Dossier

LAND DEGRADATION AND MINING IN NEW CALEDONIA

New Caledonia's geological legacy has bequeathed it rich seams of nickel deposits. Most of these deposits are at high elevations, except in the south of the island. The territory's isolation has enabled plants to evolve distinctly, giving birth to several thousand species endemic to New Caledonia, particularly in landscapes shaped by mining terrain.

A smaller environmental footprint

Government and mining companies have gradually woken up to the unique nature of these plants and to the need for measures to safeguard threatened species. The same applies to preserving wildlife and water resources.
But for a period of 25 years between 1950 and 1975, the mining sector underwent significant mechanization unhindered by any kind of environmental precautions. As figure 1 shows, New Caledonia's landscape still bears the scars of mining operations conducted at a time when the environment was not a priority.

Today, mined areas need to be rehabilitated wherever possible and mining operations must be monitored to ensure they no longer degrade the environment irreversibly.
To this end, New Caledonia's authorities are about to adopt a new legislative and regulatory framework for mining, setting environmental protection and exploitation of mineral resources as priorities.

Inventorying degraded landscapes

In 2004, the New Caledonian government began inventorying degraded landscapes to support the drafting of this new regulatory mining code. The methodology is based on processing and analysis of SPOT 5 satellite imagery. A specific budget was allocated to conduct the first surveys across the whole of the territory. The island's engineering departments were thus tasked with estimating the surface area of stripped land—quarries, storage areas, indus-

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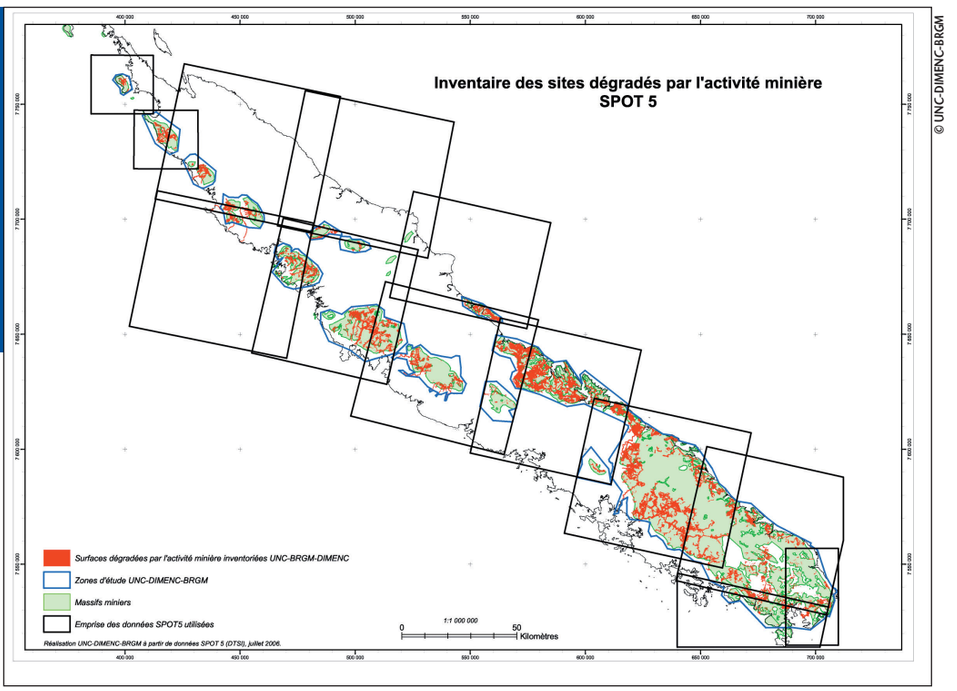
FIGURE 1

Massifs in New Caledonia degraded by mining from 1950 to 1975.

FIGURE 2

Inventory of sites degraded by mining activities – SPOT 5 Footprint of SPOT 5 scenes used for the study – correspondence with location of perioditic massifs on Grande Terre and location of zones degraded by mining activities (in red on map).



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trial facilities, deposition areas for mine waste and overburden—in each affected town and village from SPOT 5 imagery.

The survey results were obtained through collaboration between:
- DTSI, the information technologies and services agency, responsible for acquiring and processing imagery and generating end products;
- DIMENC, the industry, mining and energy agency, responsible for supplying documents and hardware for monitoring and inventorying;
- New Caledonia University (UNC), which provided two PhD postgraduate students for manual image processing;
- France's BRGM geosciences agency, which provided methodological supervision.

The first images were ordered in August 2004 and survey results were delivered in September 2006. The study therefore took a little more than two years.

Methodology

Satellite images with a ground footprint of 60 km x 60 km were acquired by SPOT 5. Spatial resolution was 5 metres (black and white) and 10 metres (multispectral). To optimize survey results, acquisitions were programmed to obtain a minimum viewing angle and reduced cloud cover.
Full coverage of the survey area required 15 scenes. Figure 2 shows individual scene coverage and correspondence with the location of New Caledonia's main peridotitic massifs.
Black-and-white (single-band) and multispectral (four-band) data were merged to obtain hybrid products combining the advantages of spectral content and spatial detail.
The merged data were then orthorectified to correct for geometric distortions due to viewing parameters and relief. The final map-quality data were generated at a scale of 1:50 000 in line with the study specifications. All features not required for the study, such as sea, clouds and cloud shadows, were removed.

For the final step before analysis, a standard brightness index was used in place of supervised classification, which is difficult to reproduce across different images. An index has the advantage of being an independent variable with respect to images acquired at different periods and therefore exhibiting different water, vegetation and illumination conditions.
The largest variations in reflectance between vegetation and soils are apparent in the red and infrared bands. The brightness index is derived from the red and infrared channels. It pulls together most of the information from the two initial channels into an index that is sensitive to soil brightness, which depends on soil moisture and surface salts.
The data are then classified into 20 categories and the results are vectorized for validation and final interpretation.
The next phase consists in discriminating natural bare soils from anthropic bare soils associated with mining activities. Non-peridotitic areas are masked to eliminate a big portion of image pixels not relevant to the study. The remaining pixels are interpreted manually using SPOT 5 orthoimages, aerial photos supplied by DITTT, the government's infrastructures agency, or surveys of degraded sites already completed by DIMENC, BRGM or other public sector agencies. Data interpretation focuses on individual geological entities or mining massifs.

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Atlas of results

Information gathered from image processing and interpretation identified about 20,000 hectares of bare soils degraded by mining activities in the 21 municipalities concerned. Figure 2 highlights the extent of these degraded soils in red. The total degraded area represents 1.2% of the area of Grande Terre, the main island of New Caledonia, well below initial official estimates.

An atlas with 21 A3 plates gives a quantified description of the areas in each municipality affected by mining activities (see example in figure 3).

This atlas contains:

- A SPOT 5 natural-colour subscene of each municipality, with different layers of information: areas degraded by mining activities, clouds and shadows, and map data (roads, towns and villages, mountains and mine centres).
- A table with the surface area of the municipality, clouds and shadows, and bare soils degraded by mining activities.
- A block showing the location of each municipality.
- Indications concerning the reference data used for the study.

Information on each municipality was then extracted from the map data (see table):

- Houillou (15.5%), Thio (15.2%) and Kouaoua (11.1%) alone account for more than 40% of degraded areas.
- Canala (6.8%), Mont-Dore (6.3%), Kaalagomen (6.2%), Bouloupari (6.2%), Pouembout (6.2%) Yaté (6.1%) and Paita (5.9%) cover 43.7% of all degraded areas.
- The other 11 municipalities account for the remaining 14.5% of these areas (more than 2,874 ha).

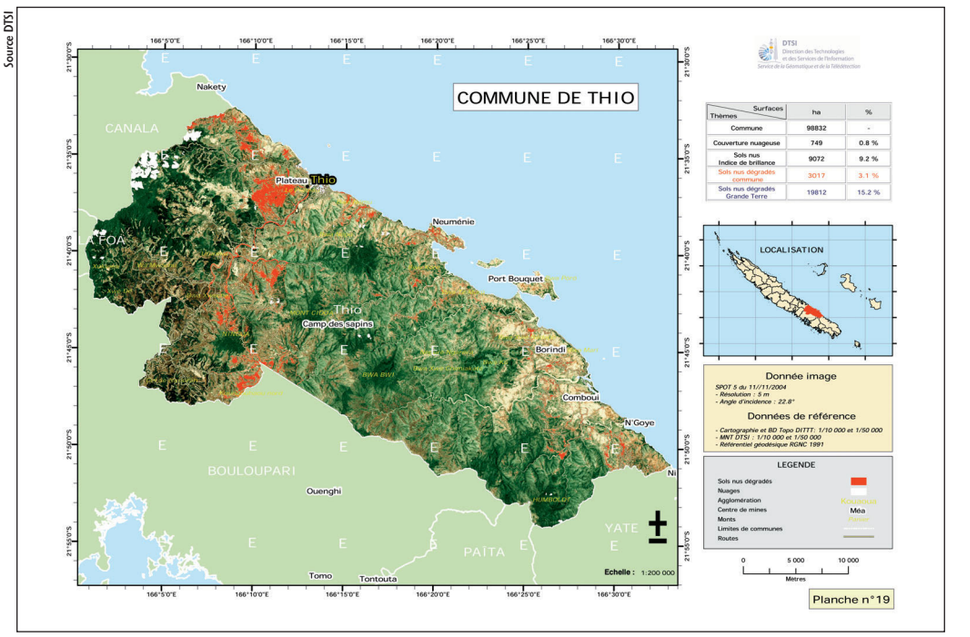

FIGURE 3

Atlas plate of the municipality of Thio.

Engaging rehabilitation

The extent of land degradation as a result of mining activities is now clear. The provinces of New Caledonia charged with enforcing mining and environmental regulations will have to engage rehabilitation programmes for these areas, giving priority to sites that pose the most problems in terms of safety of populations, water quality, adjacent farming activities and tourism, as well as to sites where erosion is continuing or pollution is most visible.

Rehabilitation will call for significant funding to cover water management and replanting costs, plus civil engineering costs. The authorities currently estimate the total cost of rehabilitation at €1.3 million.

A fund needs to be set up for this purpose. Part of the fund will be reserved for remediating degraded mining areas under an annual rehabilitation programme, or more broadly to respond in the event of a crisis in nickel production.

Inventorying degraded areas has helped the authorities to put a figure on the effort and tools required to repair the errors of the past, while laying the foundations for sustainable development of mining activities in New Caledonia through a new regulatory code. ■

Commune	Surface commune (ha)	surface dégradée (ha)	% par commune	% par rapport au total dégradé
Houailou	93562	3065	3,3%	15,5%
Thio	98832	3017	3,1%	15,2%
Kouaoua	38311	2207	5,8%	11,1%
Canala	43204	1356	3,1%	6,8%
Mont Dore	63543	1241	2,0%	6,3%
Kaalagomen	70896	1237	1,7%	6,2%
Bouloupari	86217	1229	1,4%	6,2%
Pouembout	66838	1222	1,8%	6,2%
Yaté	133386	1204	0,9%	6,1%
Paita	69343	1163	1,7%	5,9%
Poya	84286	904	1,1%	4,6%
Koumac	55144	810	1,5%	4,1%
Voh	79802	376	0,5%	1,9%
Ponérihouen	70064	178	0,3%	0,9%
Dumbéa	25496	171	0,7%	0,9%
Poum	46706	135	0,3%	0,7%
Bourail	79453	112	0,1%	0,6%
Kone	36928	93	0,3%	0,5%
Hienghène	99080	61	0,1%	0,3%
Poindimié	66512	33	0,0%	0,2%

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