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EROSION, TRANSPORT AND SEDIMENTATION PROCESSES ASSOCIATED WITH OPENCAST MINING IN NEW CALEDONIA : INTERACTIONS WITH WEATHER AND CLIMATE

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In any overall and integrated approach to management of the physical environment, one objective is to identify forms of land degradation and their evolution and also to quantify erosion, transport and sedimentation events. A study of the suspended solid load in rivers can prove an appropriate way of characterising the environment in terms of environmental disequilibrium by appraising the extent of specific erosion events and making it possible to assess the effects of old or recent mining.

A COMBINATION OF UNBALANCING FACTORS

Environmental disequilibria are attributable to complex causes springing from the convergence of two sets of parameters, one specific to the natural environment (climate dynamics and landform development) and the other induced by man's impact on the physical environment. The rainfall pattern in New Caledonia, featuring a hot and rainy season from November to April, basically depends on latitude variations in the intertropical convergence zone and in the surrounding subtropical high pressure areas. This pattern of rains can be seriously disturbed by orographic effects (annual rainfall, 2 to 3 m on the east coast and 1 m on the west coast, reaches 5 to 10 m on some summits in the central range), by tropical depressions and cyclones , which may affect the whole island (8 to 9 tropical depressions are recorded annualy on average; the highest daily rainfall figures are not far off world record values (1690 mm at Haut-Coulna on 24.12.81 during cyclone GYAN), and by the major hydroclimatic fluctuations affecting the south-western Pacific (droughts every few years). Therefore, peak flood discharge rates rise to phenomenal levels in some catchments (over 30 $m^3/s/km^2$), but run-off volumes and specific flood discharges in more permeable basins of peridotites are fortunately lower.
The nappe of peridotites which covers one-third of New Caledonia consists of ultrabasic rocks (chiefly harzburgites), which have been highly subject to tectonism (flaking and faulting). The main features of the present relief would appear to be essentially related to tectonic movements subsequent to the formation of the peridotite "nappe", but the relief which is so characteristic of these formations seems, even under the present climate, to develop by weathering at all altitudes where vertical drainage predominates. Since drainage is essentially vertical, hydrolysis of the main minerals (peridotites and orthopyroxenes) leads to :
- large-scale losses of magnesium and silica, in water which usually only trickles through in contact with less fractured (seams of gabbros) and less permeable rocks (serpentines),
- local volume reductions and the formation of more depressed areas, with a temporary perched water table, sometimes sub-emergent, where there are accretions of iron hydroxydes (red "laterites", gravelly to varying degrees, lumps) where the first crusts develops.
Mechanical erosion in these young massifs occurs where water reconcentrates after periods of intense rain on the edges of plateau crust (dismantling of crusts, colluvial deposition of laterites), on the decomposed peridotites of often very steep escarpments (often over 35 °) and in some areas of intense tectonism (landslips) and in flow channels (bank undermining). Mechanical erosion would however have been of much lesser magnitude in these areas than with other formations (coal formations of the late Cretaceous, in particular) if some human activities (burning of the forest cover, road building and opencast mining) had not deeply disturbed this environment.
The quantification of erosion implies the accurate measurement over a fairly long period of transported matter, whether suspended loads or beds loads or flows of solute matter.

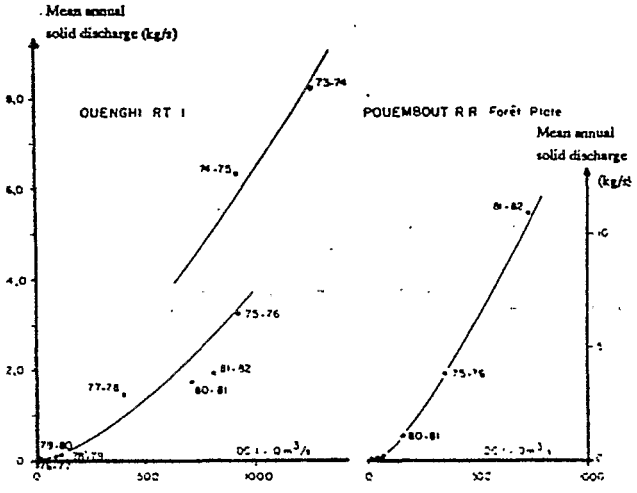
FLOWS OF MATTER

The measuring programme was conducted in 2 separate but complementary areas, one at the exit from the Ouenghi basin, mostly on ultrabasic rocks, during the whole duration of resumed mining activity (1974-82) (Kongouhaou model mine), the other in the Pouembout valley, a well-established agricultural zone, but where some tributaries drain horizons which are very vulnerable to erosion (coal-bearing terrigenous formations of the Poualoa sub-basin), such as former mining zones (Paéoua massif), untouched massifs (Kopéto Ouest - Kopéto river) or massifs spared by mining activity (Kopéto Est - Papainda river). Since very large materials move more slowly, only suspended load transports were really monitored over a period of years and during the major cyclonic events : Regular sampling was performed at a specific site to determine variations of concentration in time (turbidity measurements); measurements of solid loads associating concentration and velocity measurements in one portion for specific water heights was carried out; a liquid discharge and solid load rating curve was drawn.

Time and spatial distribution of particle loads

Connected with major rainfall irregularities, solid loads may be virtually non-existent for a number of dry years and record high values during a few floods capable of setting deposits in motion again (clearing

of accumulations on pediments and piedmonts, bank undermining). With the Ouenghi, over 94 % of the suspended load transported in 9 years was moved by the 6 biggest floods of that period. As the solid loads for any year were usually due to a major flood, clear relationships emerge by basin and period between annual transports of suspended loads and peak daily water discharges (pattern comparable to that of the semi-arid regions of the inter-tropical belt).

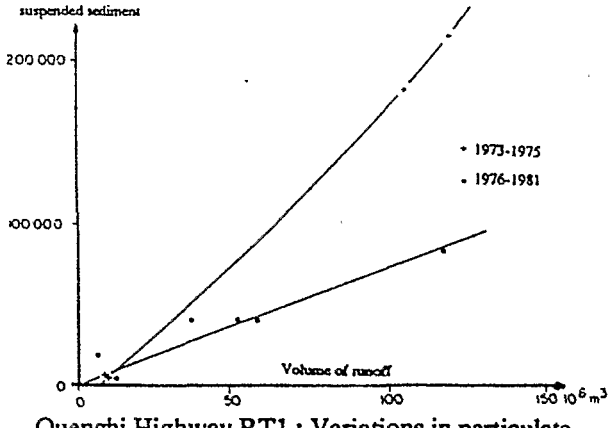


Relationships between mean annual solid load transports and peak daily discharge

The transported material records from the 3 Pouembout sub-basins, observed over a 2 year period, clearly show the limited extent of suspended load transports in catchments partly overlying peridotites but spared by mining activity (Kopéto, Papainda) and the extensive degradation of a catchment such as Poualoa where the coal formation badlands are a major feature of the landscape.

The effects of mining activity on suspended load patterns

An increase in solid loads becomes apparent right from the start of prospecting activities (road building, first scraping) as shown by the degradation registered in the Kopéto catchment. Monitoring of the Ouenghi since the Kongouahou mine was opened shows that solid loads, very high in the early years (over 200000 t/yr) later fall off considerably (60 000 t/yr).

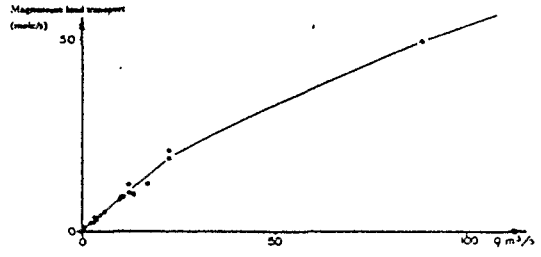


Ouenghi Highway RT1 : Variations in particulate loads as influenced by volume of run-off

These differences emerge even more distinctly because of the fact that the catchment was affected by 2 strong tropical disturbances (Cyclones Pam and Alison) while the deposit was being mined. These extra loads are apparently due to the opening of roads across a landslide areas the materials from which, unconfined by a barrier, progressed to the Ouenghi. Since mining methods were designed to minimise pollution below the deposit, suspended loads fell back to a relatively low level in 1976 and then stabilised, despite an accidental landslip in June 1977.

Flow of dissolved matter

Although meteoric erosion as such only occurs during a few rainy periods, the dissolving of materials and the resultant load transports (essentially magnesium and silica) continue for years, with contents of around 45 mg/l during low and medium-water periods (discharges of 1 to 25 m^3) in the Ouenghi, or a maximum of 50 t/yr/km^2.



Ouenghi Highway RT1 : Magnesium load transports

Total matter loads

Amounting to 47000 t from 1st November 1974 to 31st October 1982 (excluding 1973-74), when work commenced) for a volume of run-off of 2084. 10^6 m^3 and a mean annual volume of 251. 10^6 m^3, suspended load transports in the Ouenghi should be around 230 t/yr/km^2, i.e. :

- a specific degradation of 0.13 mm/yr (mean original material density assumed to be d = 1.8)
- mean annual input into the delta of around 30000 m^3 (mean mud density assumed to be d = 2.0).

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Questioner: Annette Lees, Maruia Society

Question: Have the results of the work you have been describing had an impact on legislation of the New Caledonian government to prevent further erosion?

Answer: The legislation with regards to mining impacts is always woolly. The Territorial Assembly of New Caledonia requires the main company (SLN - Societe le Nickel) to protect mining sites (revegetation, barricade of natural terrain to protect from run-off, storage dams etc.), but the problem is different for small private companies which can't financially afford these works.

Questioner: Susi Newborn, Greenpeace, New Zealand

Question: Isn't it true that the French state has a major shareholding interest in the Societe le Nickel (SLN)?

Answer: Yes, but now the SLN company works in order to protect mining sites and has some good results.