New data from platinum group minerals (PGM) in placer deposits from Rio Condoto (Colombia) and Rio Santiago (Ecuador)

/ THOMAS AIGLSPERGER (1,), JOAQUÍN A. PROENZA (1), GABRIELA LÓPEZ (1), VARNADY ARBOLEDA (1)*

(1) Departament de Mineralogia, Petrologia i Geologia Aplicada. Facultat de Ciències de la Terra. Universitat de Barcelona. C/ Martí i Franquès, s/n. 08028, Barcelona, Catalunya (Spain)

INTRODUCTION.

Placer platinum-group minerals (PGM) ore deposits associated with the weathering of concentrically zoned, ultramafic intrusions at convergent margin settings (e.g. in Alaska and the Urals) were the dominant source for platinum-group elements (PGE) from the mid 18th century until the early 20th century (Cabri et al., 1996). Today, such small-scaled but PGE-rich "Alaskan"- or "Uralian"- type complexes are known from all five continents. They show a rather similar PGE mineralization of mainly Pt-Fe and Os-Ir-Ru-Pt alloys (<1 mm in diameter but occasionally reaching nugget size), that frequently host numerous inclusions of other mineral phases (Cabri et al., 1996). Two PGM placer occurrences are reported from northern South America (Fig. 1): (i) the Chocó district in Colombia hosting various placer deposits and (ii) the Esmeraldas province in Ecuador (Weiser, 2002; Weiser and Schmidt-Thomé, 1993; respectively).

Interestingly, the first mining activity of platinum by Spanish colonizers around 1750 started somewhere along the Pacific coast, either in today´s Ecuador or Colombia (García-Guinea and Gervilla, 2016). However, whereas the primary source of placer PGM in the Chocó area is confirmed by detailed surveys of nearby Alaskan-type intrusions (e.g. Salinas et al., 1992; Tistl, 1994), such confirmation is still missing in the case for PGM found in the Esmeraldas province.

This study aims to enlarge the mineralogical data base for placer PGM from the Rio (Spanish word for river) Condoto (Colombia) and the Rio Santiago (Ecuador) as well as to gain new insights regarding the geochemical fingerprints of placer PGM from northern South America.

fig 1. *Satellite image showing the location of the study areas Rio Condoto and Rio Santiago in Colombia*

STUDY AREAS.

Colombia

The Rio Condoto (l≈50 km; E-W) is located in the Chocó district (~47 000 km²) and rises in the Cordillera Occidental approximately 120 km to the east at half height of the Pacific coast of Colombia (Fig. 1). The region is characterized by dense rain forest, tropical climate with temperatures averaging ~26°C and intense rainfall.
The primary PGE mineralization derives from the so-called Alto Condoto, a zoned ultramafic complex reaching an altitude of ~1800 m that hosts euhedral crystals of up to mm-sized Pt-Fe alloys in the dunitic core of the intrusion (Salinas et al., 1992). According to Tistl (1994) a similar but different type of primary PGE mineralization (Pt-Fe alloys often intergrown with chromite) occurs in serpentinized peridotites approximately 15 km downstream in addition. Mostly artisanal mining operations are carried out along the Rio Condoto extracting a total of approximately 1t Pt per year (Valois-Cuesta and Martínez-Ruiz, 2016).

Ecuador

The Rio Santiago (l≈100 km; SE-NW) is located in the Esmeraldas province in the northwest of Ecuador (Fig. 1). The area hosts several placer deposits of local economic importance.
Due to challenging conditions for field work (tropical vegetation), the primary source of the PGE mineralization has not yet been found. However, a detailed survey of PGM (mostly Pt-Fe alloys) in the study area points to an unknown, mafic-ultramafic Alaskan-type intrusion

palabras clave: Elementos del Grupo de Platino (EGP), Minerales de Elementos del Grupo de Platino (MGP), Placeres, Colombia, Ecuador

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* corresponding author: **thomas.aiglsperger@ub.edu**

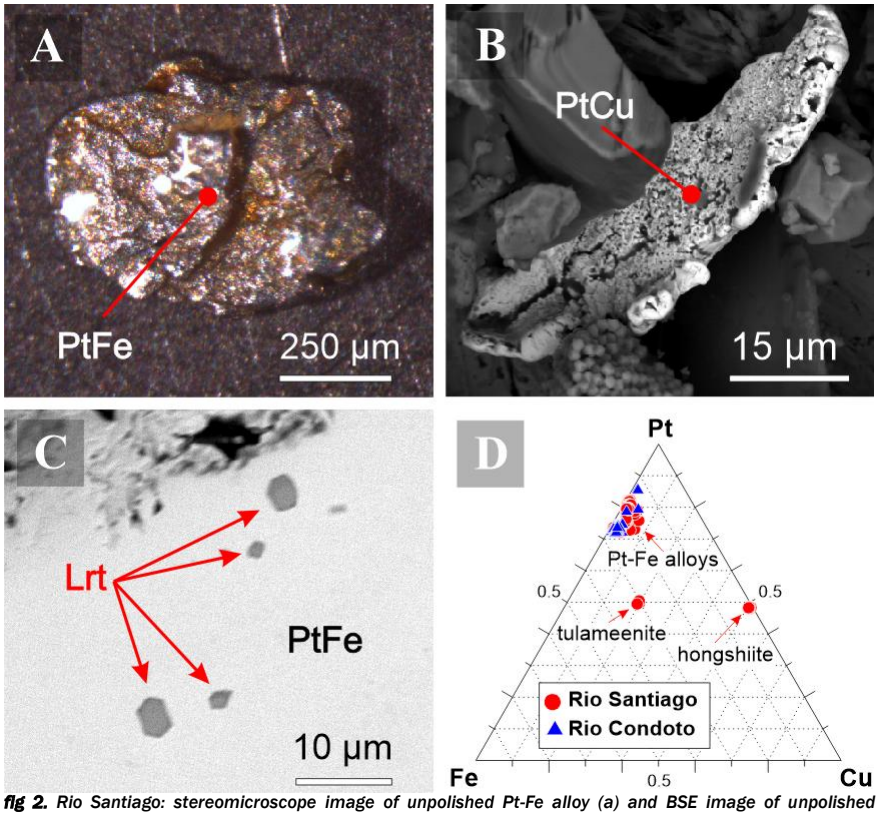

fig 2. *Rio Santiago: stereomicroscope image of unpolished Pt-Fe alloy (a) and BSE image of unpolished hongshiite (b). Rio Condoto: BSE image close-up of a polished grain of Pt-Fe alloy with inclusions of laurite (c.) Pt-Fe-Cu ternary showing the dominant compositions of Pt-bearing alloys in both study areas.*

that is feeding the placers (Weiser and Schmidt-Thomé, 1993).

SAMPLES AND METHODS.

Samples from both study areas were collected, pre-concentrated via traditional panning by local miners and sent to the University of Barcelona (UB) for further examination. Whereas direct handpicking of PGM was possible in the case of the sample from the Rio Condoto, hydroseparation techniques (www.hslab-barcelona.com) were applied to the sample from the Rio Santiago. PGM recognized under the steromicroscope were mounted on a metallic cylinder and first studied via scanning electron microscopy (SEM) at the CCiT-UB (Spain). Subsequently, the PGM monolayers were included in epoxy, polished and analysed with an electron microprobe (EMP) at the same institution.

RESULTS.

Pt-Fe alloys of rounded shapes and maximum length axes of up to 2 mm are the most abundant PGM found in both study areas (Fig. 2a). Furthermore, Cu-rich Pt-alloys such as hongshiite (Fig. 2b) and tulameenite are observed in the sample from the Rio Santiago. Inclusions of euhedral crystals of laurite (Fig. 2c), kashinite, cooperite, irarsite, chengdeite, lamellae of native osmium and several unidentified PGM inclusions occur in Pt-Fe alloys from Rio Condoto. On the other hand, cuprorhodsite and unidentified Rh-rich (10 at.%) and Ru-bearing (up to 4 at.%) Pt-Fe-Cu sulphides are present in Pt-Fe alloys from the Rio Santiago. Preliminary results suggest that Pt-Fe alloys from the Rio Santiago show in general slightly higher contents of Rh, Cu, and Pt, but lower contents of Fe-+Cu+Ni when compared in at.% to Pt-Fe alloys from the Rio Condoto. However, a detailed survey of numerous quantitative analyses from single grains demonstrates that the chemical composition of a single Pt-Fe alloy grain can be rather heterogeneous, which has to be considered when comparing results. An overview of the composition of Pt-Fe alloys in the Pt-Fe-Cu ternary is shown in Fig. 2d.

DISCUSSION AND CONCLUSIONS.

Aside from the excellent previous works on PGM from the Rio Condoto by Cabri et al. (1996) and from the Rio Santiago by Weiser and Thomé (1993) no further PGM-related studies were carried out in neither of both study areas. Hence, this study provides important additional data from these PGM placers in Ecuador and Colombia. Whereas the primary source of PGE mineralization for the formation of placer deposits in the Rio Santiago remains unknown, the discovery of tulameenite gives further support for the hypothesis of a nearby Alaskan-type intrusion, as suggested by Weiser and Thomé (1993).

The observation of chemically heterogeneous Pt-Fe alloys may point to post-magmatic modifications at low temperatures. However, in general our results suggest that Pt-Fe alloys from the Rio Santiago can be distinguished from those from the Rio Condoto, e.g. by slightly different Rh, Cu, Fe and Pt contents.

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