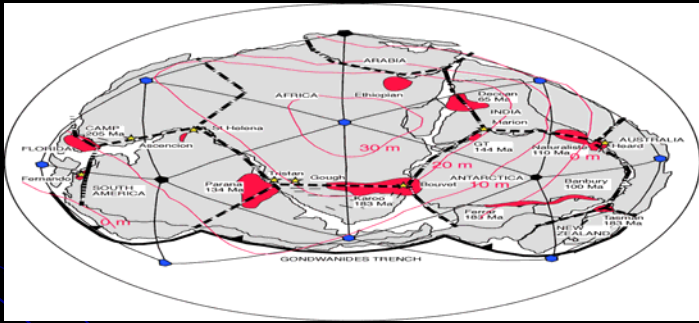




**Symposium on**  
**Sustainable Development:**  
**New Dimensions for Society &**  
**Business**  
 Espaço Tom Jobim, Jardim Botânico, Rio de Janeiro, 18 June  
 2012

**IS MINING SUSTAINABLE ?**  
**MYTHS & FACTS: Need FOR SUSTAINABLE**  
**DEVELOPMENT INDICATORS**



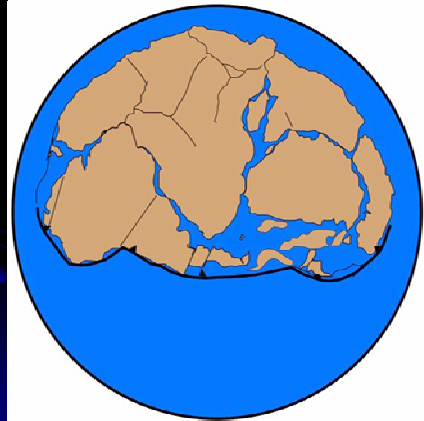
Roberto C. Villas-Bôas    CETEM & CYTED

Sustainable Development – New Dimension for Society and Business  
 VALE MIND on Sustainability - Rio+20  
 June 18<sup>th</sup>, 2012 - Jardim Botânico, Rio de Janeiro

# EULER'S THEOREM

villas-Bôas

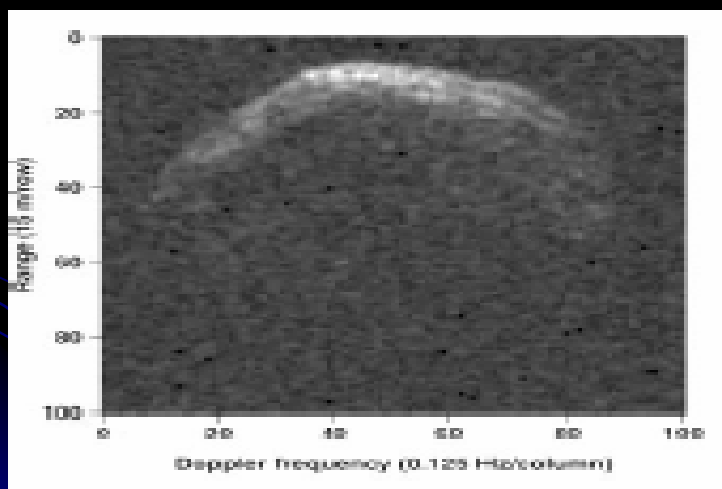
Need FOR SUSTAINABLE DEVELOPMENT  
INDICATORS



$$F + V = E + 2$$

## 1950 DA

<http://www.sciencemag.org/cgi/content/full/296/5565/132>



## 1950 DA

- WHAT IS SUSTAINABLE DEVELOPMENT ?

IT WILL  
COLLIDE  
IN ... 2880  
!!!!!!!!!!!!!!!!!!!!  
!!!

THEN, SUSTAINABILITY !



# LOGICAL FORMULATION

Villas-Bôas – 2005 :

[http://www.dundee.ac.uk/cepmlp/journal/html/Vol16/article16\\_12.php](http://www.dundee.ac.uk/cepmlp/journal/html/Vol16/article16_12.php)

- **LOGICAL FORMALIZATIONS** are needed regarding the concepts of Sustainable Development and even Sustainable Ore body and Sustainable Mine, as referred to the minerals extraction industries.
- If this is done, several **MISCONCEPTIONS** will be prevented and EVERYONE will know what is been meant by such words.
- Likewise, it seems that the old proposition of drawing a distinction between **RENEWABLE & NON RENEWABLE** resources does not quite fit anymore as such, within the current sustainable development framework, for the sake of resource exploration and development, through its more recent paths and practices.
- Therefore, the suggestion of conceptualizing **SUSTAINABLE & NON SUSTAINABLE** resources for that matter, subject to societal agreements, as proposed.

## RENEWABLE & NON RENEWABLE OR SUSTAINABLE & NON SUSTAINABLE !



- “I would like to close this section by dispelling the myth that resources are finite, a notion some policymakers sometimes like to promote.
- Resources will only become finite if limits are placed on exploration because a country has suddenly become less attractive for investment”
- **TOM ALBANESE** , RioTinto CEO(2010)

# RESOURCES

Villas-Bôas

- **LET**

$$R = \bigcup R_n$$

- $R \equiv$  is the set of all resources as, for instance:
- $R^1 \equiv$  natural resources
- $R^2 \equiv$  environmental resources
- $R^3 \equiv$  energy resources
- $R^4 \equiv$  capital resources
- $R^5 \equiv$  human resources
- $R^n \equiv$  any resource
- and
- $R^0 \equiv \varnothing$ , i.e., no resources at all

## WORK ON RESOURCE = DEVELOPMENT

**LET**  $W$  be a transform such as

$$W : R \rightarrow D$$

- where

$W \equiv$  is the transform work

$D \equiv$  is the set of development stages

and  $W$  a surjective function, i.e. it links at least one argument to every possible image.

# SET OF HYPHOTHESIS OF DEVELOPMENT

LET

$$S_i = \bigcup \{ S_{i_1}, S_{i_2}, S_{i_3}, \dots, S_{i_n} \}$$

- where  $n$  is the number of subsidiary hypothesis which characterizes  $S_i$  respectively to  $D$ .

# DEVELOPMENT & SUSTAINABLE DEVELOPMENT

• LET

$$S_d = D \bigcup S_{d_i}$$

WHERE

$S_{d_i}$  = is the set  
INTERSECTION of  
the MINIMAL  $S_i$

$$S_{d_1} \cap S_{d_2} \cap S_{d_3} \cap S_{d_4} \cap S_{d_5}$$

# WHAT ?

## INTERSECTION

$S_{d1}$   $\equiv$  set of minimal use of natural resources

$S_{d2}$   $\equiv$  set of optimal (or maximal) use of physical flow resources

$S_{d3}$   $\equiv$  set of minimal use of energy resources

$S_{d4}$   $\equiv$  set of minimal use of environmental resources

$S_{d5}$   $\equiv$  set of maximal social satisfaction states



## THUS, SD IN MINING INDUSTRY IS:

### MINIMIZING

- MASSES
- ENERGIES
- ENVIRONMENTAL IMPACTS

### MAXIMIZING

- SOCIAL SATISFACTION !

social satisfaction is the degree of societal acceptance of a given policy, or political agenda

# SUSTAINABLE DEVELOPMENT SCENARIOS

$S_d$

- set of sustainable development scenarios belonging to D, however subject to constraints

$$S_d = D \cup S_{di}$$

## WHICH CONSTRAINTS ?

$nS_{di}$

CONSTRAINTS  
OF  
SUSTAINABLE  
DEVELOPMENT

- represents the goals and targets of a political agreement \*, a political agenda, and setting for the agreed states of sustainable development \*\*.



## Political Agreement & States of Sustainable Development

- \* In this regard sustainable development might be regarded as a **Weltanschauung** (meaning a “look onto the world” in German) rather than a full Khunian paradigm shift, i.e., that describes a process and result of a change in basic assumptions within the ruling theory of Science
- \*\* which, according **Brundtland’s report** is the essence of *environmental sustainable development*

## EFFORT & PRODUCTIVE OPERATION

- Having defined, formally, sustainable development, in order to measure it one needs an indicator or indicators
- Let define effort (E) as a function, or transform, that attributes a positive number to every productive operation (P) or process.

## PUT EFFORT INTO A PRODUCTIVE OPERATION OR PROCESS

where

$$E : P \rightarrow R$$

**R** is a POSITIVE RESPONSE

## BENEFIT FROM A PRODUCTIVE OPERATION OR PROCESS

- Let define **B** as the benefit obtained by a **society** (x), on **firm** (y) who performs the **productive operation** (p)

Thus a MEASURE of AGREEMENT will be reached when :

$$B(x, y, p) - B(y, x, p) - E(p)$$

$$B : X \cap Y \cap P \rightarrow R$$

## WHAT ?

- is the measure of **agreement**, **A**, an indicator of agreement, when the **benefit B (x, y, p)** obtained by **x** from **y** through **p**, the **effort E (p)** which the **operation p** causes to **x**, and **E (y, x, p)** the **benefit** obtained by **y** as retribution to **x** to performs or allows to perform **operation p** .

## AGREEMENT: SOCIAL LICENSING !

$$A(x, y, p) = B(x, y, p) - B(y, x, p) - E(p)$$

**IF**

$$A(x, y, p) = 0$$

- it implies an identical benefit for x and y

$$A(x, y, p) < 0$$

- **x** **X**, loses

$$A(x, y, p) > 0$$

- **y** **Y**, loses.

# SOCIAL LICENCE



“Resource extraction involves not only capital and technology. It also requires a focus on sustainable development, which means earning the consent of the local people, or the “*licence to operate.*”

ALBANESE, 2012

$$A(x, y, p) = B(x, y, p) - B(y, x, p) - E(p)$$

$$A(x, y, p) = 0$$

- it implies an identical benefit for x and y

$$A(x, y, p) < 0$$

- $x$   $X$ , loses

$$A(x, y, p) > 0$$

- $y$   $Y$ , loses

$$A(x, y, p) = 0$$

- ASSM

$$A(x, y, p) < 0$$

- DUTCH DISEASE

$$A(x, y, p) > 0$$

- SUCCESSFUL MINING PROJECT !

$$A(x, y, p) = 0$$

ASSM



$$A(x, y, p) < 0$$

DUTCH DISEASE  
RESOURCE CURSE



$A(x, y, p) > 0$   
SUCCESSFUL MINING PROJECT !



LOSES AND STILL SUCCESSFUL ?

BE CAREFULL

SHALL BE READ

$A(x, y, p) > 0$   
 $y < Y$ , *loses*

**GAINS** of  $x > X$   
*surpasses*  
those of  $y < Y$

$A(x, y, p)$  IS A SUSTAINABLE  
(INDICATOR) AGREEMENT  $A_s$  IF

$$A_s = S_d \cup \{ A_1, \dots, A_n \}$$

*UNION of the SUSTAINABLE  
DEVELOPMENT SCENARIO to the  
AGREEMENT obtained !*

SUSTAINABLE ORE BODY

IF A SUSTAINABLE RESOURCE IS

$$R_{s_i} = R \cup \{ S_{d_1}, S_{d_2}, \dots, S_{d_n} \}$$

THEN A SUSTAINABLE ORE BODY IS

$$O_{s_i} = R_{s_i} \cup A_{s_i}$$

**THAT IS WHAT MINING  
SUSTAINABILITY IS ABOUT**

