks are Ca-phosphates - mainly apatite. Pure apatite contains 42% P_2O_5, and francolite, the carbonate-substituted form of apatite, may contain 34% P_2O_5. The majority of the world's phosphate resources belongs to sedimentary and marine types, and less than one-fifth stems from igneous and weathered deposits; the origin of the phosphate rock also influences the chemical specification of the apatite. In particular the solubility of the apatite appears to be related to the a-dimension of the unit-cell and the PO4/CO3 ratio.

Reactivity of phosphate rocks. The reactivity – or solubility – of phosphate rocks is a measure of the phosphate rock to release P for the plant. The reactivity of sedimentary phosphate rocks is relatively high compared to those of igneous types (fluor-apatite) (Appleton 2002). Phosphate rocks with high relative reactivity are best suited for direct application to acid soils with low Ca and P concentrations.

The soil. In particular the following chemical and physical factors impact the effectiveness of the rock phosphate: pH (the more acid the soil, the faster the dissolution); CEC (high CEC increases the solubility); P- and Ca concentration (preferably as low as possible); P-fixing capacity of the soil. In many tropical weathered soils, the condition of low pH, low exchangeable Ca and low P concentrations are common, and favours the solubility of rock phosphates. Additionally, the soil P-sorption capacities also effect the dissolution of rock phosphate.

The type of crop. Crops vary in their ability to use P from rock phosphate. High phosphate mobilization capacities are related to buckwheat, white sweet clover, white lupines, cabbage and pigeon pea.

Fertilizer management. Method of placement, timing and liming can influence the effectiveness of phosphate rocks.

3.1.1 Modification of the rock phosphate

Physical modification. The larger the surface area of the product the more effective is the rock phosphate product. This can be improved by dry milling of the phosphate rock.

Biological modification. Tests have shown improved reactivity of the rock phosphate after various types of biological modification, such as mixing with compost and manure (Chien & Menon 1995a,b; Singh & Amberger 1998; Woomer *et al.* 2003; Tabu *et al*. 2007; Odongo *et al*. 2007; Agyin-Birikorang *et al*. 2007). Some successful tests have been made using modified phosphate rock of Minjingu (Appleton 2002).

Chemical modification. Research in many parts of the world has shown that the partial acidulation technique can be successful and effective with relatively unreactive phosphate rocks with low iron and aluminium oxide content (Hammond *et al*. 1989). The technology is robust but requires access to low cost sulphuric or phosphoric acid.

Chien *et al.* (1987, quoted in Appleton 2002) showed that small amounts of water-soluble phosphates act as a starter dose for the plants until P from the phosphate rock becomes available to the plant. However, it appears that the processing techniques of the rock phosphate need to be tailor made according to the local resource and environment. A number of mixing techniques have been developed (van Straaten & Fernandes 1995) and has proven successful with the phosphate rock of Panda Hill (Mnkeni *et al*. 2000).

3.1.2 Minjingu rock phosphate – a Tanzanian manufactured fertilizer

The Minjingu deposit, situated in the Northeastern part of Tanzania, is also the brand name of the only locally produced phosphate-based fertilizer – a rock phosphate. The deposit stems from organic sediments and the mine is a mechanised open pit with the rich phosphate layers found at a depth of 15-20 metres. The deposit is estimated to contain about 10 million tonnes of phosphate. The plant is privately owned and employs a manager, about 20 staff at supervisory level and about 150 workers employed on a daily basis (personal communication, Mohan Kumar, 6.1.2010). After mining, the sediments are spread out and sun dried. The rocks are crushed and screened into minus 0.5 mm grain sized powder; present production capacity (in the processing plant) is about 100 tonnes per day. The processing requires various kind of machinery.

Previously it was believed that unless the concentrate was sold in the form of very fine powder it would not assimilate with soil. Trials have revealed high variability in the quality of the Minjingu powder from batch to batch. Szilas (2007) reports the following content of minor elements: 3.5% fluorine (F), 1% magnesium (Mg) and0.7% potassium (K) as well as minor amounts of essential trace elements such as chlorine (Cl), copper (Cu) and zinc (Zn) but also small amounts of detrimental cadmium and uranium. It should be noted, that sedimentary phosphate deposits in general has elevated cadmium and uranium content. The Minjingu fertilizer is marketed in two different forms, namely as the well-known powder (which the farmers find too dusty to apply) and as a pelletized product. In general, pellets show better trial results than the powder and will be available in shops in 2010-2011, though not throughout Tanzania in the first seasons. The pelletized product has been enriched with nitrogen and calcium (personal communication, Jerry Ngailo, 5.3.2010), and thus does not fulfil the requirements for organic fertilizer.

The country-wide promotion of the Minjingu rock phosphate started in 2008, but has not proven successful. The farmers have been advised to apply Minjingu in the holes prepared for the individual seeds and not as a long term improvement of the soil fertility. None of the rock phosphate products will show an instant impact on seeds and crops. Farmers have to learn that they need to be patient and wait for the improvement of soil fertility in two to three seasons. Thus when farmers got access to the Minjingu in 2008 the result was miserable and there was a lot of political debate in the parliament where some members raised the issue of compensation to farmers that had used Minjingu. The following year, Minjingu was also subsidized, but then only few buyers were interested, notably coffee farmers. There has been a lot of politics involved in the promotion of Minjingu, the only domestically produced fertilizer. It was introduced very fast and the Ministry of Agriculture instructed all agricultural extension officers to promote it despite that there was no time for testing (Personal communication, Lupakisyo Masuba, 12.3.2010).

3.2 Liming minerals

Very few smallholder farmers use agricultural lime, as they are unaware of its effects, and as it is often locally unavailable and/or too expensive. As proven by Mitchell *(*2005) if agricultural lime could be made locally available at an affordable price then it would give farmers an opportunity to improve their crop yields.

The primary reason for increasing the soil pH through liming is to reduce the aluminium toxicity to plant roots. Increasing the pH decreases the supply of H^+ ions and, on calcareous soils, increases the supply of exchangeable $Ca2^+$ which, through the common ion effect, will decrease the dissolution of phosphate rocks. Thus, on the one hand, liming will reduce aluminium toxicity while on the other hand reduce the dissolution of phosphate rock. A practical approach to overcome the two contrasting effects is to apply the phosphate rock well in advance of the application of liming materials, as long as the P-sorption capacity of the soil is not high. The rates of lime application should be relatively low so as not to reduce phosphate dissolution.

It is argued by many that bringing the soil pH up to or close to neutral is unnecessary. A pH of 5.2-5.5 is regarded adequate for raising the crop yields (Mitchell 2005). The liming need is calculated through determination of the exchangeable aluminium content of the soil.

The ideal agricultural lime is a ground dolomite or dolomitic limestone with a particle size of 100%<2 mm; 60%<400 micron and up to 50%<150 micron (Mitchell *et al.* 1997). It is also used to improve the physical properties of the soil.

4. Mineral resources and exploitation activities in the Mbeya area

4.1 Geological setting of the Mbeya Region

The regional geology of Tanzania is characterized by a central Archean craton surrounded by Proterozoic fold belts (Fig. 3). The Proterozoic development is marked by the formation of orogenic belts, but the Phanerozoic is characterized by rifting, affecting the area outside the rigid craton: Mesozoic rifting in the south and Cenozoic rifting confined to narrow zones East and West of the craton. The Mbeya Region lies along the southwestern edge of the Archean craton, and the geology is characterized by a NW-SE striking Ubendian Belt (2,000-1,800 Ma) dominated by quartzo-feldspathic gneisses and amphibolitic rocks, intruded by syenite-gabbro complexes at around 730 Ma, and they have all been intruded by several carbonatite complexes of Cretaceous to late Paleogene age. Prominent faults, the Rukwa, Nyasa and Mbeya-Usangu faults are related to the East African Rift zone, as well as Neogene sediments - conglomerates, clays and cherts, commonly with volcanogenic additions - are associated with the Rift Valley.

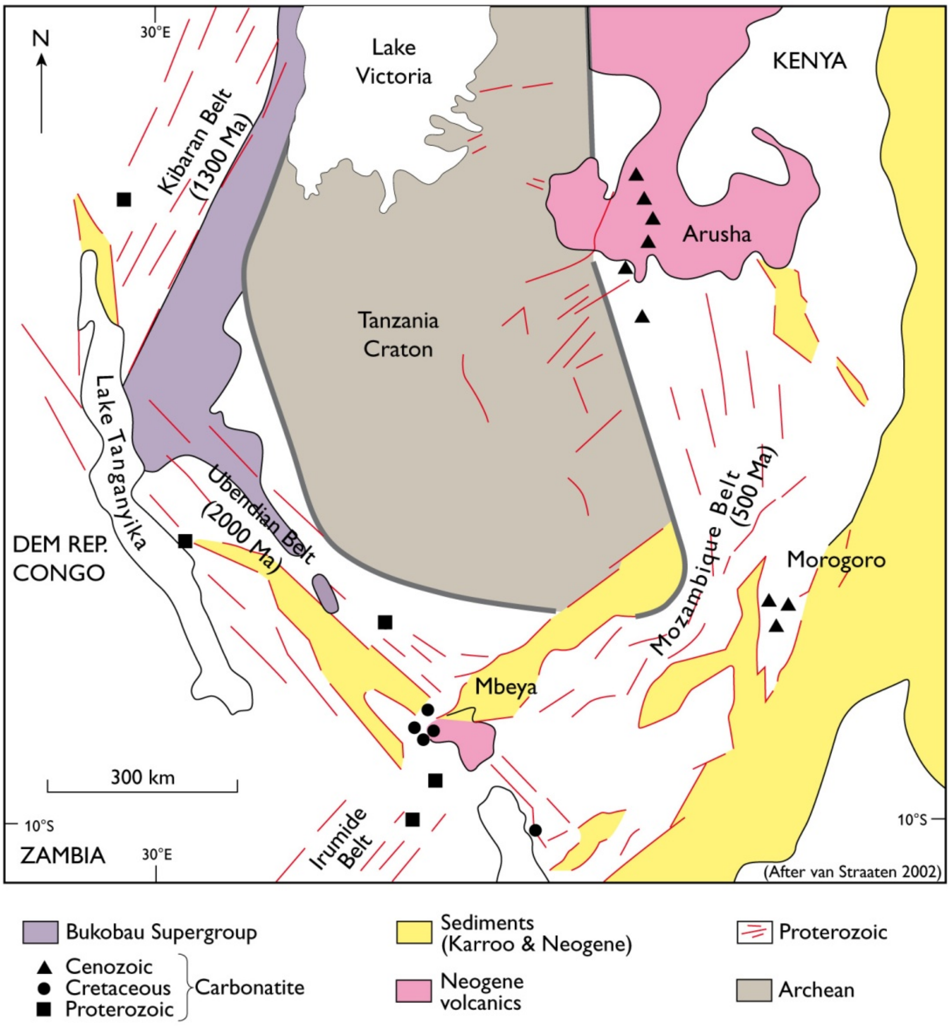

__Fig. 3:__ Regional geological sketch map of the South western Tanzania (based on van Straaten 2002).

The Songwe Scarp (fig. 4) is parallel to the regional structural trend and dips towards the rift valley (30^o -40^o). At the base of the scarp, the older crystalline rocks are abruptly truncated by the sedimentary and volcanic rocks that infill the valley. The sediments belong stratigraphically to the Rukwa Rift Basin, comprising the Karoo Supergroup, the Sandstone Group and the Lake Beds Sequence, of which the latter is dominated by unconsolidated alluvium, sand, mud and volcanic silt, of Paleogene age (Roberts et al 2004).

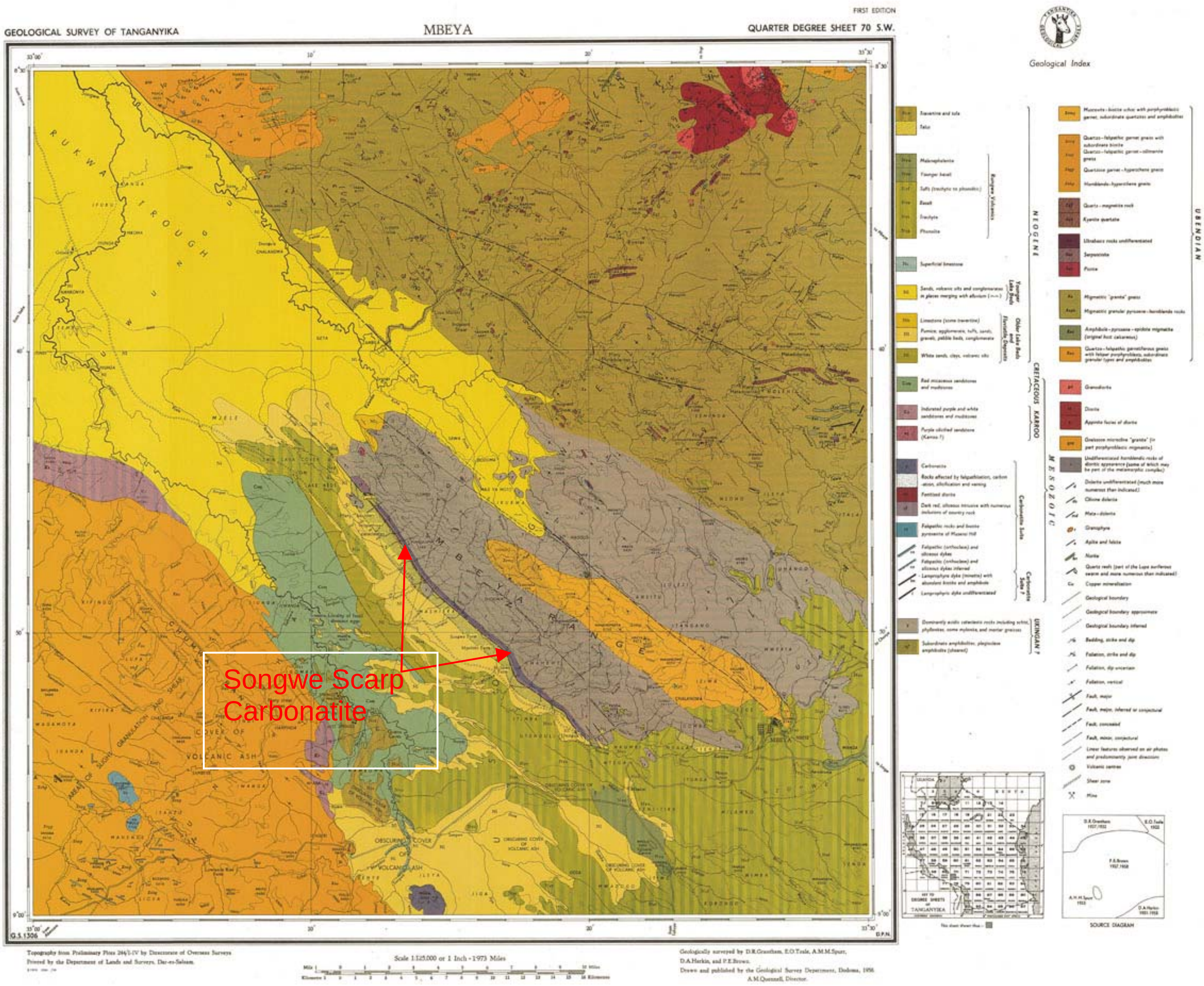

__Fig. 4.__ Geological map of the Mbeya-Songwe Scarp area.

The Mbeya Region hosts the following types of agrominerals:

- Igneous phosphates, associated with carbonatites
- Phosphate associated with guano deposits
- Limestone/travertine

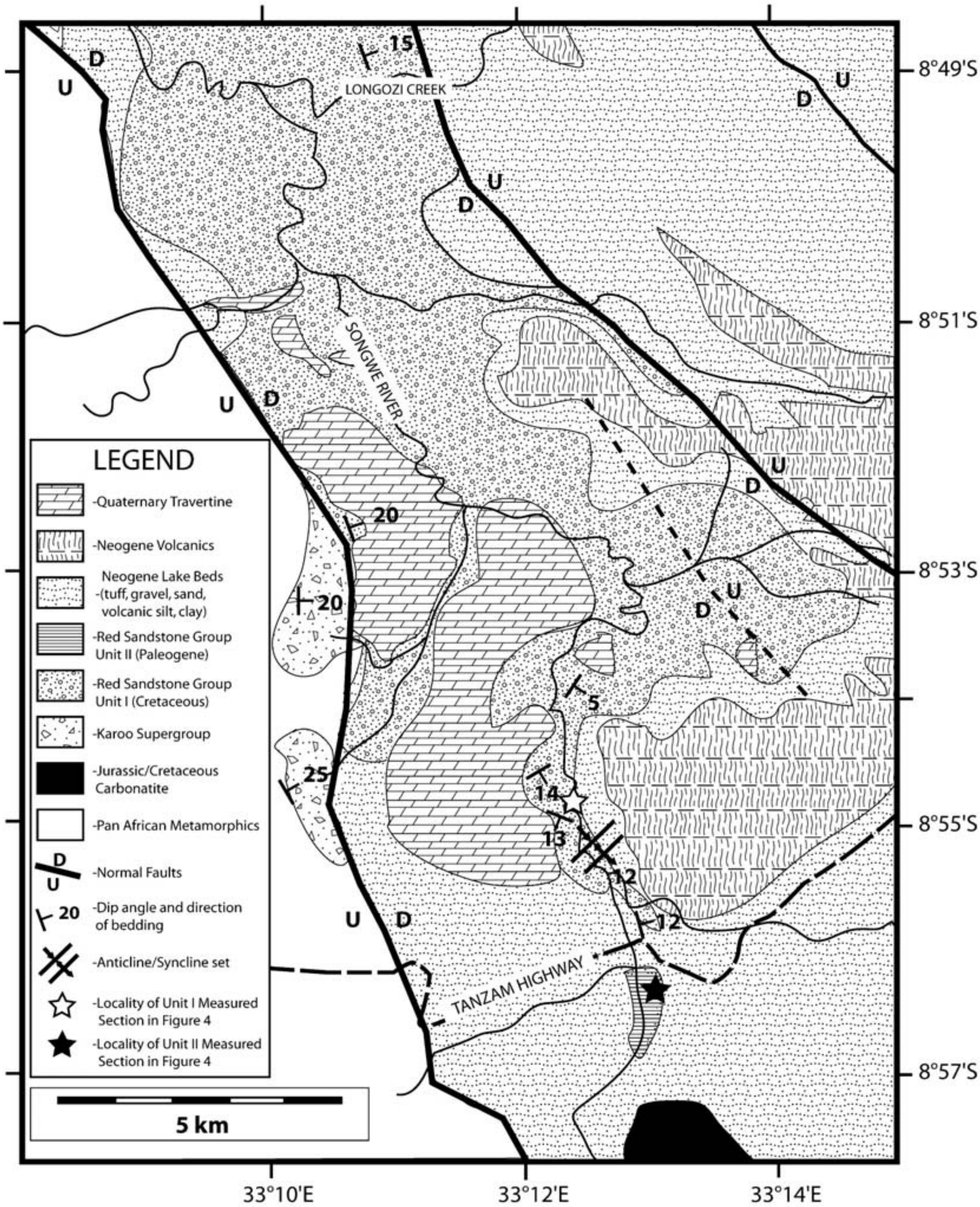

Fig. 5. *Detailed geological map of the Songwe Basin area (from Roberts et al. 2004).*

4.2 Phosphate resources in the Mbeya area

Songwe Scarp Carbonatite. The potential phosphate resource of the Songwe Scarp carbonatite is only scarcely documented; Mchihiyo *et al.* (1992) provides an overview of the resource, which is quoted below.

Two international mining companies, Anglo-American Corporation and New Consolidated Gold Fields Ltd. prospected parts of the Songwe Scarp carbonatite in 1956/57 mainly for uranium (Special Exclusive Prospecting Licence 824, 825). Detailed mapping was carried out over anomalous zones of the carbonatite, mainly at the 'Mineral Slope' some 2 km NW of Njelenje Village. In 1957 P.E. Brown mapped large parts of the carbonatite dyke, focusing the feldspatised zones and the intrusive bodies (Brown 1964). The two maps show major discrepancies, in particular regarding the limestone distribution.

The Songwe Scarp carbonatite, situated 17-35 km NW of Mbeya, is a carbonatite dyke striking over approximately 20 km in a NW-SE direction, reaching from 2 km NW of the Utengule Mission to close to Itega Village (Figs. 1 and 2). At the base of the escarpment, a gravel road leads from Mbalizi via Mshewe to Njelenje and Itega. Access to the carbonatite is good. The dyke is exposed in many stream sections at the densely populated foot of the Songwe Scarp.

Geologically, the Songwe Scarp carbonatite intruded into a rift fault zone at the foot of the Mbeya Range, which is made up of the Proterozoic Ubendian belt. Parts of the rock sequence of the NW-SE striking Ubendian were repeatedly affected by cataclastic deformation. The Songwe Scarp carbonatite lies in the continuation along strikes of the Mbalizi carbonatite, with which it seems to have a common origin despite the two carbonatites are different in terms of texture and chemical composition. The age of the Songwe Scarp carbonatite is 100+/-10 Ma (Miller & Brown 1963 in Brown 1994), the age of the Mbalizi carbonatite is 122+/-28 and 118+/-9 Ma (Pentel'kov & Vornovsky 1979 in Roberts *et al*. 2004). The Mbalizi carbonatite is a coarse-grained sövite, the Songwe Scarp carbonatite is a fine-grained ferrocarbonatite (Brown 1964). Typically, the Songwe Scarp carbonatite is grey-bluish in colour, homogeneous, hard, and breaks with a conchoidal to splintering fracture, and weathers to a yellow and ochreous limonitic mass.

The Songwe Scarp carbonatite dyke, has an average thickness of 50 m, and has intruded the post-Karroo/pre-Cretaceous rift fault over a length of approximately 20 km. The intrusion of the dyke had three principal phases: (i) the country rock was affected by K-rich fluids resulting in widespread feldspathization; (ii) the actual injection of the carbonatite dyke along the old fault zone, and (iii) brecciation forming the red 'silicious breccia'.

Fig. 6. *Songwe Scarp, near village Muvwa.*

Fig. 7. *Songwe Scarp, East of village Muvwa.*

Fig. 8. *Breccie boulders observed at the foot of the hill.*

Fig. 9: *Former exploration pit, showing the coarse grained residual soil.*

Intensive weathering has led to thick accumulations of residual soil over the Songwe Scarp carbonatite and feldspathized zones (Fig. 9). During past exploration campaigns geological, geochemical and geophysical surveys have been conducted along a baseline with 20 km and 700 m long crosslines at 400 m intervals. Additionally, soil samples were collected at selected areas. More than 300 samples were assayed for P_2O_5, several samples were analysed on their major and minor elements. The trace element analyses included the elements Rb, Sr, Y, Zr, Nb, Ba, Ce, Nd, La. However, only very few of the sample locations are identified and no technical reports have been located.

The exploration survey resulted in the delineation of several portions of the Songwe Scarp carbonatite relatively rich in primary apatite. Additionally the areas with high radiometric response near the village of Njelenje also yielded higher amounts of heavy REE and Y. The highest phosphate contents were found in limonitic residual soils overlying the carbonatite, grading up to 18-20% P_2O_5 and 6% K_2O. As pointed to in the agronomic part the Tanzania-Canada Project report, this residuum seems to be an effective resource material as phosphate fertilizer (Chesworth *et al*. 1988; Chesworth *et al.* 1989; van Straten 2002; Appletorn 2002).

The Tanzania-Canada Project identified the Njelenje area as the most promising with regard to rock phosphate but also pointed out that excavation may be potentially difficult because: (i) it is difficult to identify the phosphatic rich parts (geochemical grade control will be required) and (ii) the zones are relatively thin and at places not easy to mine. The advantage is that the area is close to farming communities and possibly could be worked and utilized on a local scale. The distance to farming areas is 0.5-10 km. The overall assessment of the Tanzania-Canada Project was that the deposit yields a potential only for small-scale mining and local application.

Fig. 9. *Landscape around Njelenje Village looking East.*

Panda Hill Carbonatite. The Panda Hill Carbonatite is roughly circular in shape with a diameter of approximately 1.5 km. In addition to phosphate, the Panda Hill also contains niobium, which has attracted strong exploration interests. It has been investigated since the 1950s, and detailed geological mapping, drilling campaigns (a total of 7,400 metres were drilled), and beneficiation studies have been conducted (Mchihiyo *et al.* 1992). Highest values of P_2O_5 and Nb_2O_5 occur in residual and transported soils overlying zones of primary pyrochlore and apatite enrichments in the fenite/sövite contact zone, in particular the Kunja-Mtoni-Mstari zone (8-15% P_2O_5) and the Museum zone (Mchihiyou *et al.* 1992).

In 1978 – 79, a joint team from the State Mining Corporation (STAMICO) and Yugoslavia estimated a resource of 480 Mt grading 0.33 % Nb_2O_5 and 3.5% P_2O_5. The highest concentration of pyrochlore and apatite occur in the fenites, which form the shallow roof cap and in the sövite zone directly beneath the cap zone.

Beneficiation tests has indicated that an input of 3.35% P_2O_5 will give a final concentrate of 36% P_2O_5, while an input of 0.3% Nb_2O_5 will give a final product of 60% Nb_2O_5. These beneficiation tests did not include residual material overlying the carbonatite. The Tanzania-Canada agrogeology team delineated approximately 1 Mt of residual phosphates with an average grade of 10.3% P_2O_5. Niobium concentrations in the 1 Mt residual soils have a mean concentration of 0.77% Nb_2O_5 (van Straaten 2002).

The Panda Hill has a great potential as phosphate resource and situated adjacent to P-deficient farmland and ideally situated adjacent to main road and railway. However, this resource is now considered as a niobium resource and phosphate will play a minor role as a by product. Van Straaten (2002) recommends small-scale mining techniques to be applied for extraction of the residual part of the deposit, and also recommends that locally adapted modification techniques should be tested.

Mbalizi carbonatite. The Mbalizi carbonatite is approximately 1.1 by 0.4 km in extent and consists mainly of coarse-grained sovite. It is cut by the main Tanzania - Zambia highway 10 km west of Mbeya. The Mbalizi and Songwe Scarp carbonatites both occur along the strike of the eastern escarpment of the Rukwa Rift, and it is probable that they have a common origin (Mchihiyo *et al.* 1992), with Mbalizi being the plutonic feeder for the extensive high-level dyke system of the Songwe Scarp carbonatite.

According to Mchihiyo (1991) the Mbalizi carbonatite has been intruded in several phases, accompanied by large-scale fenitisation of gneissic country rocks. The central pyroxenite was locally altered to phlogopite - apatite rock. Coarse-grained apatite - phlogopite - feldspar rocks to the west of the exposed carbonatite are considered to be fenitised bedrocks. The centre of the exposed carbonatite is largely sövite, locally grading up to 9% P_2O_5. Weathering of the sövite has resulted in development of a 0.5 m thick limonitic crust, which at places contain up to 30% P_2O_5 (Mchihiyo 1991). This phosphate resource is under license as a Nb-REE potential source.

Bat Guano – phosphate. Bat guano deposits are known from Sukumavera, near Mbeya, located in caverns in horizontal travertine formations. From 1934 to 1957 some 3,223 tonnes were excavated from these caves; but reinvestigation of the guano deposit revealed only small easily accessible resources, (a few hundred tonnes) with grades between 26-37% P_2O_5 (van Straaten 2002). This phosphate source is far too limited to play any a role for the community farmers.

4.3 Limestone/Travertine in the Mbeya area

The calcareous sedimentary rocks of Songwe Valley are being mined for (i) dimension stone, (ii) calcinated carbonate, and as (iii) raw material for cement. Despite these many activities, however, only very little geological information is available and the geological mapping of the resource is inadequate; thus the reported extension of the travertine resource differ substantially (Brown 1964; Roberts *et al.* 2004).

Hochstein *et al.* (2000) have investigated the geothermal resource potential and provides a summary of the travertine occurring in the Songwe Valley. Close to the Songwe River numerous small and large thermal springs discharge hot Na-bicarbonate water between 50 ºC and 80ºC, often together with CO_2 gas vents. The springs show NNW alignment and occur in clusters over a distance of around 3 km on top of extensive travertine, between 5 - 70 m thick, and cover an area of c. 13 km^2. The travertine layer is draped upon sandstones. At the south-eastern end older travertine is overlain by a young (Upper Pleistocene), up to 5 m thick flow of olivine basalt. Travertine is now being deposited by all thermal springs. Hochstein *et al.* (2000) suggest that the large volume (>150 Mio. m^3) of travertine points to a long depositional history (c. 2 Ma) if the present day $CaCO_3$ deposition (rate of c. 5g/s) has prevailed during that period. The Songwe thermal springs constitute a significant geothermal resource.

4.3.1 Present extraction industries working on the limestone

Cement. Tanzania has three main cement producers: Tanzania Portland Cement Company, Tanga Cement Company and Mbeya Cement Company. Tanzania Portland Cement Company, which is controlled by the German company Heidelberg Cement, is the country's largest producer, currently supplying over 40% of Tanzania's cement needs. It operates under the Twiga brand. Tanga Cement Company, the second largest producer, is controlled by the Swiss company Holcim and markets its cement under the brand name Simba. The majority shareholder in Mbeya Cement Company is the French producer Lafarge; Mbeya's Tembo brand cement accounts for around 18% of Tanzania's cement.

At present there are three cement factories in Tanzania namely The Mbeya Cement Company Ltd, outside Mbeya, and one each in Tanga and Dar es Salaam. The total installed production capacity of these three factories is 1.6 million tons. In 1984, the reserves were estimated at 72 Mt travertine containing 48.7-53.8% CaO (Jourdan 1990); the capacity of the Mbeya plant (which started operations in 1984) is about 250,000 t/y but production has not reached this level due to a number of technical and financial limitations. The capacities of the three plants have increased over the past decades, but their production is still inadequate to cope with the domestic demand estimated to be 2 million tons (Turana 2010).

Travertine dimension stone. A Tanzanian company is operating a quarry producing dimension stone blocks in the northern part of Nanyala Village in Mbozi District, Mbeya Region. The operation is working the travertine rock, dominated by yellowish grey colours and birds-eye structures (see Fig. 11). The quarry was not visited during fieldwork and it has not been possible to get first-hand information; however, rumours said that the management was struggling to find high quality dimension stones suited for export and therefore considered to diversify into other types of limestone businesses.

Fig. 11: *Travertine dimension stone block*

Hydrated lime. Around the Nanyala Village, Mbozi District, Mbeya Region, some hundred villagers are involved in the small-scale mining of lime. The semi-mechanised production has been ongoing since the 1980s, quarrying a whitish lime stone (travertine), which is subsequently, burned, hydrated, milled, bagged, and marketed (see chapter 6 for details).

4.4 Mineral licenses in the Mbeya area

According to a mineral license map from the Ministry of Energy and Minerals, it appears the mineral licenses have been issued for an area covering the most of the Mbeya Region (Fig. 12). The information at hand does not distinguish between the various types of licenses, and the map therefore does not necessarily provide information about which areas may be open for industrial minerals exploitation. It should be noted that licenses are often issued to individuals/companies lacking any geological background and using them for speculation hoping for a profitable resale, if precious minerals are discovered within the license area (see section 2.2).

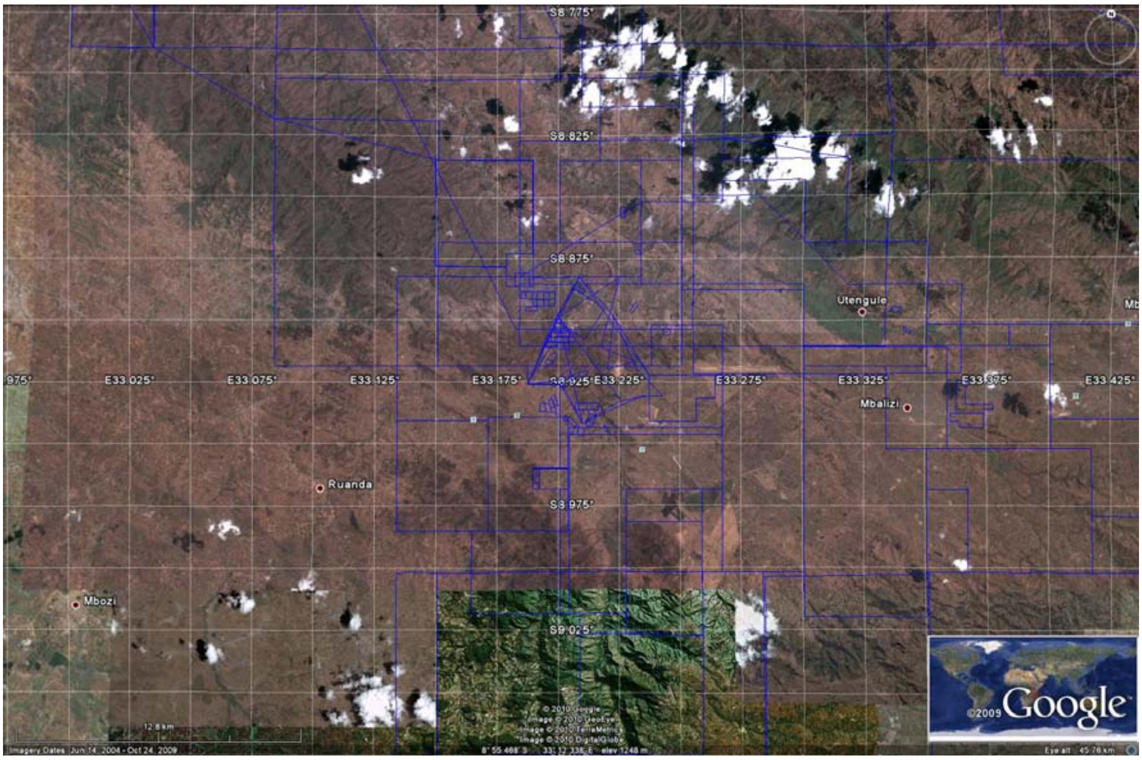

Fig. 12: *Overview of the mineral licenses in the Mbeya Region as per May 2010.*

5. Phosphate resource of Songwe Scarp – a potential local source of phosphate

5.1 Crop cultivation and fertilizer application in Muvwa - a pilot study

A pilot study was carried out to learn about the cultivation practices from farmers in the region and their views regarding demand and constraints for the use of locally produced agrominerals with phosphate. The village of Muvwa was chosen, simply due to its vicinity to the Songwe Scarp phosphate source (see Fig. 13). Muvwa is situated along the gravel road running northwest along the Songwe escarpment, from Mbalizi to Saza near Lake Rukwa. Mbalizi is located about 15 kilometres west of Mbeya on the main road (A104) to the Zambian border. Administratively, Muvwa is part of the Mshewe Ward in the Usongwe Division of the Mbeya Rural District of Mbeya Region. Actually, the village was formed by nine sub-villages that were merged in 1974 as part of the Ujamaa Programme. At that time, the village consisted of 250 HHs, while as of 2010, the total number of HHs has reached 420 corresponding to 1768 inhabitants. Most of them are children (about 1000 of the inhabitants are 13 or below) and only 331 persons are categorised as persons with capacity to work, almost equally split between men and women.

Fig. 13. *View from the Songwe Scarp overlooking Muvwa Village*

The village leaders claim that the land use pattern in the village has been quite stable since the establishment of the village. The village is dominated by agriculture with main crops being maize and beans while cash crops are coffee, sunflower and groundnuts. Only a small number of HHs are actually involved in coffee production and those who are, tend to concentrate on coffee besides producing food crops for own consumption. Most of the HHs keep poultry, whereas the number of other livestock is modest, including cattle, sheep, goats and pigs. The average size of landholdings is about five acres and most HHs cultivates a mixture of crops. The largest farmers have about 7-12 acres with five acres of maize. The most serious barrier for increased production is lack of money to buy fertilizer. Very few farmers use manure and when it is used it is primarily for gardening.

Most of the HHs owns their land according to customary law, while newcomers from outside the village have to rent land, although there still is some land available for allocation to indigenous HHs within the village area. Various tribes are present in the village but only very few HHs are not from the village or surrounding villages. Indigenous villagers, who want to expand production, are also able to rent land from fellow villagers, and village leaders estimate that about 10-20% of the HHs hire land. Usually young couples start with at bit of land allocated to them from the husband's family. If they are able to save money after some time they can expand landholdings by buying land. The outflow of villagers is relatively modest, as most of the young villagers prefer to stay. In recent years about 10 youngsters have left the village and started to work in small-scale gold mining in the neighbouring district of Chunya, and some of the young married couples have also left, mainly to Mbeya. The number of people moving to towns in 2009/10 was about 40. Perhaps the low rate of out-migration is due to the good road connections and the fact that two mobile networks (Vodacom and Zain) cover the area.

Data collection. A total of 21 HHs were selected and interviewed in order to substantiate these general patterns on a more detailed level (see1.12). Respondents were asked about basic HH data (sub-village, size of HH), access to land and land-use, use of fertilizer, labour capacity, and their knowledge of agro-minerals. The respondents were selected according to simple criteria, like the HHs access to land and location (i.e. respondents from different sub-villages). Some of the respondents also participated in a focus-group meeting with leaders of farmer-groups and sub-villages. Hence, the selection of HHs was neither random nor structured by one consistent method. Nevertheless, the results are indicative and serve to increase the validity of a future survey in the area.

Land-use pattern. The average number of HH members is about 5.8 but there are wide variations in HH-size, from 2 to 9 persons. Some of the HHs are made up by elderly persons and a grandchild and some are extended families including one man with several wives, children and grandchildren. These differences in HH characteristics obviously result in very different labour capacity per HH, as adults and grown-up children are involved in farm work (and counted as persons with working capacity). About half of the respondents stated that there was no further available labour in the HH, while the other half specified one or two periods, where some labour (up to two persons) could be allocated to other tasks than farming. This would be in the period just before the harvest of maize (i.e. in April and May) and the period immediately after harvest but before soil preparation and planting (i.e. August and September).

Fig. 14. *Interview with a Muvwa resident.*

The tight supply of labour is notable, when the structure and content of HH-livelihoods are considered. The importance and dependence of agriculture is significant: All respondents claim that income from farming is the major source of income. This is obviously no surprise for HHs without any alternative sources whatsoever, or HHs for which other income originates from petty trade. However, even HHs that have considerable income from diverse sources such as general stores, pension schemes, and salaries, claim that agriculture is their main livelihood. These latter HHs typically cultivate relatively large areas of land with food crops or specialize in coffee production (see Fig. 15).

The average size of land owned by each HH is 5.6 acres but varies significantly from 0.5 acres to 15 acres. Potentially, this points to a huge disparity in income from farming between the HHs. The real difference is somewhat lower albeit significant, because less than half (9) of the HHs actually cultivate all their land. On average only 3.7 acres are cultivated, which leaves about 2 acres idle for each 'average' HH. Obviously, the size of land lying idle also varies between the HHs (from 0.5 acres to 8 acres) but the general cause is claimed by all respondents to be lack of money for purchase of fertilizer and – to a lesser extent –

labour. Even HHs with less than average landholdings has land lying idle due to lack of money for input, including non-HH labour.

Fig. 15. *A coffee field of a smallholder farmer from Muvwa.*

Very few HHs (3) rented land from fellow villagers, although the importance of access to more land was significant, as the area of cultivated land was almost doubled in these cases. This corresponds to the low number (3) of other HHs, who rented out land to other farmers; one of the respondents explained the reason for not doing so by referring to age and lack of money to buy the necessary inputs for cultivating all available land.

All 21 HHs cultivate maize. The average size of land cultivated with maize per HH is about 2.5 acres, varying from 0.5 acres to 5 acres, a substantial difference. This indicates that some of the HHs have a significant production directed towards the market. According to one respondent, a HH with 9 members consumes approximately 8 bags (one bag being 120 kilos) per year, while the average yield is 20 bags per acre. Recent sales prices were estimated to vary between 30,000 and 42,000 TSh per bag during the recent year.

About half of the HHs also cultivated beans but in general less land is allocated to this crop (from 0.5 acres to 3 acres, average on 1.3 acres). Measured in terms of 120 kilo bags, a HH (9 persons) is estimated to consume about 1 bag per year while the yield is about 2-3 bags per acre. In contrast to maize, it is possible to produce beans twice a year without irrigation, harvesting them in March and June after a growing period of about three months (see Fig. 16). Hence, also in the case of beans, HHs that allocate more than one acre for beans, have a substantial share of market oriented production although the overall revenue from beans is lower than income from maize: average prices of a bag of beans (120 kg) is estimated to be about 90,000 TSh (March, 2010).

Apart from production of food crops – which is also produced for sale on the market by HHs in the village – a relatively limited number of HHs (8) are involved in production of other cash crops although not on a significant scale. Only one respondent reported production of coffee on two acres while another one specialized in banana (also on two acres). The remaining respondents have allocated between 0.5 and 1 acre to specialized production of vegetables (primarily tomatoes), sunflower seed or coffee.

Fig. 16. *A Muvwa farmer with harvested beans.*

The use of fertilizer. A notable feature in the land-use pattern is the high preference for cultivating fields located in the upper part of the gently sloping side of the Songwe escarpment compared to the more flat but slightly undulating land towards the river (basically west of the road). The land in the hilly area is perceived as much more fertile and the HHs allocation of resources is determined by this difference: if HHs own land in both areas, they never start cultivating land in the 'flat' area before all the land in the hilly area is fully used. As a consequence, the costs of cultivation are much higher, as more fertilizer than the recommended volumes is applied to land in this area. The difference in fertility is also revealed in the prices for land and the amount to be paid to the owner, if the land is rented (no data was obtained concerning the specific amounts to be paid for the land but several respondents and the village leaders referred to the substantial price differential).

The general attitude towards agricultural production – at least of maize, by far the most important food crop – is that money to buy fertilizer is a necessity and that it is not worthwhile to cultivate the land if fertilizers are not applied. The effect of fertilizers is well known, and their impact is highly appreciated, although some respondents raise concern over their impact on soil fertility due to continued production of the same crop year after year. However, the big majority of respondents stressed the decisive importance of fertilizers on an equal footing with the variations in precipitation. Another constraint for production was claimed to be lack of money to hire labour from outside the HH, while some respondents also added the need for money to hire oxen for ploughing. However, as also pointed out by the village leaders, the availability of money to buy fertilizer seems to be the crucial factor blocking increased production. However, it is clear that social differences among the HHs is generated and enhanced by differences in both the size of landholdings and in the available labour resources within the HH.

The widespread agreement about the important role of fertilizer is partly reflected in the pattern of fertilizer use and allocation to particular crops. Regional and district extension officers disseminate a simple rule to farmers in the area, namely to use one bag of DAP (diammonium phosphate) per acre to be applied during planting and one bag of Urea (or carbamide – $(NH_2)_2CO$; typically 46% nitrogen); and one of CAN (Calcium Ammonium Nitrate; 27% nitrogen, also per acre) to be applied during the growing period. This recommendation is well known by most of the farmers and is partially followed in maize production. All respondents applied Urea, and almost everybody did apply the recommended volume on their maize fields. Two thirds of the respondents apply DAP, when they plant maize, and the doses are very close to the recommendation, although several farmers are using less than one bag per acre. However, using CAN as supplement to the Urea is only practiced by one of the 21 farmers and none use Minjingu rock-phosphate. No fertilizer is used in the production of beans (only 1 out of 10 farmers use DAP).

As for cash crops, Urea and CAN are used by the coffee farmers, while those cultivating tomatoes seem to be somewhat experimenting with fertilizer application. Although DAP and CAN is applied by three out of four, no typical pattern and dosage is identifiable. The farmer, who cultivates sunflowers, uses one cap of Urea per seed-hole. Summing up, the general pattern of fertilizer use shows a heavy reliance of fertilizer for maize production, although the use of CAN is insignificant due to its high price. Use of fertilizer for cash crops like coffee and tomatoes is moderate, whereas beans and some of the alternative cash crops are produced with very small – if any at all – volumes of fertilizer.

Provision of extension services has decreased steadily during the last decade, as funding for these activities has been reduced. The frequency of visits to farmers by extension officers have significantly declined and visits are now focused on farmers' groups or dynamic and relatively prosperous individuals. In order to participate in a farmers' group, each participant must contribute a fee and many of the poorer farmers cannot afford membership. As a consequence, they do not get direct access to the information from the formal extension service. One of the respondents sardonically added that lack of access to information from extension service officers was not really harmful, as the advice was impossible to follow in any case – the poor simply could not afford to buy the recommended volumes and types of inputs. Some are happy with the new forms of extension service and praise the officers: these visit them regularly and are willing to come on demand to discuss concrete problems, particularly related to livestock, or new modern farming methods. One respondent from a farmers' group also participated in tests of Minjingu phosphate and claimed that the new type mixed with Urea worked as opposed to the old plain one, which was useless.

Willingness to participate in an agromineral trial project. It appears that all farmers are interested in participating in limited experiments and use of alternatives to commercial fertilizer. About half of respondents, including leaders of sub-villages and representatives from farmers' groups, have heard about the nutritional potential of phosphate rocks. Several of them recalled different teams of both white and black experts, who have settled in the area and carried out examination of the rocks. In 1998, a team camped in the neighbouring village, Njelenje. They were prospecting for agro-minerals both on the scarp and in the residuals forming the foot of the hill; no reports have been made available to the villagers on this work. Some of the respondents learned more about agro-minerals in this area on the radio news and from rumours among acquaintances. Despite the disappointing outcome of previous missions, all able-bodied respondents seem to be eager to participate in a future pilot project dealing with mining and crushing of the phosphate-bearing rocks in addition to limited field trials on specific soil types. The willingness to participate is expressed both in terms of contributions with labour (for mining, crushing, transporting, and application) as well as allocation of land for field trials.

5.2 Technical aspects and practical challenges

Nitrates and phosphates are the main agronutrients lost through smallholder agricultural practices, and conventional chemically nitrate and phosphate fertilizers are unaffordable in adequate amounts by this group of farmers. Smallholders' yields of staple crops like maize are typically less than one ton/hectare, compared to c. seven tons/hectare, if farmed with adequate investments in soil fertility (Jack 2010). Increasingly, the use of low cost inputs by smallholders seems to be the only practical and sustainable way to increase food production in many sub-Saharan countries.

As a result of long periods of intense weathering, which is characteristic for soils in the tropics, extensive losses of phosphate are common. In addition, low availability of phosphate is a function of the aluminium and iron combinations that are the dominant forms of phosphate in the tropical soils. However, undisturbed natural ecosystems in these regions contain enough phosphate in the biomass and soil organic matter to maintain the vegetation, and very little is lost as long as the system remains undisturbed. Once a piece of land has been cleared for agriculture, the losses of phosphate occur through soil erosion and in biomass removals. Within just a few years the system may lose most of the phosphorus that were previously cycled between the plants and the soils. The major problem to overcome by using rock phosphate, is their low solubility under non-acid soil conditions. Most rock phosphates show responses to crops 2-3 years after application, and thus it is difficult to generate interest by smallholders who may often have a shorter term view on returns to soil management practices

The use of rock phosphate and the practical challenges involved and potential benefits is widely discussed in the literature (Chesworth *et al*. 1988, 1989; Mchihiyo 1991; van Vuuren & Hamilton 1992; Sale & Mokwuny 1993; Weil 2000; van Straaten 2002, 2006; Appleton 2002; Woomer *et al*. 2003; Vanaluwe & Giller 2006; Agyin-Birikorang *et al.* 2007; Odongo *et al.* 2007). The general view is that use of rock phosphate for local agricultural use is justified, provided the addition of rock phosphate is managed in accordance with the type of crop and the conditions of the soil.

At this stage no calculations on the required amount of local rock phosphate per hectare can be done, because a number of technical data are yet to be collected; these include (i) the actual fertility of the soils in the Songwe Valley – as well as local variations, (ii) the depletion rate of P, (iii) the most P-demanding crops, (iv) and the average P-content of the potential rock phosphate.

5.2.1 Proposal for small-scale phosphate operation to supply local small holder farmers

The Songwe Valley area is endowed with two potential raw material sources for the production of rock phosphate: the apatite rich (i) residuals of the carbonatite – and (ii) the carbonatite. Given that previous studies indicate that P-enrichment has taken place in the residual apatite rich soil (Mchihiyo *et al.* 1992) and that a production based on the residual soil is technically more straight- forward, this study considers this source only. Mchihiyo *et al.* (1992) reports that exploration has taken place in the vicinity of the village of Njelenje and that P_2O_5 content reached up to 18-20% and K_2O reached 6%. Njelenje is situated some five km north of the interview area. As no data on the survey area is available, the Njelenje data may give an indication of the P content in the survey area.

Identification of the resource. The phosphate rich parts of the soil can not be identified by the naked eye. Consequently, the identification of the potential P-source will have to be based on geochemical analysis, gathered from drill holes (i.e. banka drilling) or sample pits. These data will provide information enabling grade and tonnage calculations, and subsequent pit planning. Cost estimates for this phase should be included in the feasibility study.

The geochemical data gained during this phase should also include information on the P-grade with respect to grain-size, enabling the most efficient production planning to be determined. The grain-size distribution of the end-product will probably be determined in practical tests, but less than 1 mm appears likely.

Site clearance. Prior to any operation it is recommended to clear the site, involving both bush clearing and removal of the top-most barren soil. Site clearance can be done manually or by rented earth moving equipment.

Excavation. It is regarded possible to extract the phosphate manually using pick-axes and shovels. But despite the technique, the excavation should be undertaken in accordance with a pre-designed plan for the excavation.

Loading and hauling. Manual loading and hauling with a wheelbarrow can be done, provided accessible routes are maintained from the mining site to the crushing station and sieving station.

Classification / Crushing. Depending on the grain-size distribution of the high grade P-material, it can be decided, if primary classification should be done prior to the crushing process in order to reduce the amount send to the mill. The crushing process can be carried out as a manual process only, or as a combination of sledgehammers and fine crushing using a jaw crusher, in which case the first crushing reduce the size to 5-10 cm in size, and the jaw crusher to less than 1 cm.

Milling. If milling is required a TD hammer mill as recommended by Mitchell & Mwanza (2005) for milling the crushed limestone, may be suitable. The actual grain-size distribution will be determined at a later stage.

Distribution of the rock phosphate. The concept is to supply rock phosphate product to the farmers living in the villages adjacent to the pit, and therefore bulk distribution by truck is suggested. In the event that more distant markets should appear, bagging (50 kg bags and/or big-bags) of the products may be considered. It should be noted that the products are distributed/sold without any declaration on the P_2O_3 content. Variations in the P-content among the batches may be expected, unless additional mixing steps are implemented to minimize this.

6. Limestone resource of Songwe Valley

6.1 Production of hydrated lime in Nanyala

In Nanyala Village in Mbozi District, Mbeya Region, an estimated number of 200 people, predominantly from the village, are involved with the small-scale mining of lime, some in full-time employment, and others as a supplement to other livelihood activities. The production of hydrate lime has been going on since around 1980, when a missionary initiated some production. The production is semi-mechanised. The whitish, yellowish and greyish raw lime stone (travertine) is quarried, burnt, hydrated, milled, bagged, and marketed.

More than ten PMLs cover the lime producing area. The licenses are mainly owned by people living in Nanyala and the neighbouring villages. As seen with the small-scale extraction of other minerals in Tanzania, many PML owners sub-contract the quarrying, burning, transportation and milling process to groups and individuals, who then pay a certain percentage of their produce to the PML owner. The organization of the lime production is presented below.

Quarrying. The quarrying of limestone is undertaken by hand held tools, and extracted from a large number of m-scale excavations, 1-2 metre deep and extents over several hectares, in what appears to be a non-systematic way. The rock selected is primarily a partly weathered limestone, which breaks fairly easily. The use of vertical kilns requires boulder sized raw material to allow air flow in the kiln; the unused smaller fraction is left around each pit as a waste material.

Fig. 17. *Small-scale quarrying of limestone aimed for hydrated lime.*

Fig. 18. *Contact between top-soil and weathered limestone.*

Fig. 19. *Vertical kiln system for burning of*


Fig. 20. *Packing of the kiln with rocks and firewood*

Burning. After excavation, the limestone is burned. This takes place in vertical kilns, 2-3 metres wide, 3-4 metres deep, and lined with bricks (see Fig.19 and Fig. 20). They are constructed close to slope sides of the terrain in order to allow a small opening in the bottom of the kiln for lighting the firewood and for intake of air. Boulder size lime stones are used, and the kiln is stuffed with layers of limestone and firewood. To pack the kiln with rock and firewood takes about one day for a group of three workers. The burning process takes about ten days, enabling three operations per month in the dry season and less in the rainy season. The lime will burn from below, layer after layer. When one layer has been burned, the heat will light the following layer of firewood, which will subsequently heat the above limestone and so on. One batch produces between 400 and 550 bags of 25 kilo each, depending on the size of the kiln, equivalent to between 10 and 14 tons. After burning it takes 1-2 days to cool down a batch. The burning is commonly organised and carried out by groups, which sometimes consist of equal partners and sometimes of an owner, who has paid for the fire wood, the bricks and the kiln production, and his employees. Typically one group operates 3-6 kilns at the same time.

Hydrating. After the lime has been burned water is poured on the batch, while it is still inside the kiln, and the lime rocks start to disintegrate. A lot of heat is produced in this chemical process and the batch has to cool down again, adding a few more days, before the lime can be transported to the mill. Prior to the milling, the hydrated lime is classified manually (see Fig. 21); oversize pebbles are crushed by means of hand-tools.

Fig. 21. *Classifying the hydrated lime, prior to the milling process step.*

Fig. 22. *Maize mill used for milling the hydrated lime.*

Milling. After burning and hydration the lime material is soft. Thus, normal maize milling equipment is sufficient for the further processing (see Fig. 22). The PML owners and the owners of the milling plants are sometimes, but not always, the same. While some of the plant owners are local people, others come from Mbeya town, 30 kilometres away. The owners of the milling machines consist both of people who have initiated their own companies with a lime brand, which is printed on water proof 25 kg bags, and by people with no brand and no bags, who sell the milled lime product to one of the five companies with proper bags. The subcontractors, most of whom only produce by order from one of the branded milling companies, receives 2,000 TSh. per bag. The price of milling machines is around 1.8 million TSh. with people in Nanyala choosing between one of the below two:

- A 20 horsepower (hp) machine attached to a 50-75 hp milling machine with a capacity to produce around 300 25 kilo bags per day.
- A 25 hp machine attached to a 100 hp milling machine with a capacity to produce around 400-450 25 kilo bags per day.

Market. The main market for the lime is the construction industry, which mainly uses the lime for lime wash of walls. Additional markets include the paper industry, the sugar industry, the steel industry, and, in small quantities, commercial coffee farmers and smallholder cocoa farmers, who use the lime for acidity treatment. Five of the Nanyala milling plants have their own branded bags. Four of these are: Twiga Lime Ltd, Jambo Lime, Nyati Goods, and Nanyala Lime Ltd. The lime is mainly marketed in the regions of Mbeya and Iringa with main markets being the towns of Mbeya and Makambako. The price on site for a waterproof 25 kilo bag is 3,000 TSh. The price if the bag is delivered to anywhere else is 3,500 TSh. per bag.

Earnings and expenses. An estimation of earnings and expenses along the commodity chain of lime looks as follows:

- Profit per batch for those who quarry and burn the lime in their own kiln is approximately 125,000 TSh.
- The ‘kiln owner’ pays 15 bags per batch to the PML owner in return for extracting the lime within his claim.
- The workers stuffing the kiln are paid around 15,000 TSh. per batch; the work is hard, but is normally done in one day.
- Expenses for firewood, which come from a site several kilometres from the mining site, are around 200,000 TSh. per batch depending on the size of the kiln.
- People transporting the burnt lime from the kiln to the mill, a distance of between 100 and 400 metres, are paid 100 TSh. per 25 kilo bag.
- The people involved with the manual handling and bagging internally in the milling plants are paid around 80 TSh. per bag.
- The cost for plastic bags with company logo is 2.2 millions TSh. for 5,000 bags, which is 440 TSh. per bag.
- The foreman for one of the plants was paid 100,000 TSh. per month.

An informant estimated that the capacity of all the milling plants if all machines would be up and running would be 15,000 bags per week. This, however, seems somewhat exaggerated.

6.2 Technical aspects

The limestone resource in the Songwe Valley is composed of various grades of quaternary to recent travertine deposits, of which neither the quantity nor the quality has ever been thoroughly investigated. Based on field visits, the travertine varies from greenish-grey, hard rock used for dimension stone production, to poorly consolidated, partly weathered, whitish rock used for hydrated lime production.

The ideal agricultural lime is a ground dolomite or dolomitic limestone, but no geochemical data on the travertine resource is available for this study; however, it is assumed that the chemical composition of the limestone resemble dolomite. Most agricultural lime products have the following particle size distribution: 100%<2mm, 60%<400 micron, and up to 50%<150 micron (Mitchell *et al.* 1997).

The production of agricultural lime is a relatively straightforward process involving the following main components:

Site clearance. Prior to any operation it is recommended to clear the site, involving both bush clearing and removal of the top-most loose soil, to ensure that only proper limestone with the adequate chemical specifications are processed. The cost related to the clearance should be part of the investment cost scheme.

Manual extraction. In the Songwe areas, it is regarded possible to extract the loose limestone manually using crowbars, sledge hammers and picks. Based on a small-scale dolostone operation in Zambia, Mitchell & Mwanza (2005) estimate that a single worker will be able to extract approximately 1 ton of rock per eight-hour working shift; we assume that this is on the low side compared with the Songwe travertine resource.

Loading and hauling. Manual loading and hauling with a wheelbarrow can be done provided accessible routes are maintained from the mining site to the crushing station. Mitchell & Mwanza (2005) estimate that a two-man team will be able to load and haul 10 tons of limestone over an average tramming distance of 500 m in an eight-hour working shift.

Crushing. The crushing process can be carried out as a manual process only or as combination of sledgehammers and fine crushing using manual jaw crusher, in which case the first crushing reduce the size to 5-10 cm in size and to less than 1 cm in the second stage. For a manual process, Mitchell & Mwanze (2005) estimate that one person can produce 100-150 kg /day depending on the hardness of the limestone.

Milling. A TD hammer mill is recommended by Mitchell & Mwanza (2005) for milling the crushed limestone; this mill allows a mill feed of 200-500 kg/h, depending on the size-fraction of the feed material (a detailed technical description of the modified TD Hammer Mill, and supplementary technical drawings is given in Mitchell & Mwanza 2005).

Cost estimates. Mitchell & Mwanza (2005) provides the production cost figures producing agricultural lime, based on small-scale mining operation in Zambia, and at a labour rate of US$1/day, as follows:

Site clearance:	1.13 US$/ton loose soil (investment cost)
Extraction of rock from the ground:	1.00 US$/ton of rock excavated
Loading and hauling:	0.20 US$/ton of rock loaded and hauled
Crushing - manual:	10.00 US$/ton
Crushing – mechanically:	1.00 US$/ton
Milling (TD hammer mill):	20.00 US$/ton

The production cost thus may vary between c. 22 – 32 USD/ton, depending on the technology applied, and disregarding investment costs.

6.2.1 Potential diversification, expansion of production, and labour supply

There seems to be a potential for diversifying the lime production into a larger variety of lime products, of which the largest potential seems to exist within the agricultural sector, where agri-lime can be used as a soil input in order to increase the soil's pH value and thus reduce acidity. Besides being a means to expand lime production in Nanyala, this is likely to improve and increase the agricultural yields significantly in farms, commercial and smallholder, where soils have a high acidity. Agri-lime is produced in Songea Town in Ruvuma Region, more than 500 kilometres from Nanyala and in Tanga Town in Tanga Region, a 1,000 kilometres from Nanyala. This indicates that there should be a market for increased lime production from Nanyala. Although Nanyala is located within the Mbeya Region, a region known to be one of the largest agricultural producers in Tanzania, surplus labour from the neighbouring villages should be available.

7. Conclusions

In general, the sub-Saharan African soils are poor and have a need for nutrients – in particular phosphor – because the fertility of the soil is low, which in turn is one of reasons for poverty in the region. Local use of agrominerals - minerals with the potential of improving agricultural production by contributing essential nutrient elements to the soil – carries the potential of being a low cost alternative to commercial fertilizer for some of the farming communities. This appraisal study has demonstrated that a potential for local extraction and application of agrominerals exists in the Mbeya Region of Tanzania's Southern Highlands. The agrominerals appear available in various exploitable deposits. In this study, two deposits have been examined in some detail, i.e. the currently unexploited phosphate deposits of Songwe Scarp and the limestone deposits of Nanyala; the latter being exploited for different industrial purposes. Both deposits are located adjacent to farm land, on which the need for additional fertilizer for the improvement of the agricultural production is evident.

The Government of Tanzania has increasingly looked towards the domestic extraction industry, which is dominated by small-scale mining operators, for alternatives to foreign large-scale mining companies in order to ensure a higher degree of domestic revenues from mining. In 2005, the National Strategy for Growth and Reduction of Poverty in Tanzania stated that "small-scale mining is increasingly becoming dynamic, as it provides alternative economic opportunities to the rural communities" (URT 2005:7). Also, the 'Kilimo Kwanza Resolution' stipulates that backward and forward linkages from the agricultural sector need to be strengthen including the availability of fertilizers via increased production in existing facilities (TNBC 2009b). In addition and corresponding to this, there is a need to explore the potential within the small-scale mining sector to extract agrominerals, as this could facilitate diversification and industrial upgrading of local economies.

A feasibility study of the potential to extract and apply agrominerals from the Mbeya area would be remunerative, initially pertaining to the rock phosphates from the Songwe Scarp. With regards to the limestone deposits of Nanyala, a feasibility study of the scope for expansion of the current operations aiming at a diversification of the product portfolio is also considered profitable. As a minimum, such feasibility studies needs to consider the following:

Geology. Additional geological data need to be gathered in connection with a feasibility study, i.e. a mapping of the size, grade, variation, and applicability of the addressed agromineral deposits. Also, the actual fertility of the soils in the area and local variations, especially with regards to acidity, the depletion rate of P, the most P-demanding crops, and the average P-content of the potential rock phosphate, needs to be documented. Pertaining to the rock phosphate, the phosphate rich parts of the soil can not be identified by the naked eye. Consequently, the identification of the potential P-source will have to be based on geochemical analysis, data from which will provide information enabling grade and tonnage calculations, and subsequent pit planning. The geochemical data gained during a pre-feasibility phase should also include information on the P-grade with respect to grain-size, enabling the most efficient production planning to be determined.

Institutional framework. As seen in Figure 12, mineral licenses of various kinds already cover most of Mbeya Region. This could pose a potential constraint to the efforts to promote small-scale mining of agrominerals in the Songwe Scarp and elsewhere, as these areas may be occupied. However, the vast majority of these mineral licences are apparently not being actively prospected, explored or mined. Instead they are most likely used for speculation purposes by the licence holders, who in many cases simply wait for someone to make a discovery of a precious mineral deposit, after which the license holder will attempt to sell the license with a profit. The Mining Act of 2010, however, stipulates that license holders need to be engaged in activities within their license area and use a minimum amount of money on their activities in the area annually. In case this does not happen, the license is to be relinquished. Taking the enhanced focus on agricultural development in Tanzania as well as the new mining act's explicit mentioning of designating areas solely for small-scale mining purposes into account, the government could monitor mineral license holders more actively ensuring that they live up to their obligations in terms of actively engaging in prospecting, exploration and mining respectively. Vacant land could then be designated for small-scale mining purposes with license areas being put up for tender by community-based cooperatives or private entrepreneurs eligible for applying. The division between the administration of mining and other sectors, in this case especially agriculture, could pose a threat towards successful implementation of a project attempting to extract agrominerals, i.e. a small-scale mining operation, in order to improve land fertility, i.e. agriculture. In this connection, it would be of great assistance if a pilot project on agromineral extraction and application would find support from the government's central administrations as a joint project between the Ministry of Agriculture and the Ministry of Energy and Minerals.

Organization. The findings of this appraisal study strongly points to the existence of local support to a pilot project of extraction and application of rock phosphates. According to respondents at Nanyala limestone site, there is also scope for improving the production of lime. Still, it is vital for the success of a potential pilot project that the support of the local community is unquestionable. As a minimum, representatives of the local community need to be involved at all stages of a pilot project, and thus also in a feasibility study. At best, community members should feel as owners of a pilot project in order to ensure as high a degree of project sustainability as possible. Whether or not the owners of an extraction process should be private people, i.e. individuals and people partnering up, or it should be the village in a form of cooperative, needs to be closely investigated. In the limestone production of Nanyala, the production is privately run and should probably remain organised in this way. Pertaining to the rock phosphates of Songwe Scarp, it is something that needs to be incorporated into the feasibility study. In a similar vein, the pros and cons of either using mechanised equipment or manual labour needs to be thoroughly examined.

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Appendix 1: Organisations and individuals met

Date	Organisation/Institution	Persons met
1. Mar. 2010	Ministry of Energy and Minerals, Dar es Salaam	Mr. Alex Magayana, Assistant Commissioner, Small-scale mining Mr. John M. Nayopa, Project Manager, Sustainable Management of Mineral Resources Project
3. Mar. 2010	Geological Survey of Tanzania, Dodoma	Mr. Fabian Mbalwa, Principal Geologist Mr. Aniset Minde, Acting Executive Officer and Director of Database and Info. Services
5. Mar. 2010	Zonal Mines Office, Mbeya	Mr. John Isandiko Shija, Assistant Commissioner for Minerals Mr. Mtui; technical officer
5. Mar. 2010	Uyole Agricultural Centre, Mbeya	Mr. Jerry Ngailo, Principal officer, Soil & Natural Resource Management
6. Mar. 2010	MVIWATA, Mbeya (a national network for smallholder farmers)	Mr. Stephen Ruvuga, Director Mr. Yazid Ame Makame, Chairperson Mrs. Lydia Ruliho, Vice-Chairperson
7. Mar. 2010	Muvwa Village	Mrs. Christa Mbusa, Village Chairperson Mr. Malongo Sumuni, Village Executive Officer (VEO)
8. Mar. 2010	Tanganyika Farmers' Assoc. Ltd., Mbeya	Mr. Henry Lisanga, Branch Manager
8. Mar. 2010	Regional Agricultural Secretariat	Mr. Wilfred Kayoma, Agricultural Officer Mr. Enock Nyasebwa, Agricultural Officer
8. Mar. 2010	TechnoServe	Mr. Carol Nyangaro, Manager
9. Mar. 2010	Muvwa Village	Mrs. Christa Mbusa, Village Chairperson Mr. Malongo Sumuni, VEO Leaders of sub-villages, Leaders of development group, Respondents
10. Mar. 2010	Muvwa Village	Respondents
11. Mar. 2010	Nanyala village – lime producing area	Respondents
11. Mar. 2010	Tanzania Fertilizer Company (TFC), Mbeya	Mr. Omara Ayupo Accountant
11. Mar. 2010	Small Industries Development Organisation (SIDO) Mbeya	Mr. Charles Peter Hingi, TDC Manager
11. Mar. 2010	Utengule Coffee Estate	Mr. Tino, Manager
12. Mar. 2010	Mshewe Ward Agricultural office	Mrs. Rehema Omari Manlid, Ward Agricultural Extension Officer
12. Mar. 2010	Mbeya Rural District Agricultural Office	Mr. L.N. Masuba, District agricultural officer for input
12. Mar. 2010	Mbeya Regional Commissioners Officer	Regional Administrative secretary
15. Mar. 2010	Mbeya Regional Small-Scale Miners Association (MBEREMA)	Mr. George D. Mwaikela, Chairman
23. April 2010	TechnoServe, Moshi	Mr. Msanjo, Coffee Senior Business Advisor

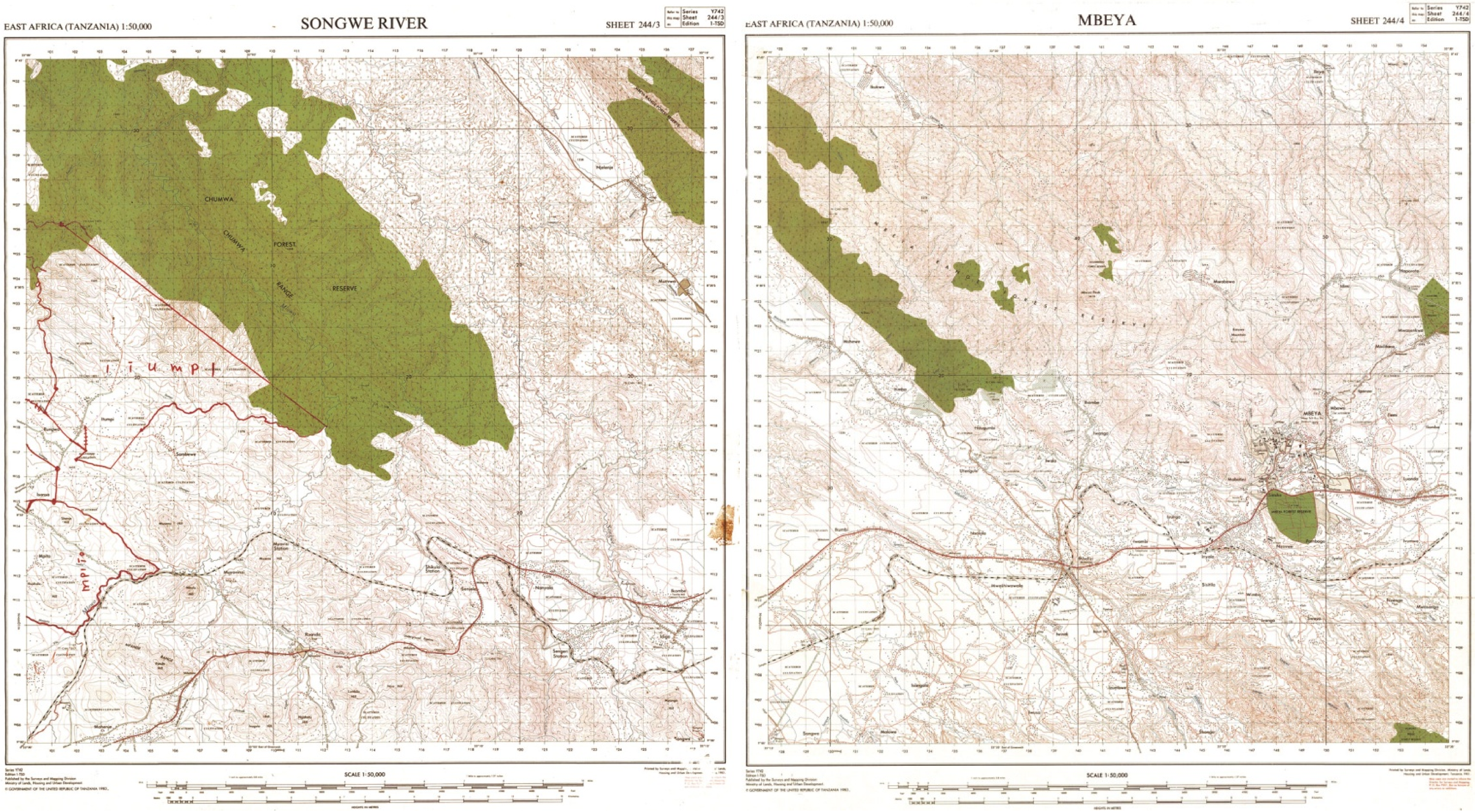

Fig. 2. Topographic map of the Mbeya and Songwe area.