Mining Activity in New Caledonia

Societal and environmental impacts

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Lateritic landscape in New Caledonia, from the mining plateaus to the lagoon.
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Introductory note

In 2017, IRD launched a pilot project to identify and analyse the impact of its research on societies in the Global South. The chosen approach was based on *ex-post*, i.e. "after the fact", case studies.

The studies selected for this project are representative of the IRD's major scientific fields of expertise, with sustainable development as an underlying issue and partnership-based research as the approach used. These impact analyses were inspired by methodological approaches developed in the agricultural research field by Inrae (Asirpa) and Cirad (Impress). These studies were chosen for their proven impacts in relation to research activities conducted by IRD and its partners, which have been reported by the scientific community.

Within this general framework, the investigative work consisted in identifying the various stakeholders and elements involved, and highlighting the interactions that contributed to the transition from research to societal impact. This article examines the context, the stakeholders' contributions to the research, the research products, the parties who created the conditions for the appropriation and transformation of the research outcomes, and the impacts generated.

The "impact pathway" mapped out in this way and the associated "timeline" are key instruments for characterising stakeholder networks and the processes that generate impacts. These stakeholders are divided into broad categories: political, institutional, environmental, economic, social health, educational, cultural, capacity-building, and academic.

Each impact identified and described has been documented on the basis of interviews with stakeholders who contributed to the impact pathway.

To find out more about the approach used for these studies, you can consult the methodological guide in the Multidimensional impact analysis of research and resulting innovation on development in the global South (Miriades) published in the "Chemins d'impacts" collection.

Thank you to everyone who has helped to forge closer links between research and society, and to highlight the diversity of these reciprocal contributions.

Research evaluation and programming mission

Contents

Introductory note 5

Summary 10

Background 12

- Mining policy in New Caledonia 12
- Nouméa Accord 13
- The research situation in New Caledonia 14
- Report by Fabrice Colin: bases for the development of research in New Caledonia from 2002 onwards 14

Actors' contributions 17

- Scientific issues 17
- Scientific expertise and structures mobilised for the research 18
- Funding 19
- Knowledge base 20

Research products 23

- Academic publications 23

Establishment of a fungus collection ... 23
Creation of a mycological society ... 24
Standards, methods, guides, analysis procedures, etc. for service companies and mining companies alike ... 24
International scientific symposia ... 25
Agora White Paper ... 26
Dissemination of scientific knowledge to society ... 26
Resources: monitoring stations ... 27
Reinforcement and optimisation of platforms ... 27
Collegial surveys ... 28
Capacity building: teaching ... 28
Capacity building: student training ... 29

Circulation of knowledge and intermediaries ... 33
The "Institut agronomique néo-calédonien" ... 34
Public authorities ... 34
Bureau of Industry, Mines and Energy – New Caledonia (Dimenc) ... 34
Mining operators ... 35
Local populations, associations and NGOs (including the WWF) ... 35
Students trained in research laboratories ... 36
The University of New Caledonia (UNC) ... 36
Researchers ... 36

Initial impacts ... 37
Institutional ... 38
Creation of the CNRT "Nickel and its environment" ... 38
Creation of the New Caledonia Environmental Observatory: L'Œil (The Eye) ... 39
Economic ... 40
Improvement of procedures for prospecting and exploitingmining areas ... 40
Encouraging and facilitating the creation of innovative enterprises by making innovative services linked to job creation available to stakeholders ... 41
Involvement of the population in the creation of satellite nurseries ... 42
Job creation ... 43
Capacity-building, furthering of scientific expertise ... 43
Continuation of a course of study for students ... 43
Towards participatory science ... 44
Vocational training of Kanak families and perpetuation of innovative knowledge promoting the creation of business opportunities ... 44
Health, social, educational and cultural issues ... 45
Better protection for mine workers exposed to asbestos dust ... 45
Environmental ... 45
Implementation of the provincial Environmental Codes ... 45
Academic ... 46
Towards the financing of multidisciplinary consortia ... 46
Restoring legitimacy to human and social sciences ... 46
Creation of the Agora-HSS network ... 47

Widespread impacts ... 49
Rapid growth of the Amedéé international network ... 50

Appendices ... 55
Interviews conducted ... 55
Documents cited ... 57
List of abbreviations ... 58

Summary

In 1999, under the terms of the Nouméa and Bercy (1998), and Matignon-Oudinot (1988) Accords, the Ministers for Research and Overseas France asked IRD to assess the conditions for the creation of a centre for research on nickel prospection and mining in New Caledonia, and also to evaluate the environmental and societal impacts of these mining activities.

Following this feasibility study, the ministers approved the report and then asked IRD to conduct a comprehensive study to prepare for the creation of this centre. At the same time, a multidisciplinary geoscience research team was assigned to New Caledonia. As well as working on the different reports (scientific, status, and budget) in conjunction with all the public and private stakeholders, the idea was also to develop this future induction research unit on the basis of research projects jointly developed with the local or external stakeholders involved.

From the outset, it was therefore decided to adopt a holistic ecosystem-based approach (from prospection through to the restoration of degraded environments) that would be multidisciplinary, multi-institutional and include public-private partnerships.

The research developed would lay the foundations for numerous findings in geophysics, geomorphology, geochemistry and hydrology with a specific and detailed focus on nickeliferous regolith and its functioning, in nickel ore mineralogy, in plant biology for the restoration of land impacted by mining, and in health following the discoveries concerning asbestos in ultrabasic nickel-bearing rocks.

This “catalytic” effect of the research carried out soon led to the formation of consortia that won numerous calls for tenders, established an essential climate of trust between public and private partners based on the specific competencies of each operator, and triggered the exponential development of local expertise, while establishing New Caledonia as an attractive destination for this field of research. The research conducted thus produced key knowledge for mining activity and land revegetation, and concerning impacts on the lagoon.

The New Caledonian research community has a multitude of components, including the government, the North and South Provinces, the participation of Kanak tribes on the islands, mining operators, service companies, and NGOs. Together with researchers, these associations, through their interest in research outcomes, have been key “transmitters” of knowledge to society.

This transmission has led to the emergence of impacts generated by the numerous and diversified research and development activities (environmental, economic, academic, institutional, etc.). These numerous positive impacts include: the creation of the “Nickel and its Environment” National Technological Research Centre, founded at the request of government ministries and inaugurated in 2008; the creation of an environmental observatory in 2009; innovative non-destructive exploration techniques, and modifications to the metallurgical reprocessing technique following research on effluent discharges into lagoons; revegetation guides and the regulatory requirement for mining companies to determine a reference state of soils and ecosystems before any new land clearing operation. Another positive impact has been the creation of start-ups and jobs.

Research projects have therefore covered a wide range of scientific fields over time, including human and social sciences, particularly anthropology and economics, thus branching out from scientific issues into other fields. The development of a highly interwoven, multi-partner discussion process has guaranteed the production of innovative research serving the needs of society.

The results thus acquired, and the partnership development methodologies developed are transferable, shareable and adaptable to all countries in the Global South. Jointly devised with partners, the research can both contribute to increasing knowledge of the field and to reinforcing each country’s scientific and technological sovereignty.

Background

Fabrice Colin, a IRD senior scientist from Cerege, was appointed to conduct an assessment mission by the French Ministers for Research and for Overseas in 1999, at the request of the local public authorities and the New Caledonian Mining Industry Union (Syndicat des industries de la mine de Nouvelle-Calédonie), in the context of generating economic development prospects and establishing a new balance, in line with the 1998 Nouméa Accord.

Mining policy in New Caledonia

For more than a century, New Caledonia's economy – particularly in terms of exports and employment – has been largely based on mining of its mineral resources, particularly nickel, although efforts to diversify into the aquaculture, fisheries, tourism and agri-food sectors are underway.

Other substances, including coal, manganese and gold, have also been mined in an episodic but economically insignificant manner. Only nickel has been mined uninterruptedly since 1875, following its discovery by Jules Garnier in 1864. The silicate-rich ores known as garnierites were mined throughout the 20th century using the pyrometallurgy process (carried out by Société Le Nickel – SLN – part of the Eramet Group).

In a depressed global context, complicated by Russian uncertainties following the devaluation of the ruble, new operators emerged. In addition to pyrometallurgy, they decided, well in advance of projections, to use new industrial hydrometallurgy processes to mine hitherto unexploited "lateritic" ores. This change of method is a decisive economic factor insofar as the announced operating costs are half those of pyrometallurgical processes, and hydrometallurgy enables the processing of lateritic ores, which have high iron but lower nickel content. Furthermore, hydrometallurgy enables the recovery of cobalt as a by-product, which is difficult to recover otherwise and has considerable added value.

In New Caledonia, the accelerating decline of garnierite nickel reserves and the higher cost of the pyrometallurgical method have naturally led to a shift towards the mining and hydrometallurgical processing of laterites.

At present, worldwide, nickel from nickel laterites accounts for 60% of world production.

Nickel mining area in Kopéto, New Caledonia.
© IRD/C. Gay

Nickel ores (goethite and garnierite), Poro, New Caledonia.
© IRD/J.-M. Boré

Nouméa Accord

At the political level, New Caledonia entered a historic phase following the Nouméa Accord of 5 May 1998, signed ten years after the Matignon-Oudinot Accords.

Prior to 2004, New Caledonia was required to draw up a plan for the exploitation of mineral resources, including a mining inventory and a plan for the mining of deposits, as well as environmental protection guidelines. It should be noted that authority for the "environment" and "economic development" was transferred to the provinces by the Organic Law of 1999.

The research situation in New Caledonia

It had been observed that over a period of twenty years or so, the scientific community had almost totally neglected environmental geosciences in New Caledonia, with regards to lateritic regoliths and their functioning (as a source of nickel ores).

However, research topics had been developing for several years on the behaviour of metals in soils (L'Huillier, 1998[1]), floristic diversity in mining areas, and ecology in mining areas (from Jaffré, 1980, to Jaffré et al., 1998)[2]. If we consider the biosphere (terrestrial ecosystems) to be a soil compartment, these studies are related to surface geosciences. This innovative global topic – one of the strengths of IRD research teams in tropical regions – was of particular interest to mining companies (Third International Conference on Serpentine Ecology, 1999, South Africa).

A project on nickel and its environment would therefore enable the resumption of research activities, in close partnership with the mining sector, in a field that addressed a real need throughout the territory at that particular time, in relation to the development of new mining projects on a global scale and new processing techniques, all in the framework of an internationally acclaimed political agreement.

Report by Fabrice Colin: bases for the development of research in New Caledonia from 2002 onwards

The founding report (Document 1)[3], which Fabrice Colin submitted to the Ministries of Research and Overseas France in December 1999, presented a detailed assessment of the situation and recommendations for the future project. The main thrusts of the recommendations contained in this report are set out below.

The review of the territory's strengths found that such a project would require the local reinforcement of disciplines associated with water: hydrogeology, hydrodynamics, and hydrochemistry, and also with surface geology: supergene mineralogy, supergene geochemistry, geophysics, geomorphology, and agropedology. Three topics were broadly defined: exploration and mining, environmental impacts, and societal impacts.

It was essential to provide research training for a certain number of New Caledonians through doctoral schemes, financed by specific grants for this project. In the same perspective, the expertise of organisations and universities (IAC, Cirad, Ifremer, IRD, IP-NC, and SME/BRGM, UNC)[4] would need to be mobilised in order to generate the knowledge required to address the combination of local issues.

The shortage of analytical resources in New Caledonia required the provision of additional large to medium-scale equipment and facilities for research and analysis bodies. These shared resources were both indispensable for the "Nickel Project" and also very useful for the maintenance and development of other research projects carried out in New Caledonia.

From an organisational and operational standpoint, a nickel research centre "without walls" was proposed in order to address issues relating to nickel and its environment by conducting scientific, technical and industrial research, and to ensure that the spin-offs from top-flight research would meet the needs of the territory's political and economic spheres. The general idea was that a robust research strategy would increase the potential of local expertise and generate knowledge to provide concrete solutions, enhancing New Caledonia's influence and reputation. The expected scientific spin-offs would not be strictly confined to the nickel sector, and would benefit the "Mines, Environment and Societies" topic as a whole, which is relevant to many countries in tropical regions.

1. L'Huillier L., 1998 – *Mise en valeur des sols dérivés des massifs ultrabasiques de Nouvelle-Calédonie. Détermination de la sensibilité des plantes cultivées aux métaux (Ni, Mn). Résultats sur des espèces maraîchères, fruitières et fourragères*. Nouméa, Orstom Conv., Ici, Vie, Agropédo, 44, 40 p.

2. Jaffré T., 1980 – *Étude écologique du peuplement végétal des sols dérivés de roches ultrabasiques en Nouvelle-Calédonie*. Thèse universitaire. Paris Sud, Orstom, Paris.
Jaffré T., Boucher B., Veillon J.-M., 1998 – Plant extinction in New Caledonia: is the system of protection adequate? *Biodiversity and Conservation*, 7: 109/135.

3. The documents cited as evidence of impacts are referenced as "Documents" and numbered in order of appearance in the text (cf. complete list in the appendix). They are publicly available at the Research evaluation and programming mission (MEPR) at IRD.

4. Cf. list of acronyms in the appendix.

Actors' contributions

The research activities examined in this study began in 2002, with the setting of the "Supergene Biogeodynamics and Tropical Geomorphology" team from Cerege in New Caledonia, led by Fabrice Colin and composed of geochemists, geophysicists, geomorphologists, geologists, mineralogists and hydrogeologists (annual funding of the operation, allocation plus consolidated IRD operations: approximately €600K). Traditionally, research is conducted within research teams that receive institutional and external funding and draw on a knowledge base developed by their predecessors. This chapter presents the different components mobilised in this study for the research carried out between 2002 and 2008.

Scientific issues

The key scientific challenges set out in the report submitted to the Ministers of Research and Overseas France were to:

– characterise ecosystems and understand the natural functioning of a massif prior to mining with the aim of establishing initial reference states;

– provide solutions to optimise exploration and mining;

– understand the impacts of mining on the environment (soil, plants, water and society);

Mining activity, impacted ecosystems.
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– reduce the negative impacts on humans and their environment;

– offset the negative impacts of mining activity by promoting the restoration of degraded soils and ecosystems.

In summary, the aim was to understand the interfaces:

Mining <=> Ecosystems <=> Populations

Mining <=> Degradation <=> Reduction <=> Repair

Scientific expertise and structures mobilised for the research

Several researchers operating in various Joint Research Units (UMRs) already based in New Caledonia, or who had recently arrived to start their projects, were involved in conducting the research. Only the organisations to which they were attached are referenced here.

Four research units played a more central role (Cerege, Amap, LSTM and Camélia), but the rapid aggregation of expertise enabled the need for multidisciplinarity to be met from the very start of the project and helped establish a critical mass of complementary IRD researchers:

– Cerege – European Centre for Research and Education in Environmental Geosciences: team established in 2002, which initiated the application of the report to the Ministers for Research and Overseas France;

– Amap – Botany and Modelling of Plant Architecture and Vegetation: team created to further knowledge of the flora and plant ecosystems of New Caledonia, and metal hyperaccumulating plants on ultrabasic rocks in particular;

– LSTM – Tropical and Mediterranean Symbiosis Laboratory: a team whose services were requested by Cerege, which arrived in 2006 with the task of studying microbiology and plant biology, and the functioning of symbiotic microorganisms vis-à-vis the response and adaptation of plants to these microorganisms and to extreme environmental conditions;

– Géoazur – geology of New Caledonia, mechanisms underlying the formation of ophiolitic layers;

– Camélia team – hydrodynamic functioning of the New Caledonian lagoon, sedimentology, modelling, tracing and speciation of elements transferred by anthropogenic or natural inputs;

– Espace-Dev – multi-scale environmental analysis and data interoperability;

– Lama – Analytical Resource Laboratory: multi-element analyses of soils, plants, water;

– IMPMC – Pierre and Marie Curie Institute of Mineralogy, Physics of Materials and Cosmochemistry: mineralogy and pedology.

Funding

The research was partly funded by various national and local partners.

The supervisory authorities of the participating Joint Research Units, which are in the front line when it comes to providing researchers with infrastructure, contributing to operations and above all paying the salaries of the statutory staff involved:

– IRD – French National Institute of Research for Sustainable Development: Cerege, LSTM, Amap, Geoazur, Camélia, Espace-Dev, Lama;

– Cirad – Agricultural Research for Development: LSTM, Amap;

– Inra – French National Institute for Agricultural Research: LSTM, Amap;

– CNRS – French National Centre for Scientific Research: Cerege, LSTM, Amap, Geoazur;

– Université Aix-Marseille: Cerege;

– Université de Nice: Géoazur;

– Montpellier Sup-Agro: LSTM;

– Université de Montpellier: Amap, LSTM, Espace-Dev;

– Ifremer – French Research Institute for Exploitation of the Sea;

– Université de Lorraine.

The supervisory ministries and funding agencies involved in the form of calls for projects:

– Ministry of Overseas France: MOM and CIOM projects;

– Ministry of Foreign Affairs: Pacific Fund Project;

– Ministry of Higher Education and Research: ANR – French National Research Agency.

The other in situ operators and research partners:

– BRGM – Bureau of Geological and Mining Research: funding of theses and agents;

– IAC – New Caledonian Agronomic Institute: participation in research via its own programmes and FTE agents;

– SIRAS Pacifique: private company specialising in the restoration of degraded sites involved in the project, within the Cifre scholarship funding framework;

– University of New Caledonia for the joint supervision of theses and of the agents involved;

– Mining companies (SLN-Eramet, Falconbridge-SMSP, Goro Nickel) through research contracts, Cifre scholarships, logistics assets and data access, and funding for colloquia and workshops;

– Institut Pasteur de Nouvelle-Calédonie: via scientific collaborations;

– Dimenc – Bureau of Industry, Mines and Energy – New Caledonia: access to data (geology, mines, energy);

– provinces and government: research and conference funding, research incentive grants;

– Congress of New Caledonia: financing of publications and symposia.

Knowledge base

Nickel hyperaccumulating species Sebertia acuminata*, called the nickel tree or "blue sap".*
© IRD/T. Jaffré

Significant work had been carried out since the 1980s on furthering the knowledge of lateritic formations and their functioning (geomorphology, general and isotopic geochemistry, mineralogy, petrology, geophysics, hydrology) in Africa and South America. The published work enabled the qualification, quantification and dating of tropical soil formation and erosion processes and of material flows on different scales (from the mineral and plant levels to catchment areas and landscapes). When related to mining activity, these results could be applied to the knowledge of deposits and to the improvement of non-destructive exploration methods, such as electrical resistivity tomography, which can be used to map the geological structure of subsoils and thus identify and characterise lateritic supergenic metalliferous deposits. In this way, the knowledge acquired formed the basis of the competencies used, developed and optimised in New Caledonia after 2002. It should be noted, for example, that although the tomography method had been presented in New Caledonia in 2000, it had been adopted only a few years later. The work carried out in public-private partnerships built on trust, and the overall dynamics generated, served to strengthen the scientific and applicative credibility of the research.

As far as knowledge of plants and ecosystems is concerned, the Laboratory of Botany and Applied Plant Ecology was already operating in New Caledonia in 1998, and Tanguy Jaffré was supervising seminal projects on the characterisation of species and soil ecology.

Research products

There have been numerous and varied research products of relevance to mining activity and the impacts on development. IRD has undoubtedly made important and innovative contributions to creating the products presented in this chapter. The Institute's background in soil physics and chemistry, and in the study of biodiversity, has been fundamentally important.

Academic publications

Original articles on the different fields explored by the research have been published in international journals. Document 2 contains references to the main publications (2003-2008):

– soil geophysics and geochemistry: 12 publications related to deposits and mining activity, followed by two publications related to asbestos studies;

– fields of ecological soil restoration: seven publications.

Establishment of a fungus collection

In the framework of land restoration studies, the characterisation of New Caledonia's plant ecosystems led to the establishment of a collection of reference fungi managed by the local mycological society (see below) and duplicated at the MNHN in Paris. Ecto and endomycorrhizal fungi have proved to be one of the keys to the adaptation of plants to the conditions of New Caledonia's lateritic soils and are therefore an indispensable lever in plans to restore land degraded by the mining activity. At the same time, additions

were made to the pre-existing New Caledonia herbarium at the IRD centre in Nouméa. On this occasion, a method for georeferencing the location of species in the field was launched.

Creation of a mycological society

The innovative studies of fungi provided an opportunity to create the Mycological Society of New Caledonia in 2008. The mission of the SMNC[5] association is to encourage studies of New Caledonian fungi and to disseminate their findings as widely as possible.

Standards, methods, guides, analysis procedures, etc. for service companies and mining companies alike

One of the expected outcomes of the industrial contracts signed by IRD and the mining industries (SLN, Falconbridge-SMSP, Goro Nickel) was the drafting and provision by researchers of "standards" and "methods" for industrial operators with a view to optimising prospection and ore extraction techniques, but also for the remediation of degraded environments.

Numerous reports and recommendations were therefore submitted to industrial operators and local authorities, sometimes at the numerous contractual working sessions. Examples (Document 3) include:

– applied geophysical projects with confidential quarterly reports;

– studies on mining areas with reports transmitted to the New Caledonian government and local authorities, as well as to mining operators, concerning mineralised regoliths;

– studies on asbestos with reports submitted to the Ministry of Overseas France and the New Caledonian government;

– applied conclusions of doctoral theses carried out in collaboration with mining operators; i) Nicolas Perrier: *Biogéodiversité fonctionnelle des sols latéritiques miniers: application à la restauration écologique, massif du Koniambo* (Functional biogeodiversity of mineral-rich lateritic soils: application to ecological restoration, Koniambo massif) (IRD-Cerege and LSTM in collaboration with IAC, UNC, Falconbridge/SMSP); ii) Alexandre Lagrange: *Études écologiques et microbiologiques des espèces du genre* Costularia *: application à la restauration écologique* (Ecological and microbiological studies of species of the genus Costularia : application to ecological restoration), in collaboration with Cerege, UNC, IAC, Pacific Siras. A summary guide to land restoration was drawn up (Document 4).

These documents also subsequently served as the basis for changes to the Mining Code (2009), the reference framework in force for mining in New Caledonia, the mining development scheme (2009) and the provincial Environmental Codes (2008-2009).

International scientific symposia

Several symposia were held over the research period. Both researchers and scientists contributed to these events by participating in the traditional exchanges of results within the scientific community.

However, particular emphasis should be placed on a major international event initiated by Cerege and jointly coordinated by IAC, Cirad, BRGM, CNRS and UNC Live, also involving the local IRD joint research units, as it played a particularly important role in initiating the impacts produced by the research. This was the international colloquium entitled "Preservation and ecological restoration in tropical mining environments: Technical, scientific and strategic perspectives" held in Nouméa in 2003. The idea was to bring together international and national expertise, share knowledge and develop on a research strategy for the future. Private operators and local authorities were also heavily involved in the organisation, financing and active participation of their agents, both at the conference venue at the IRD centre in Nouméa and on the mining sites. During this event, an initial presentation of the research outcomes, discussed by the different stakeholders concerned (miners, local populations, scientists), led to a list of objectives being drawn up.

This consultation culminated in a major outcome at this colloquium: a roadmap addressing the challenges posed by the consequences of mining activity in New Caledonia. This document guided the implementation of many actions that were responsible for the political, environmental and health impacts covered

5. https://fr-fr.facebook.com/Soci%C3%A9t%C3%A9-Mycologique-de-Nouvelle-Cal%C3%A9donie-SMNC-1463909283861263/.

in this study. This roadmap was formalised in the slide show that concluded this colloquium (Document 5).

In addition, many of the researchers and professors who came to the symposium were won over by the scientific approach and subsequently contributed their expertise, further expanding the networks of expertise that had been developed.

Agora White Paper

The roadmap that emerged from the 2003 symposium and the conclusions of the conference on French research in the Pacific (Nouméa, IRD centre, 2004) highlighted the need to reflect on the role of human and social sciences in New Caledonia. At the request of the President of the New Caledonian government, IRD proposed to organise a workshop with its local partners, involving the Credo.[6] Driven by this strong desire to reflect on promoting disciplinary and institutional decompartmentalisation in order to open up human and social sciences (SHS), "Agora" events were organised in 2006, and concrete proposals for structures, programmes and methodological tools were formalised. The recommendations can be found in a White Paper entitled *La recherche en sciences humaines et sociales en Nouvelle-Calédonie* (Human and social science research in New Caledonia) (Document 6). Following this workshop, UMR-Gred, which was asked by Cerege to participate in research on the societal impacts of mining activity, started operating out of the IRD centre in Nouméa.

Dissemination of scientific knowledge to society

Conferences for the general public were organised in the towns and villages of New Caledonia, particularly among the Melanesian tribes, with the aim of sharing scientific and traditional knowledge and informing the local population about the progress made in research projects and how this could be beneficial at the societal level.

Reports and films were produced on issues and research methods associated with mining activity in general, on ecosystems and their profusion of plant varieties, their endemic biodiversity including that of micro-organisms (bacteria, mycorrhizal fungi), and their role in maintaining the functional equilibrium of soils and therefore in the remediation of degraded soils. *L'Île Nickel* (Nickel Island), 2007, a 52-minute film co-produced by IRD, Europimages and Public Sénat, showed local and national audiences the role of scientific research in addressing the questions raised by citizens and in promoting sustainable development in the context of mining activities and their impacts.

Research outcomes were also used to update the *Atlas de la Nouvelle-Calédonie* (Atlas of New Caledonia), a project coordinated and co-financed by IRD at the request of the Congress of New Caledonia, which began in 2008 and was finalised in 2012.

Resources: monitoring stations

Stations were set up to monitor the impacts of mining in 2004, in both terrestrial and marine ecosystems. The levels of metals in soils, sediments, plants and water were regularly analysed, in addition to rainfall, temperatures and lagoon currents. These stations were developed predominantly in the south-western region of New Caledonia and are components of the impact observatory that monitors the Goro-Vale project. The data collected are added to metadata bases, whose interoperability has enabled the development of multi-scale and spatio-temporal analyses of the impacts generated.

Reinforcement and optimisation of platforms

The platforms were reinforced during the development of the research programmes. This involved normative upgrades to the Lama's methodologies and equipment as well as to the protocols for soil preparation and capillary electrophoresis in chemistry. The life science platform was created on a co-management basis with UNC and IAC at the IRD centre in Nouméa, in order to carry out genetic sequencing analyses of plants.

6. https://www.pacific-Credo.fr/.

Collegial surveys

A collegial survey of invasive species was conducted from 2003 to 2006: *Les espèces envahissantes dans l'archipel néo-calédonien à la demande du gouvernement de Nouvelle-Calédonie* (Invasive Species in the New Caledonian Archipelago at the request of the Government of New Caledonia).[7] Indeed, mining-induced deforestation also contributes to the development of invasive species as a consequence of deforestation.

A collegial survey of energy management in the development of New Caledonia enabled the performance of exhaustive assessments of domestic and industrial mining consumption, including carbon emissions, and the proposal of alternative solutions (2008-2011).[8]

Capacity building: teaching

IRD researchers have been regularly solicited to contribute to teaching at the University of New Caledonia.

Following on from the DEUST undergraduate diploma in Applied Geosciences: Mining, Water and Environment, a professional bachelor's degree on mining licence was developed and then discontinued.

A PPF (multidisciplinary research programme by the MERS) on "Functional biodiversity, alterations and transfers in the ecosystems of the catchment areas and lagoons of New Caledonia", involving IRD and UNC teams, was launched in 2008 for four years.

7. https://books.openedition.org/irdeditions/7612?lang=fr).
8. http://hal.ird.fr/ird-00527440/document.

Capacity building: student training

Approximately 40 students on DEA postgraduate programmes, studying for master's degrees or on internships were trained by the research teams during the 2001-2008 period.

Several theses were supervised:
– three theses were produced during the 2003-2008 period, relating to research in the field of environmental geosciences (geochemistry, geophysics, geomorphology, biology), in collaboration with local public and private partners, with IRD grants, Cifre funding and BRGM funding;
– three theses were begun in 2007 and 2008 (finalised in 2009 and 2010), funded by the university, Cifre and the Institut Pasteur;
– Postdoctoral studies were carried out in 2003 in partnership with SLN (Geophysical Validation of Tomography).

Nickel processing plant, Koniambo Nickel SAS, North Province of New Caledonia.
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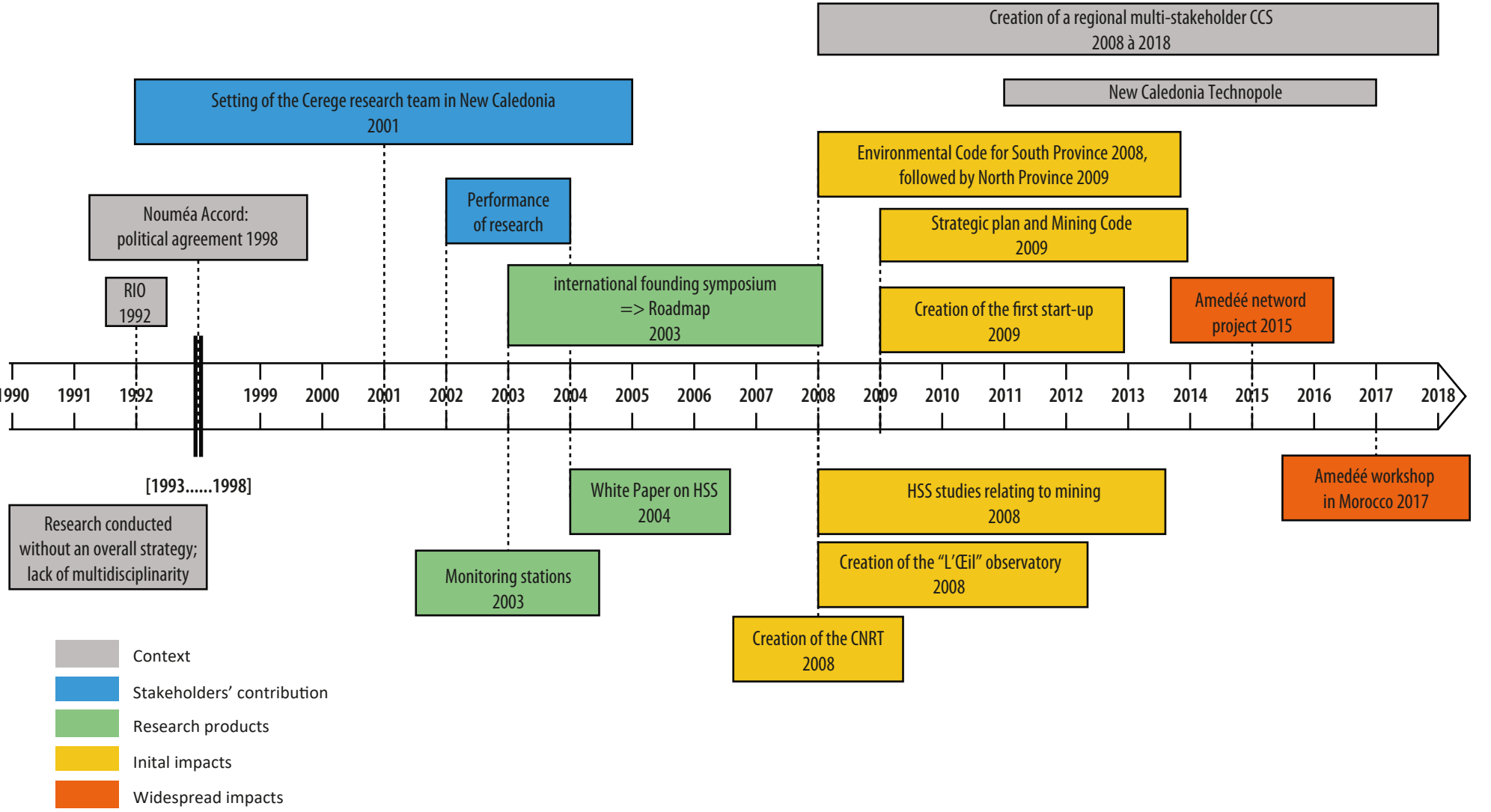
Timeline

Mining Activity in New Caledonia: Societal and environmental impacts



Circulation of knowledge and intermediaries

The identification of the stakeholders whom we refer to as “intermediaries” in this study, is particularly important, because they take ownership of all kinds of research outcomes, and then develop them and/or transform them into objects, concepts, regulations, etc., which have an impact on society.

The intermediaries in this study are numerous and varied. Some of them were involved in conducting the research. Witnesses of and/or participants in these processes were interviewed in order to better understand how this transition from research outcomes to impacts actually occurs. In most cases, this transition requires a chain of interests, creativity and competencies, often combined with innovation and above all time and collaboration, in order to transform these sometimes very fundamental findings into a benefit for a community.

It should be stressed that communities in New Caledonia are closely linked and in constant interaction. This Dialogue – sometimes calm, sometimes tense, but ever-present and always diverse in terms of its components – is both an asset and a handicap to the impact-generation process. It is deeply rooted in the community and enduring, even if it is never perfect!

These are the stakeholders we interviewed in order to discover their interpretation of this adventure and its repercussions on their community and on New Caledonian society. They were the people who provided the content of this report. The interviewees are listed at the end of the document.

The "Institut agronomique néo-calédonien"

Also involved in conducting the research, the New Caledonian Agronomic Institute played a key role in the implementation of the Environmental Code. The institute disseminates knowledge of ecosystems, biodiversity and all land restoration methodologies included in the Environmental Code.

Public authorities

Different types of public authorities exist in New Caledonia, from the government, its departments and the various provinces including the Kanak tribes, to various committees such as the CCR (Research Advisory Council), established under the Nouméa Accord, which covers the research component of the territory represented by researchers including IRD staff and the CMM (Municipal Mining Committee), and the CICS (Information, Consultation and Monitoring Committee) for the Vale-NC site (formerly Goro Nickel), in which members of the research team were actively involved as experts. All of these stakeholders are involved in implementing the legal regulations in force, i.e. the provincial Mining Codes, the government's Environmental Code and the asbestos regulations. They also contribute to the strategy and programming of major resources such as the observatory known as "L'Œil" (The Eye), and the CNRT. These stakeholders are far-removed from the research outcomes but in contact with the people who use them directly and others who defend society's interests. They therefore act as an interface and bring the two components together, producing benefits for society while taking the various stakeholders' interests into consideration.

The DRRT (Regional Directorate of Research and Technology) plays a particularly important role in the implementation of these processes, operating at this interface between the various institutions and intervening at all levels – from political to institutional – in order to promote ideas and programmes and help bring them to fruition.

Bureau of Industry, Mines and Energy – New Caledonia (Dimenc)

Dimenc is attached to both the Government of New Caledonia and the High Commission of the Republic (State). However, we felt it was important to give a special mention to its Geology Department, which plays a very active role as a bridge between the research outcomes and their practical applications. The continuum between the academic world and Dimenc is sustained by the funding of Cifre grants for staff employed in the department. As they possess their own laboratories, programmes and research interests, this creates an entire community of researchers with shared interests, which certainly contributes to raising the awareness of the importance of research outcomes at the highest level of the public authorities.

Mining operators

SLN-Eramet, Glencore-SMSP and Vale-NC have taken direct ownership of the research outcomes in the form of recommendations, guides, standards, etc., which have been submitted by the researchers. In addition to directly modifying their practices, these deliverables have also informed the Dialogue between mining companies and the public authorities concerning the implementation of the Mining Code.

They have also been directly involved in establishing the CNRT. They now contribute to the programming of research in this centre and to defining the orientations of calls for projects.

Local populations, associations and NGOs (including the WWF)

These locally born or based people and organisations participate in the transformation of research outcomes while benefiting from their spin-offs. Their mobilisation and contribution to public debate at different key moments in the history of their territory were partly responsible for the creation of the independent observatory known as "L'Œil" (The Eye). Their actions have also led to the implementation of more accessible, inclusive and comprehensible information processes providing real-time information about the consequences of mining activity on the quality of life.

Citizens are also involved in associations such as Adevy, which, with the mining operator's assistance, help to Incorporate laboratory-based theoretical knowledge into farmers' practices to enable the revegetation of degraded sites. This vector for the transmission of knowledge of biodiversity and cultivation methods generates a significant amount of paid work, and therefore makes a significant

and economically sustainable financial contribution to families' lives. The mining operator's environmental manager carried out his doctoral studies at IRD and has maintained constant links with IRD and scientific partners (IAC in particular).

Students trained in research laboratories

Students have transmitted outcomes and knowledge to society by creating innovative service companies. In addition to making expertise in different innovative fields available to society, their activities have also helped to create employment throughout the territory. Their development gives society faster access to the benefits of scientific advances. The acquisition of new expertise often proves too costly for established companies, which can be an obstacle to the implementation of best practices. Start-ups offering constantly evolving services make the best practices readily available to professionals by staying in touch with developments in the research fields from which they originate. It should be noted that links with the Adecal-IRD incubator are particularly important and guarantee win-win exchanges between researchers and the business sector.

The University of New Caledonia (UNC)

The UNC plays a appropriate role is in training students who will, in the future, contribute to their local communities and become specialised employees with a strong awareness of the value added by links with research. They will continue to uphold the values generated by diversity in communities, including in the research community.

Researchers

Some of the participating researchers are "transmitters" of their own results and advocates for research culture. To this end, they participate in numerous scientific councils. They are responsible for ensuring the consideration of factual research data in the various programming decisions on which they issue opinions. Their commitment to serving the common interest is commendable.

Initial impacts

At the end of the interviews conducted with the various stakeholders involved in the transformation of research outcomes, their contributions enabled us to characterize proven impacts that have led to long-term changes in the functioning of a societal group (farmers, industrial operators, lawyers, politicians, the population at large, etc.) in a specific field. We sought to identify these fields by developing a typology of impacts, divided into six types of impact:

- institutional;
- economic;
- capacity building, furthering of scientific expertise;
- social, health, educational and cultural;
- environmental;
- academic.

Impacts were identified and characterized in each of these categories. Under no circumstances do we claim to present an exhaustive view of the positive or negative impacts that may result from the research results we have considered in this study. Our findings are based solely on the impacts we were able to document from the interviews we conducted for this study.

Institutional

Creation of the CNRT "Nickel and its environment"

A research funding agency was created to enable the concerted multi-stakeholder programming of research project orientations and funding. The research team that moved to Nouméa in 2002 was instructed to establish a new research centre (the future CNRT). The success of the CNRT can certainly be attributed to the proposal to design this structure jointly and collegially with all the public and private partners. This required eight years of consultation and the adaptation of objectives. Indeed, links needed to be developed between members of very different cultures – mining operators, the government, provincial communities and researchers, including those in the HSS field. The project was finally implemented in 2008. The CNRT, established as a Public Interest Group (GIP), has a board of directors consisting of 15 members, one third representing mining operators including the mining industries union, one third representing local public authorities and the French State, and one third representing scientific institutions including IRD. It is the product of the research consortia development, trust and expertise during the previous 2000-2008 period, and the appropriation of research outcomes that convinced the different stakeholders of the value-added benefits of such a proposal and, with support from the State, enabled the establishment of this centre which is responsible for collecting funds from different sources: provincial authorities, the Government of New Caledonia, the State, mining operators (€5 million for a five-year mandate), which are redistributed in the form of calls for projects whose themes are decided according to a three-stage process: 1) requests from stakeholders; 2) formulation in terms of research programming with assistance from a Scientific and Approval Board; 3) calls for research projects, monitoring and dissemination of reports. Stakeholders are consulted at all levels and Dialogue is encouraged. Since 2007, two five-year contracts have been carried out and 45 projects have been co-financed. Document 7 presents the CNRT's activity report between 2007 and 2017.

The model has proven its worth and is now cited as an example by President Emmanuel Macron during his visits to other French overseas regions such as Guyana (Document 8). Even though the model is perfectible and must be adapted to specific contexts (type of ore, exploitation, ecosystems, and societal and political contexts), the method is reproducible and takes account of local specificities.

Creation of the New Caledonia Environmental Observatory: L'Œil (The Eye)

In 2008, an environmental observatory was established to monitor the territory, inform the population and leaders, and support industrial operators. The monitoring stations mentioned previously have been at the forefront of the L'Œil[9] observatory's activities, and have undoubtedly helped to demonstrate the value-added benefits of the monitoring measures and the scientific relevance of the indicators proposed by the researchers. The L'Œil observatory was created in response to demands from local associations received by the South Province, and upon the proposal of IRD researchers (Cerege/Camélia) who carried out the feasibility study and supported its creation in close collaboration with the South Province's Environment Department (DENV). It plays a key role at the policy level by monitoring the impact of mining activity in the South Province.

The L'Œil has a tripartite board of directors: industrial mining operators/South Province/NGOs. The observatory has a Scientific Board that approves analyses before their dissemination. It is composed of 22 members, half of whom are from outside New Caledonia. It also carries out scientific monitoring to check whether the indicators can be optimised and, if so, calls for projects can be launched to give researchers an opportunity to contribute to this optimisation.

The L'Œil's activity reports present all the activities and impacts listed in Document 9 (available online at www.oeil.nc).

An external audit carried out by the L'Œil observatory in 2013 (Document 10) highlighted several impacts:
– launching studies to define environmental monitoring indicators (e.g. three working groups on freshwater, marine and terrestrial environments and the optimisation of some twenty indicators);
– helping to finalise certain indicators, such as the IBNC30, develop reliable and comparable monitoring methods, and new indicators (fresh water: diatom indicator; marine waters: fishing pressure indicator; terrestrial environments: land take indicator);
– based on an information exchange charter (Document 11), gathering available information about the state of the environment in southern New Caledonia

9. http://www.oeil.nc.

(e.g. 2,500 references entered) and pressures, and bridging the current gaps in environmental information;

– helping to set up monitoring systems for certain environmental parameters (e.g. 18 indicators used for monitoring);

– launching studies to complete missing environmental data (e.g. production of 70 environmental studies), and production of thematic summaries;

– creating a battery of very well constructed and widely disseminated communication tools for sharing the information collected: website, mapping tools, newsletters printed in 25,000 copies, publications, 10 to 20 public meetings per year, etc., and the survey conducted in 2012 shows that 25% of the population of the Southern Province know about the L'Œil observatory;

– responding very quickly to accidents occurring in the area in order to provide the public with quick and reliable information;

– gaining the confidence of local people and probably of the general public through transparent activities ;

– contributing to certain regulations that have been inspired by recommendations made by the L'Œil observatory, e.g. the law defining rainforest protection.

Economic

Improvement of procedures for prospecting and exploitingmining areas

The standards and guides produced as a result of research activities have enabled modifications to be made to the Mining Code (documents 12 and 13), which have had a direct impact on the practices of mining professionals. Dimenc plays an important role in these processes. The introduction of the Mining Code in 2009 made it possible to abandon the regulations proposed by Australian legislation that were ill-suited to this region, and adapt metropolitan regulations to take account of New Caledonia's specificities (political, societal, environmental, geographical, geological and biological). Developments in prospection generate considerable savings while reducing destructive impacts. These new techniques and knowledge enable mining operators to limit the number of boreholes drilled. Examples include the use of electrical resistivity tomography, 3D imaging of mineralized regoliths, and a variety of airborne geophysical methods facilitating more focused prospecting and in this way reducing the size of the prospection area from 200 ha to 10 ha, for example, which requires less drilling. Given that one borehole costs 1 million CFP francs, the savings are appreciable.

Detailed knowledge of lateritic ores that can be exploited by hydrometallurgy, including mineralogical speciation of nickel and cobalt, has also improved the efficiency of mineralurgical processes.

With regard to land, mining operators hare required to restore the soils they strip off, which is a strong negative impact from an economic standpoint, in light of the cost of remediation as required by the Environmental Code. According to the research carried out in this field, this cost is estimated at around €20,000/ha if it is not carried out progressively throughout the mining operations, not counting the inherent loss of ecosystem services, which is estimated at €50,000/ha, and the risks of erosion and hyper-sedimentation of rivers and the lagoon. The research outcomes also enable mining operators to reduce these costs by simultaneously managing the mining operations and the conservation of certain ecosystems and stripped soils, and by restoring them more effectively and efficiently.

Encouraging and facilitating the creation of innovative enterprises by making innovative services linked to job creation available to stakeholders

The IRD research centre in Nouméa established a start-up incubator in 2007. This incubator was subsequently part of Adecal-technopole-IRD in 2014. It has given several students who completed their thesis or followed a postdoctoral internship at the Nouméa research centre, and engineers from IRD joint research units, opportunities to create their own innovative start-ups in a favourable scientific and public-private partnership environment:

– The GeophysiCAL consultancy specialising in tomography[10]. Created in 2005, it left the incubator in 2010. The director currently laments the lack of links with research, which she sees as detrimental to her capacity to evolve and to ensure that research remains in touch with practical issues in the field.

– The Environmental Analysis Laboratory AEL[11], which remains on the IRD site, sharing equipment and facilities with the centre. It maintains close partnerships with certain research units (IMPMC and MOI) on the development of new analytical methods.

10. http://www.geophysical.nc/la-societe.
11. http://ael-environnement.nc/fr/.

– Bluecham a company that develops operational environmental decision support solutions, is also still based at the centre. It maintains close links with certain Joint Research Units and has won numerous international prizes in recognition for its innovations (data interoperability and spatio-temporal analysis from satellite to field).

– The Biocénose Marine[12] (Marine Biocenosis) company combines research and expertise in monitoring the marine environment, and works on the IRD site in close collaboration with the Entropie (Entropy) Joint Research Unit.

– GIE Océanide, a centre of expertise and research for the integrated management of territories and the environment, based at the IRD centre with the Espace-Dev laboratory.

And based outside the incubator:

– BOta Environnement is a company involved in land restoration.

In the North Province, Koniambo Nickel SAS-KNS[13] has created more than 700 companies that subcontract numerous economic activities associated with the development of the Glencore-SMSP project, including analysis laboratories, seed-harvesting companies and plantations for restoration, all driven by a highly developed corporate social responsibility policy.

Involvement of the population in the creation of satellite nurseries

Other enterprises have been created by Kanak groups within their tribes, close to the mining sites. In the South Province, it all started with the "Pact for a Sustainable Development of the Greater South" which included the inclusion of the local population in land remediation projects. The construction of satellite nurseries in connection with the mine nursery was proposed.

These satellite nurseries in the Southern Province are run by families from the local Kanak tribes, and cultivate plants for land restoration. The families were selected after a call for applications, based on the ecosystemic quality of the property they owned. This activity is a significant source of Income for these families. The price paid can be estimated at approximately 220 CFP francs per plant with a guaranteed order of 200,000 plants per year.

12. http://www.biocenose-marine.net/.
13. http://www.koniambonickel.nc/.

It should be noted, however, that choosing the families on the basis of their land ownership has led other families to question the distribution of land within the tribes.

Job creation

As shown by the results for capacity building (below), many students have been trained and have gone on to start their own businesses. They have then hired their own staff, who have been trained and joined either the industrial mining operators (the biggest being SLN, Vale-NC, and Glencore-SMSP), or other international companies and consulting firms such as Golder Associate. Some of the students trained in research and through research during the 2001-2008 period now hold senior positions at mining companies: the knowledge developed and the acquisition of a common "research" language perpetuate the trust-based relationship established with the research community, and continue to contribute to the creation of public-private consortia that enable the improvement of mining practices and the development, through research, of an increasingly virtuous circle.

The number of permanent jobs generated can be estimated at around 100.

Capacity-building, furthering of scientific expertise

Continuation of a course of study for students

Different study programmes have been established throughout this period, on a more or less permanent basis. One remains active to this day: the Master's degree in Environmental Management created by the University of New Caledonia. IRD researchers are not directly involved in this master's degree but it is partly based on the research outcomes acquired. The students trained on this programme are recruited by industrial mining operators and public authorities.

Towards participatory science

The dissemination of information to the general public has improved and a well-informed community has been created, including the creation of the New Caledonian Mycological Society (SMNC). The SMNC's mission is to educate and disseminate knowledge, in order to raise awareness among people interested in these aspects in New Caledonia. The Society currently has 433 members and 462 website subscribers. It participates in science festivals, organizes conferences and debates, exhibitions and field trips.

For their part, citizens can share the discoveries they make and thus help to increase the capacity to explore new areas and make new discoveries in accordance with best practices.

Vocational training of Kanak families and perpetuation of innovative knowledge promoting the creation of business opportunities

Greenhouse managed by the Digoue family, a local operator subcontracted by the Vale-NC company. Romain Barrière, manager of the Botanic company and Annie Digoue, greenhouse manager, in the Goro region.
© IRD/I. Henry

The involvement of Kanak families in the production of seedlings of endemic species to be used by mining operators for land restoration, required these farmers to be trained in cultivation methods that are adapted to the germination and growth of several plant species. In the South, for example, a local association – Adevy – manages this training, which enables the local community to increase its capacities, and to conserve and cultivate endemic species that are particularly difficult to cultivate.

Health, social, educational and cultural issues

Better protection for mine workers exposed to asbestos dust

The characterisation of the different forms of asbestos (different mineral species and different morphologies) likely to cause cancer, has enabled the introduction of regulations to protect people from asbestos dust, on nickel mining sites as well as, more generally, in certain other specific geological environments with a high risk of asbestos dispersion and contamination of the population. Regulations have been put in place; Documents 14 and 15 are examples of orders concerning the protection of workers.

Environmental

Implementation of the provincial Environmental Codes

The Environmental Codes of the North Province (Document 16) and South Province (Document 17) set out the mining regulations to be followed in terms of the monitoring of polluting processes and post-mining restoration. These rules are available for consultation and are universally applicable in order to perpetuate virtuous environmental practices. They are inspired by the land restoration guide, which is one of the research outcomes and also one of the published research works (reports, publications, doctoral theses). It should be noted that the ongoing links between research and the public authorities enables the continued integration of research outcomes into these documents.

The existence of these Environmental Codes has influenced the implementation of decrees that compel miners to remediate soils and manage water. Two examples of operating orders are presented in Documents 18 and 19. Miners are encouraged to move away from "green washing" and instead adopt an ecosystemic approach to restoration, which involves combining at least five different species on a restoration site.

The various regulatory documents (Mining Code, Environmental Codes and some of the L'Œil observatory's recommendations) are interlinked and complementary.

Academic

In this section, we have only mentioned the major academic impacts that are real advances for research and not continuations of work on the topic in the laboratory.

Towards the financing of multidisciplinary consortia

The results obtained by the research teams have undoubtedly enabled funding to be obtained from the ANR and Europe:

– 2006-2008: ANR *Écosphère continentale et risques environnementaux* (Ecco Niko Continental atmosphère and environmental risks) project: "Biogéochimie des éléments métalliques dans le continuum sol/eau/microorganismes/plantes des écosystèmes latéritiques de Nouvelle-Calédonie : activités anthropiques *vs* cycle naturel" (Biogeochemistry of metallic elements in the soil/water/microorganisms/plants continuum of lateritic ecosystems in New Caledonia: anthropogenic activities vs natural cycle), coordinated by IRD;

– 2007-2010 : ANR Ultrabio project: "Biodiversité et stratégies adaptatives végétales et microbiennes des écosystèmes ultramafiques en Nouvelle-Calédonie" (Biodiversity and adaptive plant and microbial strategies of ultramafic ecosystems in New Caledonia), coordinated by IRD;

– European EDF Sysmin 2007 programme (with the involvement of IRD);

– European Inco-NET PACE-NET programme from 2008: networking of stakeholders in the Pacific (coordinated by IRD).

Restoring legitimacy to human and social sciences

Prior to reflecting on the programming, research in the human and social sciences (HSS) needed to be revitalised. In accordance with the roadmap originating from the 2003 international symposium, a researcher was asked to visit the field in 2008 in order to develop the HSS dimension of "Mines and Society" issues. The researcher's arrival improved the consideration of important societal issues in the calls for projects launched by the CNRT: i) mining governance; ii) land tenure and emerging conflicts; iii) small-scale mining enterprises. Although an impact was observed, it remained relative. However, it is included in the CNRT's report (Document 7).

Creation of the Agora-HSS network

The Agora association emerged as a creator of links between scientific institutions following the eponymous workshops in 2006 and the White Paper on the development of HSS. This go-between organisation had an impact on the development of HSS in general, and on the "Mines and Society" topic in particular from 2006 to 2011.

Widespread impacts

Widespread impacts occur when an impact observed locally spreads more widely to another territory or subject. The application of the approach to generating impacts from research outcomes that has been used in New Caledonia to mining operations in Morocco is an example of a widespread impact that is relevant to this report.

In 2007, in view of the research and development (R&D) dynamics generated, Fabrice Colin contacted scientific partners, the government and local authorities to raise the idea of creating an “Island Ecosystems: knowledge, uses, management of natural and anthropogenic risks” competitiveness cluster (Document 20). In partnership with AFD, funding was obtained to carry out a feasibility study, which agreed on the capacity to create a competitiveness cluster, driven by the mining industry. The proposed model, revolving around mining activity but backed by R&D, consisted in using the knowledge generated to diversify the economy and help it become a sustainable economy. However, the mining operators did not support the proposal, considering the activities of the lead organisation in the cluster to be too far removed from their mining objectives in the strict sense of the term.

However, the work carried out laid the foundations and IRD, remaining the lead institution, promoted it with its partners through several ideas that would subsequently come to fruition and consolidate the structuring of research and innovation throughout the territory.

Rapid growth of the Amedéé international network

As mentioned previously, research strategies on the "Nickel, Environment and Societies" topic (organisation and programmes) have produced advanced knowledge in New Caledonia, which has become a research laboratory on a truly territorial scale.

The idea of combining mining and environmental issues – linking the sectors rather than opposing them – was already a cornerstone of the CNRT's feasibility study (1999). In fact, it was also one of the main underlying thrusts of the research conducted from 2000 to 2008, to the extent that such a generalisation can be made.

In 2008, the IRD submitted a proposal to the UNC to create a Unesco Twin-Twin Chair on this issue entitled Amedéé (Mining, Environments, Development, Economics, Ethics). This project did not come to fruition.

However, the reflections undertaken with the French Development Agency (AFD) on the competitiveness cluster, and a summary of the Research, Development and Innovation research carried out in New Caledonia (Colin, 2012)[14], led to the idea of triggering a paradigm shift in primary mining activity towards a circular economy (no longer an oxymoron), based on the multidisciplinary knowledge generated by the research.

Based on the results obtained in New Caledonia, a model was formalised, in which IRD's historical partners in the Global South were invited to co-construct a network of research projects that would facilitate the sharing and development of the knowledge acquired, and the joint exploitation of materials – both sustainable (during the transitional period) and sustainable (in the long term) – in order to integrate mining activities into a more virtuous circle. In this way, mining becomes a generator of economic diversification, and the influence of mining projects extends beyond the narrow confines of their economic activities by promoting genuine projects for sustainable societies, provided that they are accepted and shared.

Following six workshops (Morocco, Madagascar, Senegal, New Caledonia, France, Côte d'Ivoire) carried out between 2016 and 2017, with strong backing from IRD's senior management and partners from countries in the Global South, in association with IRD's participating joint research units and with the national partners who joined the initiative (BRGM, Cirad, INERIS, mining schools), the Amedéé network was created in December 2017, at a joint event to launch the "Regional Centre of Excellence for Mining and the Environment" at the INPHB in Yamoussoukro (ACE). (Document 21).

The Amedéé digital platform was created in January 2018 (www.Amedéé-network.science).

The international Amedéé network is the first collaborative platform developed by scientific partners from countries in the subtropical and inter-tropical zones and from France with the aim of promoting a new model of responsible and virtuous mining activity through R&D.

Amedéé adopts a comprehensive approach covering mining and industrial issues in their entirety, from prospection through to the closure of mining sites. The platform informs the thinking on this model by bringing together research/action/training projects related to this activity, led by researchers and professors from the countries concerned, particularly in South America, the North Africa, Sub-Saharan Africa, the Pacific and South-East Asia. Research projects are multidisciplinary and multi-institutional, combining earth, bio and environmental geosciences, and human and social sciences. They rely on a partnership built on trust between operators.

Highland forest, Mount Panié, New Caledonia, a remarkable endemicity.
© IRD/V. Héquet

The overall objective of this platform is to promote – through research – sustainable and ethical mining activities, which are measured, accepted by populations, and conform to the general principles of circular economy within the overall framework of sustainable development goals. By sharing knowledge, seeking innovative solutions, and promoting a societal model that respects people and their environment, this platform supports a resolutely ecological and economic transition.

The network's governance is shared by the project leaders and the Amedéé representatives in each country concerned.

The network is already involved in supporting the activities of centres of excellence in Africa, in the framework of World Bank calls for tenders. Together with the IRD Joint Research Units, it supports the development of IRD resources in the South (JEAI and LMI), which will subsequently inform the partnership-based research carried out.

14. Colin F., 2012 – *Recherche et développement en Nouvelle-Calédonie : équilibres, déséquilibres et équilibrages*. Faberon J.Y. (dir.),Mennesson T. (dir.), 2012 - *Peuple premier et cohésion sociale en Nouvelle-Calédonie : identités et rééquilibrages*. Aix-en-Provence, Presses universitaires d'Aix-Marseille : 287/306. (Droit d'outre-mer). ISBN 978-2-7314-0854-6

Impact pathway

Mining Activity in New Caledonia: Societal and environmental impacts

CONTEXT:
Matignon, Bercy and Nouméa
Accords => Redistribution of mining resources => Setting a new economic balance

Actors' contributions

Request for a State survey

Survey report (Nickel research cluster)

UMRs & supervisory authorities:
Cerege, LSTM, Espace-Dev, Amap, Camélia Team, Other UMRs

Operators:
Public: ministries, communities, provinces, government, etc.
Private: mining companies,etc.

BRGM, UNC, IAC, etc.

Knowledge base

Research products

Request for survey by mining operators and communities

Study programmes
Courses
Students

Public dissemination
SMNC Association
Conferences, workshops

Resources
Monitoring stations
Analytical platforms
Herbarium
Fungus strain collection

International conf.
Roadmap

Documentation
Analytical methods
Standards and guides
Agora White Paper

Publications

Collegial surveys

Flows of knowledge and intermediaries

Agora Network

Mining stakeholders Consulting firms

North and South Provinces Public authorities Government
Dimenc
Environmental Services

Local Associations

Local people

Trained researchers and students

IAC

Initial impacts

Impact: capacity building
- Professional Master's degree => Mining employment
- SMNC => Participatory Science
- Training for the public on the cultivation of endemic species from an ecosystem perspective

Economic impact
- Optimisation of mine-related activities
- Creation of innovative enterprises
- Innovative mining services
- Job creations
- Creation of a local economy based on nurseries

Environmental impact
- Environmental regulations, codes
- Monitoring of environmental impacts in the South
- Provision of information to the population and society in general (local and international levels) by appropriate means

Health impacts
- Protection of minors against asbestos
- Pollution alerts in the lagoon

Academic impacts
- Structuring of intersectoral research
- Programming of HSS research

Institutional impacts
- CNRT: creation and funding of multidisciplinary, intersectoral research
- L'Œil: creation of an observatory of impacts on ecosystems in the South

Widespread impacts

Environmental & economic impacts

•Amedéé Network: export and sharing (partners from the Global South) of the intersectoral & interdisciplinary approach to R&D covering the entire life cycle of mining projects

Appendices

Interviews conducted

Jean-Philippe	**Ambrosi**	researcher at Cerege
Jean-Sébastien	**Baille**	deputy director, Dimenc
Romain	**Barriere**	director of Botanic
Anicet	**Beauvais**	researcher at Cerege
Gaëlle	**Bouchet**	geological engineer
Laurent	**Chatenay**	director of Nord Avenir
Fabrice	**Colin**	researcher at Cerege and manager of Amedéé
Victor	**David**	researcher at Gred
Marc	**Ducousso**	researcher at LSTM
Pierre	**Epinoux**	director of Operational Excellence at SLN
Digoue family		family in charge of a nursery
Jean-Michel	**Fernandez**	company director, AEL
Bruno	**Fogliani**	deputy director of IAC
Pierre	**Genthon**	researcher at HSM
Hubert	**Geraux**	director of WWF New Caledonia
Amir	**Hamid**	professor, University of New Caledonia
Édouard	**Hnawia**	IRD representative in New Caledonia
Tanguy	**Jaffre**	emeritus researcher at IRD
Philippe	**Jourand**	researcher at LSTM
Farid	**Juillot**	researcher at IMPMC

Mathieu	**Junker**	director of the L'Œil observatory
Alexandre	**Lagrange**	company Director, Bota-Environnement
Laurent	**Lebrun**	director of Sofinor
Pierre-Yves	**Lemeur**	researcher at Gred
Didier	**Lille**	company director, Bluecham
Stéphane	**Mac Coy**	director of Vale-NC industry nurseries
Morgan	**Mangeas**	chairman of the Scientific Council of the L'Œil observatory
Jean-François	**Marini**	ex-DRRT
Vincent	**Mary**	engineer, South Province
Pierre	**Maurizot**	retiree from BRGM
Jean-Michel	**Nguyen**	Vale-NC Corporate Environment Department
Bernard	**Robineau**	director of the Geology Department at Dimenc
Cécile	**Savin**	company director, Geophysical
Tony	**Seremele**	conservation of flora and fauna - Vale Environment
Brice	**Servin**	geological survey - Dimenc
Daouda	**Traore**	geonickel
Mina	**Vilayleck**	communication IRD-Nouméa
Jacqueline	**Vouti**	Adevy association

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Doc. n° 2 List of main publications.

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Doc. n° 4 Reference of the book on land restoration.

Doc. n° 5 Roadmap from the 2003 symposium.

Doc. n° 6 Agora-HSS White Paper.

Doc. n° 7 CNRT Activity Report 2007-2017.

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Doc. n° 10 Activity Report for the L'Œil Observatory.

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Doc. n° 12 Legislative section of the Mining Code.

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Doc. n° 14 Order no. 2010-4553/GNC of 16 November 2010 implementing the ruling on the protection of workers against dust from asbestos-bearing sites in mining, construction and public works activities.

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Doc. n° 16 North Province Environmental Code.

Doc. n° 17 South Province Environmental Code.

Doc. n° 18 Example of an order concerning the obligation to repair damage caused by mining.

Doc. n° 19 Example of an order authorizing the operation of mining sites and the conditions related to land restoration.

Doc. n° 20 Competitiveness cluster project.

Doc. n° 21 Kick-off document for the Amedéé international network.

List of abbreviations

3D: 3 dimensions

AAP: Appel à projet (Call for Proposals)
ACE: African Centre of Excellence
Adecal: Agence de développement de la Nouvelle-Calédonie (New Caledonia Development Agency)
Adevy: Association pour le développement économique de Yaté (Yaté Economic Development Association)
AEL: Laboratoire d'analyses environnementales (Environmental Analysis Laboratory)
AFD: Agence française de développement (French Development Agency)
Agora: Ateliers gouvernance et recherche appliquée (Governance and Applied Research Workshops)
Amap: Botanique et modélisation de l'architecture des plantes (Botany and modelling of plant architecture)
Amedéé: Activité minière, environnements, développement, économies, éthiques (Mining activity, environments, development, economics, ethics)
ANR: Agence nationale de la recherche (French National Research Agency)
Asirpa: Analyse des impacts de la recherche publique agronomique (Analysis of the impacts of public agricultural research)

BRGM: Bureau de recherches géologiques et minières (Bureau of Geological and Mining Research)

CA: Conseil d'administration (BoD: Board of Directors)
CCR: Conseil consultatif de la recherche (Research Advisory Council)
Cerege: Centre européen de recherche et d'enseignement des géosciences de l'environnement (European Centre for Research and Education in Environmental Geosciences)
CICS: Comité d'information, de concertation et de surveillance (Information, Consultation and Monitoring Committee)
Cifre: Conventions industrielles de formation par la recherche (Industrial agreements for training through research)
CIOM: Comité interministériel des Outre-mer (Interministerial Committee for Overseas France)
Cirad: Recherche agronomique pour le développement (Agricultural Research for Development)
CMM: Comité municipal des mines (Municipal Mining Committee)
CNRS: Centre national de la recherche scientifique (French National Centre for Scientific Research)
CNRT: Centre national de la recherche technologique (French National Centre for Technological Research)
Credo: Centre de recherche et de documentation sur l'Océanie (Oceania Research and Documentation Centre)
CS: Conseil scientifique (Scientific Board)

DEA: Diplôme d'études appliquées (postgraduate diploma of applied studies)
Dial: Développement, Institutions et MonDialisation (Development, Institutions and Globalisation)
DENV: Direction de l'environnement (Environment Directorate)
DEUST: Diplôme d'études universitaires scientifiques et techniques (two-year undergraduate diploma in science and technology)
Dial: Développement, Institutions et MonDialisation (Development, Institutions and Globalisation)
Dimenc: Direction de l'industrie des mines et de l'énergie de Nouvelle-Calédonie (Bureau of Industry, Mines and Energy – New Caledonia)
DRRT: Direction régionale de la recherche et de la technologie (Regional Directorate of Research and Technology)

Espace-Dev: Espace pour le développement
EDF: European Fund and Development

FTE: Full-time equivalent

GIE: Groupement d'intérêt économique (Economic Interest Group)
GIP: Groupement d'intérêt public (Public Interest Group)
Gred: Gouvernance, risque, environnement, développement (Governance, risk, environment, development)

HSM: Hydrosciences Montpellier

IAC: Institut agronomique néo-calédonien (New Caledonian Agronomic Institute)
IBNC: Indice biotique de la Nouvelle-Calédonie (Biotic Index of New Caledonia)
Ifremer: Institut français de recherche pour l'exploitation de la mer (French Research Institute for Exploitation of the Sea)
Impress: Impact of research in the South
IMPMC: Institut de minéralogie, de physique des matériaux et de cosmochimie (Institute of Mineralogy, Materials Physics and Cosmochemistry)
Inco: International cooperation
INERIS: Institut national de l'environnement industriel et des risques (National Institute for Industrial Environment and Risks)
INPHB: Institut national polytechnique Félix Houphouët-Boigny
Inra: Institut national de la recherche agronomique (French National Institute for Agricultural Research)
IP-NC: Institut Pasteur of New Caledonia
IRD: Institut de recherche pour le développement (French National Institute of Research for Sustainable Development)

JEAI: Jeune équipe associée à l'IRD

Lama: Laboratoire des moyens analytiques (Laboratory of Analytical Resources)

Live: Laboratoire insulaire du vivant et de l'environnement (Island Laboratory of Life Sciences and the Environment)
LMI: Laboratoire mixte international (Joint International Laboratory)
Leda: Laboratoire d'économie de Dauphine (Dauphine Economics Laboratory)
LSTM: Laboratoire des symbioses tropicales et méditerranéennes (Laboratory of Tropical and Mediterranean Symbioses)

MEPR: Mission de l'évaluation et programmation de la recherche (Research evaluation and programming mission)
MERS: Ministère de l'Enseignement supérieur et de la Recherche scientifique (Ministry of Higher Education and Research)
MNHN: Museum national d'histoire naturelle (National Natural History Museum)
MOM: Ministère des Outre-mer (Ministry for Overseas France)

NC: New Caledonia
NGO: Non-governmental organisation

Orstom: Office de la recherche scientifique et technique outre-mer (Office of Overseas Scientific and Technical Research)

PACE-NET: Pacific-Europe Network for Science and Technology
PPF: Programme pluriformation (Multidisciplinary programme)

R&D: Research and development
RDI: Research, development and innovation

SHS: Sciences humaines et sociales (HSS: Human and Social Sciences)
SLN: Société Le Nickel
EMS: Service des mines et de l'énergie de Nouvelle-Calédonie (Department of Mines and Energy – New Caledonia)
SMNC: Société de mycologie de Nouvelle-Calédonie (Mycological Society of New Caledonia)
SMSP: Société minière du Sud Pacifique
Sysmin: Système de développement du potentiel minier (Mining potential development system)

Ummisco: Unité de modélisation mathématique et informatique des systèmes complexes (Mathematical and computer modelling unit for complex systems)
UMR: Unité mixte de recherche (Joint Research Unit)
UNC: University of New Caledonia
Unesco: United Nations Educational, Scientific and Cultural Organization

WWF: World Wildlife Fund

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