Available online at www.sciencedirect.com
ScienceDirect
Journal of Volcanology and Geothermal Research 169 (2008) 61–86
Journal of volcanology and geothermal research
www.elsevier.com/locate/jvolgeores

Research paper

The role of phreatomagmatism in a Plio-Pleistocene high-density scoria cone field: Llancanelo Volcanic Field (Mendoza), Argentina

Corina Risso [a,*], Károly Németh [b,c], Ana María Combina [d,e], Francisco Nullo [a,d], Marina Drosina [f]

[a] *University of Buenos Aires, FCEyN, Geology Department, University campus-Block 2, City of Buenos Aires (1428EHA), Argentina*
[b] *Volcanic Risk Solutions, Institute of Natural Resources, Massey University, PO Box 11 222, Palmerston North, New Zealand*
[c] *Volcanology Projects, Department of Mapping, Geological Institute of Hungary, Stefánia 14, H-1143, Budapest, Hungary*
[d] *CONICET, Argentina*
[e] *National University of San Luis, Chacabuco 917 (D5700BWS) San Luis, Argentina*
[f] *Halliburton Argentina S.A., Argentina*

Received 10 July 2006; accepted 6 August 2007
Available online 28 August 2007

Abstract

The Plio-Pleistocene Llancanelo Volcanic Field, together with the nearby Payun Matru Field, comprises at least 800 scoria cones and voluminous lava fields that cover an extensive area behind the Andean volcanic arc. Beside the scoria cones in the Llancanelo Field, at least six volcanoes show evidence for explosive eruptions involving magma–water interaction. These are unusual in the context of the semi-arid climate of the eastern Andean ranges. The volcanic structures consist of phreatomagmatic-derived tuff rings and tuff cones of olivine basalt composition. Malacara and Jarilloso tuff cones were produced by fallout of a range of dry to wet tephra. The Malacara cone shows more evidence for a predominance of wet-emplaced units, with a steep slump-slope characterized by many soft-sediment deformation structures, such as: undulating bedding planes, truncated beds and water escape features. The Piedras Blancas and Carapacho tuff rings resulted from explosive eruptions with deeper explosion loci. These cones are hence dominated by lapilli tuff and tuff units, emplaced mainly by wet and/or dry pyroclastic surges. Carapacho is the only centre that appears to have started with phreatomagmatic eruptions, with lowermost tephra being rich in non-volcanic country rocks. The presence of deformed beds with impact sags, slumping textures, asymmetrical ripples, dunes, cross- and planar lamination, syn-volcanic faulting and accretionary lapilli beds indicate an eruption scenario dominated by excessive water in the transportational and depositional regime. This subordinate phreatomagmatism in the Llancanelo Volcanic Field suggests presence of ground and/or shallow surface water during some of the eruptions. Each of the tuff rings and cones are underlain by thick, fractured multiple older lava units. These broken basalts are inferred to be the horizons where rising magma interacted with groundwater. The strong palagonitization at each of the phreatomagmatic cones formed hard beds, resistant to erosion, and therefore the volcanic landforms are well-preserved.

Keywords: phreatomagmatic; mafic; explosive; tuff rings; tuff cones; scoria; sideromelane; palagonite

* Corresponding author.
E-mail address: corina@gl.fcen.uba.ar (C. Risso).

0377-0273/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.jvolgeores.2007.08.007

1. Introduction

Monogenetic volcanoes are traditionally referred as those volcanoes that erupt only once during their eruptive history (Walker, 1993). They are small volcanoes and occur as scoria cones, tuff cones and rings, and maars (Vespermann and Schmincke, 2000). They form from typically short-lived single and brief eruptions commonly but not necessary through mafic volcanism. Monogenetic volcanic fields in continental settings are commonly dominated by scoria cones and associated lava spatter cones as well as extensive "aa" or "pahoehoe" lava flows. Many scoria cone fields, however, also contain volcanic landforms formed by phreatomagmatic explosive eruptions, such as the Pinacate Volcanic Field in Sonora, Mexico (Gutman, 2002). Since phreatomagmatic volcanoes such as maars and tuff rings are considered as the "wet" equivalent of scoria cones, the presence of such volcanoes in an otherwise "dry" eruption environment, especially a scoria cone field carries significant paleoenvironmental information of its evolution (Schmincke, 1977; Lorenz, 1985; Houghton and Schmincke, 1989; Büchel, 1993; Houghton et al., 1999).

High-density scoria cone fields are those containing large number of closely spaced scoria cones erupted over a relatively short period (e.g. large number of volcanoes per area). In well-drained areas with large volumes of near-surface and/or ground water, tuff rings and/or maar volcanoes form (Heiken, 1971; Martin and Németh, 2004). In other areas, where the magma/water interaction occurs within deeper sub-surface aquifers in fractured hard rock, maar volcanoes with deep craters may form (Aranda-Gomez and Luhr, 1996). The presence of subordinate phreatomagmatic volcanoes in a volcanic field could indicate variations in the physical conditions of the sub-surface stratigraphy of the volcanic field, or variation of the water saturation state of the sub-surface sediments or rock units over time (Aranda-Gomez and Luhr, 1996; Gutman, 2002). The total volume and/or type of vent and conduit derived country rock clasts of the pyroclastic rock units of these centres may help to understand the sub-surface stratigraphy of an otherwise lava-flow and scoria cone covered field. The abundance of accidental clasts from near-surface, fluvio-lacustrine clastic units could indicate a soft rock environment where phreatomagmatic volcanoes erupted and formed "champagne-glass" shape maar/diatremes (Lorenz, 2000, 2002).

Early studies of many volcanic fields commonly neglected the potential role of phreatomagmatism in their evolution. Revisiting of many volcanic fields has confirmed that phreatomagmatism was often a significant eruptive mechanism, which hence changes the perception of potential volcanic hazard for these. Here we present new evidence to highlight the importance of phreatomagmatism in the evolution of a high-density scoria cone field formed behind the Andean volcanic arc in Argentina. The Llancanelo Volcanic Field is among the largests by area and number of volcanoes behind the Andean arc in South America. The Plio-Pleistocene Llancanelo Volcanic Field has, up to now, been considered a scoria cone-dominated mafic volcanic field with extensive lava flows. Presented here are newly identified pyroclastic rocks suggesting a subordinate phreatomagmatic eruptive history of the field, with some volcanoes being dominantly formed through phreatomagmatic eruptions. Here we give a brief description of the eruptive history of the Llancanelo Volcanic Field and a detailed facies analysis. Description and interpretation of the newly identified phreatomagmatic pyroclastic successions demonstrate the importance of phreatomagmatism in the evolution of this area. We use tephra (tuff) ring and cone in a sense of the basic morphology and associated pyroclastic successions of the identified volcanic edifices. Tuff (tephra) rings here refer to low slope angle pyroclastic constructs with wide crater and typical pyroclastic succession dominated by pyroclastic beds rich in evidences of phreatomagmatic origin (e.g. angular, low vesicular pyroclasts commonly with larger volume of accidental lithic clasts). Tuff (tephra) cones (Verwoerd and Chevallier, 1987) here understood steep flanked, usually larger volume pyroclastic structures with smaller crater to base diameter ratios in comparison to tuff (tephra) rings. Tuff (tephra) cone pyroclastic successions are dominated by pyroclastic units with phreatomagmatic fragmentation history and small volumes of accidental lithic clasts. Transition from tuff (tephra) cones to larger volume pyroclastic cones formed by products of "dry" magmatic fragmentation is commonly continuous. Here we still use tuff (tephra) cone for pyroclastic constructs if they are volumetrically dominated by phreatomagmatic units. Usage of the term "sub-Plinian" eruptive styles here refers to those eruptions producing widespread and thick successions of tephra. Due to incomplete (or unexposed) pyroclastic units of the studied volcanic fields, more-specific quantification of distributional pattern of certain units, and therefore exact classification of certain eruption styles (e.g. sub-Plinian) was not possible.

2. Geologic setting

The Llancanelo Volcanic Field (Fig. 1A) is located in the south-eastern region of the province of Mendoza, Argentina, between latitudes 35° 39′ and 35° 50′ S and