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GEOPOLITICS OF THE NEW MATERIALS: THE CASE OF THE SMALL SCALE MINING AND NEW MATERIALS DEVELOPMENTS

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CNPq CETEM

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SUMMARY

ABSTRACT

This paper presents the mining bussinesmen concerns about the declining curves in metals demand, and discusses some issues regarding dematerialization and transmaterialization as affecting the minerals world.

The economic cycles and their effects on the consumption of ores and metals are presented through the transmaterialization concept of materials demand.

Small scale mining definitions are presented and the small scale mining concept is focused on the production of chemical compounds directly from orebodies. As an illustration a case study, showing the production of a copper salt, is presented.

1. INTRODUCTION

Mining businessmen and ore dealers all over the world have been, here and there, astonished by the declining curves in metals demand, as well as by the pessimistic projected trends for such demand.

The dematerialization of the modern world - in fact of the consumer society - has been shown through historical sequences of production and consumption curves, indicating that the bonanza days of high demand for major metals are over.

However, where is the real paradox ?

If a consumer society increases its demand for materials, then why are the demand curves declining ?

The answer to this question is found within the framework of transmaterialization thinking.

Those [1,2] who rely on the analysis of the decreasing or stagnation of materials demand, base their considerations on:

- common metals (Pb, Zn, Cu, Sn, etc...), excluding the new ceramics, plastics, composites and, as a general rule, industrial minerals;

- normally they overlook the "life cycle theory" of product development in explaining the observed trends regarding materials or commodity consumption.

More recently, transmaterialization studies [3] have pointed out the need to detect the existing "life cycle" for a given material, commodity and/or classes of materials and commodities. This "cycle" may be described as having five successive phases:

- introduction: where the performance of the commodity or material has not been proved and sales are low;

- growth: consumption experiences a rapid increase, the properties of the commodity or material being appreciated and promoted throughout the industry;

- mature: acceptance, into industrial processes and levelling off;

- saturation: peaking of the consumption rate and an observed tendency to decline;

- declining: total consumption declines, alternative materials start to appear as competitors.

Data from 1900 to 1986 were analysed and the following "materials predominance cycles" were detected for the North-American economy [3]:

- 1900 to 1950: copper, lead, tin, zinc and iron ore;

- 1925 to 1970: metal alloys (molybdenum and nickel), asbestos and bismuth;

- 1935 to 1975: metal alloys (manganese, crome, vanadium), lithium and ilmenite;

- 1945 to 1985: aluminium, cobalt (superalloys), phosphates, barite and rutile.

- 1955 up to today: galium, germanium (electronics), titanium, hafnium, platinum group metals, rare earths (advanced ceramics and catalysers), ytrium and polyethylene.

It is quite evident that these "life cycles" vary from national economy to national economy, and even within a given economy they might acquire "wave lenghts" that are pecculiar to that economy.

Notwithstanding, the systematic study of such curves and profiles area are adequate instruments of the mineral industry to forecast the market behaviour in the medium to long run.

It has to be stressed that chemical compounds, requiring given

specifications of purity and particle distribution, are gaining increasing importance in modern industry and need, as well, to be analysed by means of these demand profiles.

2. ECONOMIC CYCLES AND THE ORE AND METALS[4]

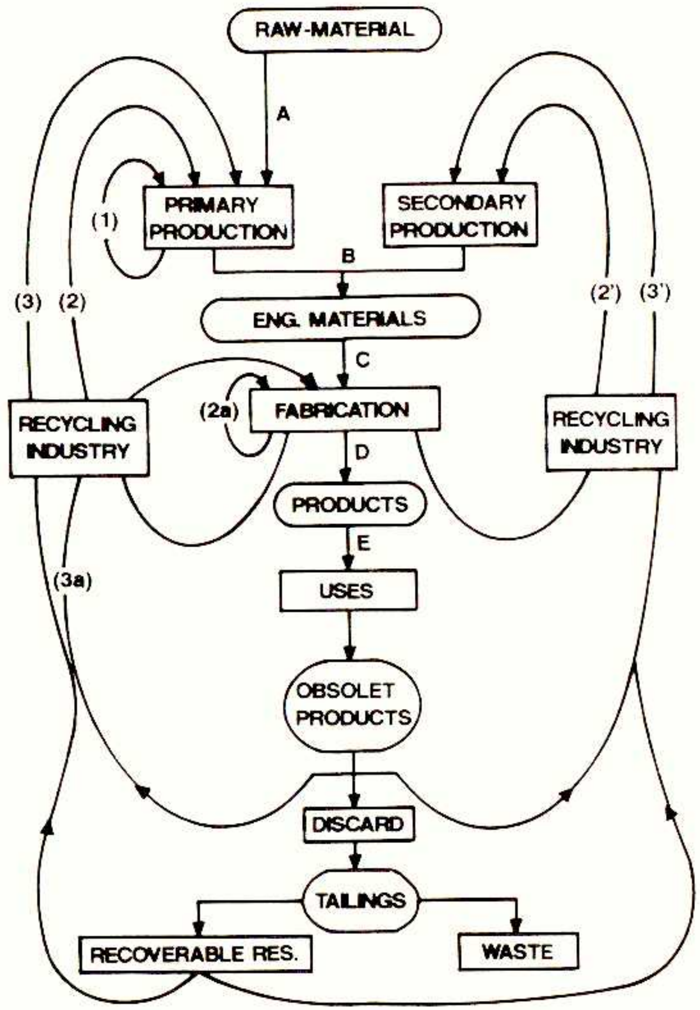
The production and utilization of raw-materials in general, and of ores and metals specifically, obey, within a given framework of industrial development, the economic cycles that are in effect at a given time. These cycles, as discussed, might reflect a world trend, a local trend or even a geopolitical trend.

Thus, the industrialized, or advanced countries, determine, to a greater or lesser extent, the consumption of a given commodity, inducing the market to adapt itself to this new reality. This is conducted at the level of consumption of goods and commodities of these countries, as well as of those consumed in the underdeveloped economies. It would be rather naive to believe that the underdeveloped world can have total freedom to choose by itself the needed production and utilization of raw materials in its own economies.

In fact, quite the opposite happens (in general): there exists a search for raw-materials that suit an available technology, and not the development of technology for an available raw-material !

Let us visualize the consumption-production pattern for minerals and metals in Figure 1[5]:

Figure 1 - PRODUCTION - CONSUMPTION MATERIALS CYCLE .



The letters shown in Figure 1 represent the progressive production stages, which vary, in complexity and adequacy, from economy to economy and the numbers within parenthesis represent materials recycling.

The recycled materials, also varying in recoveries from economy to economy, need, as a general rule, lower capital and energy expenditures and more man-power than primary processing. They require lower pollution control costs than the primary ores.

However, and this is again an apparent paradox, the recycling of materials is more intense as the sophistication of a given economy increases. Such a paradox is only apparent, since, in order to recycle, economically viable quantities must be available.

Another very important difference from economy to economy is the ore recovery from a given ore body.

The inherent losses attached to the several unit operations that build up the basic stages of minerals processing are shown in Table 1.

Table 1 - MINING AND METALLURGICAL LOSSES[6]

STAGES	LOSSES
Mining	25%
Ore Dressing	15%
Metallurgy	10%

Thus, the average losses in extraction of a given ore is of the order of 37,5% !

It is true that there are big deviations from this average, as for example in the case of copper, for which the overall recovery, from mining to wire, is around 85%.

It is also true that mining methods, beneficiation and metallurgical processes vary from economy to economy and from time to

time as well. The average metal recovery from ores ranges from 60 - 70% to 98 - 99%, not only due to technical problems but also due to market impositions - that also vary from economy to economy, or time to time -.

What really interests us in this discussion on Small Scale Mining and New Materials is the growth of production and consumption of certain substances nowadays required by modern industry and for which, until quite recently, no appreciable demand was observed. See Table 2.

Table 2 - OBSERVED CONSUMPTION OF SOME NEWS MATERIALS[7]

MATERIALS	CONSUMPTION	
	60's	80's
Silicium	0	3.500 t/a
Arsenium	0	10.000 - 20.000 t/a
Zirconium	700 - 800 t/a	4.000 - 5.000 t/a
Rare Earths	5.000 - 10.000 t/a	20.000 t/a

Furthermore, in 1983 - 1984 the consumption of chromium, cobalt and molybdenum were of the order of 8.000 t/a, 15.000 t/a and 70.000 t/a, respectively.

Thus, as shown, the economic cycles do substantially alter the raw-materials profile of demand, originating, or reflecting, the market instabilities of the mining-metallurgical industry.

3. SMALL SCALE MINING

The several problems that one faces when trying to define the term small scale mining have been discussed throughout the literature[8], conferences[9,10] and symposia[11], being such term borne with controversies arising from economy to economy* as scale of production, metal and non-metal, value of production, number of employees, mechanization, energy consumed, etc.

In this paper, however, we are not concerned with the definitive aspects of a small scale mining operation, nor with the eventual legal aspects involving such operations, such as laws and government programmes designed to assist them.

Rather, the focus will be on the total expected production of a given mineral product as related to the ore available to do so.

Thus, the concept to be discussed here is radically distinet from those generally utilized when discussing small scale mining.

In fact, when visualizing a small mine for the production of chemical compounds, it is of no interest if such a mine needs or does not need to employ a small number of people per se, does or does not satisfy any "small mine law", unless using special financial incentives from such a law.

Such production of chemical compounds from ores is an operation that, due to the amount of final product produced, according to more or less stringent specifications - depending on the degree of sophistication the market is asking for -, will necessarily be of a much smaller scale than the corresponding metal

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*It may be remembered, as well, that large mines might have started out as a small mine. Examples: Uranium mines in the U.S.; Bouganville before going into Cu operated as a small Au mine[9].

mine of the metallic element of the chemical compound.

The ultimate object of mining is profit from a corporate point of view, and socio-economic benefit from a governmental point of view. If, at the outset, such a result is unlikely to ensue, the work is not undertaken and the orebody, at least for the time being, is considered "non-commercial".

In evaluating any deposit for possible production, the three important points to be borne in mind are tonnage, grade and costs, which allied to proven technology, will constitute the necessary framework for a first appraisal of the prospects of allowing for the extraction of ore at a profit, and a sufficient margin to provide for a return on the capital invested in properties, plant and complementary equipment.

An example of what has just been presented may clarify some points of discussion:

- let us consider a copper deposit of 12×10^6t of proven ore, chalcopyrite, 1% Cu average;

- let us consider working this deposit into a mining operation;

- such an operation will produce:

a) a copper concentrate to be sold to a "nearby" smelter

or

b) metallic copper

or

c) a copper chemical compound, for instance, a salt.

- conceptual studies have shown:

a) underground mining is to be employed;

b) a 27% Cu concentrate, 90% recovery, is attainable;

c) no "nearby" smelter was available and the deposit, being rather small, meant that the production of concentrate at a profit was discarded. Regarding this point, if a "nearby" smelter is available, see reference[12], for higher grade ores.

- as for metallic copper, two routes were considered:

a) SM - Solution Mining;

b) RLE - Roast, Leach, Electrowinning.

- SM was disregarded since the deposit characteristics did not fit any of the necessary requirements for such. See reference[13].

- an economic evaluation was made for the purpose of comparing relative costs of operation for RLE and a route to produce $CuSO_4.5H_2O$.

- process steps for such are shown on next page. The column COMPARATIVE COSTS, are for the same capacity of ROM.

- a preliminary cash-flow analysis, based on several sources [14,15,16,17,18,19] (among others), is presented for RLE and SALT, involving different treatment capacities, for a 1980 data-base.

Figure 2 - PROCESS STEPS IN ECONOMIC EVALUATION*

GENERAL STEPS

MINING

↓

CONCENTRATION

↓

RECOVERY

↓

PRODUCT**

*Capital costs for conceptual metallurgical plants are difficult to estimate since so many cost components are, in fact, dependent upon plant layout and final capacity.

**No regard is to be given to byproducts, although they may considerably alter economics.

Table 3 - CASE STUDIES

***COMP.COSTS	CASES	METALLIC Cu****	$CuSO_4.5H_2O$
Cu	$CuSO_4.5H_2O$		
S	S	Mining	Mining
S	S	Concentration	Concentration
S	S	Roasting	Roasting
≅ S	≅ S	SO_2 Recovery	SO_2 Recovery
↑	↓	Leaching	H_2O → Leaching
↑↑↑	↓	Solvent. Extraction	Purification
≅ S	≅ S	Waste	Waste
↑↑↑	↓	Electrowinning	Cristallization
		Cu^0	$CuSO_4.5H_2O$

***S = Same; ≅ S = Roughly same; ↑ = Higher; ↓ = Smaller; ↑↑↑ = Much Higher. For = Cap.

**** RLE Route, see, for instance, Ref(15).

Table 4 - PRELIMINARY CASH-FLOW ANALYSIS (10^3 US$)

ITEMS / TECHNOLOGY	RLE 1100	RLE 1430	RLE 1650	SALT 1100	SALT 1430	SALT 1650
Inv. Capital	33.120	33.120	33.120	4.875	4.875	4.875
Sales	7.920	10.138	11.905	1.430	1.860	2.145
Dir. Oper. Costs	7.200	7.200	7.200	1.040	1.040	1.040
Depletion	1.426	1.857	2.143	257	335	386
Depreciation	2.096	2.096	2.096	55	55	55
Ind. Costs	432	432	432	62	62	62
Local Taxes	396	516	595	72	93	107
Total Oper. Costs	11.550	12.101	12.446	1.476	1.576	1.641
Operating Income	-3.630	-1.783	-561	-46	284	504
Invest. Credit	-	-	-	-	100	200
Net Income	-3.630	-1.783	-561	-46	384	704
Pay-Out Year	-	15.3	9	18.3	6.2	4.3
Cash-Flow	-108	2.170	3.678	266	774	1.143

Observations:

Type of operation: underground mine + recovery plant

Deposit: 12 x 10^6t of ore, 1% Cu, chalcopyrite

Contained copper: 120 x 10^3t

Recoverable copper: 114 x 10^3t

Plant capacity: 7200t/year of Cu (RLE) and 1300t/year of contained copper for a 5000t/year plant of salt.

Production life: 15.8 years (RLE) and 89 years (SALT)

Copper prices: 1100 (US$/t), 1430 (US$/t), 1650 (US$/t); SALT following aproximately copper prices.

In conclusion, it may be said that the production of the salt showed much better prospects than that of the metallic element, from a small-scale ore body and utilization a small-scale operation.

This simple case illustrates the real possibilities of producing chemical compounds directly from a primary source, adding value to this, otherwise, unused resource.

Finally, it is never too much to remember that the limited economic results obtained by several important mining and metallurgical developing countries calls for the need to search for strategies of development for the different non-ferrous metals industries that would have a greater impact on creating a more integrated development, satisfying the basic needs of the population and increasing the surplus of foreign currency[20].

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