



Climate change and surface mining: A review of environment-human interactions & their spatial dynamics



Jason Phillips ^{a, b, *}

^a Universidad EAN, Campus El Nogal: Cl 79 # 11-45. Sede Av. Chile: Cl 72 # 9-71, Bogotá, Colombia

^b Institute ForWARD, Edificio Parque Los Alpes, Calle 31E Transversal 71D, C103, Los Alpes, 130005, Cartagena de Indias, Colombia

ARTICLE INFO

Article history:

Received 16 April 2015
 Received in revised form
 29 December 2015
 Accepted 1 July 2016

Keywords:

Mineral resources
 Earth system
 Coupled dynamic relationship
 Impacts
 Pollution transport
 Resource security

ABSTRACT

How climate change interacts upon human activities necessary for meeting the needs of a society is important to understand. Mining is such an activity, as it provides the fundamental raw materials required in everyday life. However, mining is potentially extremely vulnerable to climate change. This is because of the exacerbation of interactions already occurring to the local environment-human system, as well as the development of new interactions and their subsequent impacts. Within the literature, there has been no generic review or synthesis of the fundamental interactions between climate change and surface mining. This paper intends to undertake such a review and synthesis of the literature. The paper discusses the potential and actual interactions between climate change and surface mining in relation to five core themes: Heavy Metals; Hydrological Processes & Resources; Ecological Impacts; Air Pollution; and Mass Movement. This is based upon an extensive and focussed review of the current and available literature. The paper then concludes with a discussion of open themes and future research concerning climate change and surface mining in relation to three fundamental spatial dynamic questions.

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* Universidad EAN, Campus El Nogal: Cl 79 # 11-45. Sede Av. Chile: Cl 72 # 9-71, Bogotá, Colombia.

E-mail address: jp1@tiscali.co.uk.

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1. Introduction

1.1. Scene-setting

Mining involves the extraction and processing of minerals, and the disposal of waste rock and by-products. In the case of a surface mining operation, as exemplified in Fig. 1, the mine and its processes, infrastructure and employees are all exposed to the local climate of the area. This means that surface mining is vulnerable to the effects of climate change.

The potential and actual interactions of climate change upon, and intensified by, mining are only now beginning to be evaluated and understood, e.g. Pearce et al. (2011); Prowse et al. (2009); Nelson and Schuchard (2014); Lin (2012); ICMM (2013). This is partly due to the fact that climate change may very well further exacerbate or cause new impacts upon the local environment and communities where mining operations are located. In addition, mining has importance to the local and national economy as a source of income, as well as a source of skilled employment, e.g. Canada, Australia, South Africa. And yet, it is an often neglected fact that in the case of surface mining, it is a climate-influenced activity. This is in relation to the extraction and processing of mineral resources, the health and safety of employees, and the potential and actual impacts upon the local community and wider area or region because of variations in climatic conditions. The advent of climate change science has brought to the forefront significant concerns. Specifically, over the potential and actual consequences of extreme variations to established weather patterns at all spatial-temporal scales.

The potential and actual interactions between climate change and surface mining have been, until recently, poorly understood and even neglected. This despite the relationship between the environment and humans being conceptualised as a coupled dynamic relationship, where feedbacks and synergisms occur between the two. This coupled relationship has been discussed by Schellnhuber (1998, 1999, 2001), Lovelock (1988, 2000, 2003), Rockström et al. (2009a, b) and Dearing et al. (2014), for example. Therefore, how climate change may and will interact with surface mining, or cause exacerbations of current impacts of mining, has become more important to begin to develop an understanding of. This represents a fundamental gap within the current literature. The current available literature could be described as ad hoc and sparse in nature. This has consequently resulted in the literature having no clear direction concerning the interactions between climate change and surface mining. In addition, case studies are examined and discussed without a larger contextual framework of climate change and surface mining. Having such a fundamental understanding and context of potential and actual interactions is therefore crucial. This will provide the ability to properly evaluate the significant potential and actual risks to the mining industry, the local community, and the local and national economy.

1.2. Purpose of paper

1.2.1. Overview

This paper is intended to provide a synthesis of the current available literature concerning the potential and actual fundamental interactions between climate change and surface mining. The term ‘interactions’ in this paper refers to the impacts and effects/consequences of climate change upon/by surface mining. Therefore, the paper is concerned with the fundamental issues which makes surface mining more vulnerable because of climate change, and their potential or actual impacts/consequences. In order to achieve this, the paper focuses on five core themes where climate change may/will have significant potential and actual interactions within a surface mining context. The core themes are (i). Heavy Metals; (ii). Hydrological Processes & Resources; (iii). Ecological Impacts; (iv). Air Pollution; and (v). Mass Movement. From these core themes, the paper will propose three fundamental spatial dynamic questions. The purpose of these questions is to provide a focus for research concerning the interactions between climate change and surface mining at all spatial-temporal scales.

1.2.2. Objective and limitations of the paper

The paper is primarily intended to provide a platform for further research to be conducted. This is based upon three fundamental spatial dynamic questions discussed in the final section of this paper. However, it should be pointed out in all fairness and honesty that this paper does not and cannot provide a definitive description of the potential and/or actual interactions between climate change and surface mining. The reason for this is because it is impossible to provide a comprehensive description of all of the potential and/or actual interactions. This is partly because many of the factors concerning the progression and outcomes of climate change are still unknown or unclear. Furthermore, the effects and progression of climate change will have interactions which are area-specific because of the nature and type of local environment-human system. As a consequence, how current or former surface mining operations in those areas may or will be affected, and impact upon the local area, does require a case-study approach. Therefore, the three questions, raised at the end of this paper, are intended to provide the foundations and focus for further research concerning the interactions between climate change and surface mining (past, present and future).

1.2.3. Literature selection

The available literature, which has been synthesised within this paper, is primarily focussed upon the local level impacts and consequences of surface mining. The literature cited in this paper has been chosen and evaluated with great care and attention. This is in order to provide the reader with a clear understanding of how climate change may and/or will interact with surface mining, and the resultant consequences upon the environment-human system. The synthesis also highlights where the current literature is

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