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Agromining: Farming for Metals

Extracting Unconventional Resources Using Plants

Springer

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Preface

Metallophytes (metal-tolerant plants) have been used for centuries to locate valuable metallic ore deposits (in fact as early as 1556 in Georgius Agricola's *De Re Metallica*). A subset of metallophytes, those plants that accumulate extraordinary amounts of metals or metalloids within their living tissues, are called hyperaccumulators. Although first reported in 1865 in the zinc-hyperaccumulating *Noccaea caerulescens*, the reporting of the exceptional blue-green latex, containing 25 wt% Ni, in the endemic New Caledonian tree *Pycnandra acuminata* by Jaffré et al. 40 years ago, has really spawned scientific interest in these unusual plants. We have come a long way since then to find innovative uses for these plants. One such emerging technology is phytomining or agromining, which involves the cultivation of hyperaccumulator plants and harvesting their biomass to obtain particular metals or metalloids. Whereas phytomining describes the process of exploiting plants to obtain valuable elements, agromining refers to the full agronomic chain in using hyperaccumulator plants as 'metal crops'. The process involves the farming of 'metal crops' on sub-economic deposits or industrial or mineral wastes to obtain valuable element(s) from their harvest biomass via the production of a 'bio-ore'. The demand for critical metals, including rare earth elements (REEs), platinum group elements (PGEs), nickel and cobalt, is more under pressure in the twenty-first century as a result of resource depletion and geopolitical factors. Agromining is expected to be transformative in the extraction of unconventional resources of these elements not accessible by traditional mining techniques.

This seminal book presents the complete chain of metal farming—'agromining'. It brings together for the first time individual contributions by active research scientists and practitioners currently engaged in fundamental and applied aspects of hyperaccumulator plants. The emergence of the great opportunities they present has taken several decades for acceptance, a fact which is discussed in detail in the introductory chapter. Further chapters address the agronomy of 'metal crops', the latest developments in the processing of bio-ores and associated products, the current state of knowledge on the global distribution and ecology of hyperaccumulator plants, biogeochemical pathways involved in the basic processes, the influence of rhizosphere microbes, as well as aspects of propagation and conservation of these unusual plants. It then summarizes the state of the art in new

tools for hyperaccumulator discovery and in the understanding of their physiology and molecular biology. The opportunities for incorporating agromining into rehabilitation and mine closure strategies are presented and ecosystem service provision and life cycle analysis discussed. The possibilities for agromining nickel, cobalt, manganese, selenium, arsenic, thallium, REEs and PGEs are discussed in separate case study chapters. Finally, an overview concludes the book, looking ahead to the prospects for the development of agromining in the future.

This book is edited and authored by pioneers in the field who have been at the forefront of the development of agromining over the past three decades. The book is timely, as agromining is now on a pivotal point in its development, with rapid expansion of activities in the field worldwide. As such, the book will be of significant interest to environmental professionals in the minerals industry, government regulators and academia.

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