

Accepted Manuscript

The Palaeocene Cerro Munro tonalite intrusion (Chubut Province, Argentina): A plutonic remnant of explosive volcanism?

C. Rodríguez, E. Aragón, A. Castro, R. Pedreira, A. Sánchez-Navas, J. Díaz-Alvarado, F. D'Eramo, L. Pinotti, Y. Aguilera, C. Cavarozzi, M. Demartis, I.R. Hernando, T. Fuentes

PII: S0895-9811(17)30062-7

DOI: [10.1016/j.jsames.2017.06.002](https://doi.org/10.1016/j.jsames.2017.06.002)

Reference: SAMES 1716

To appear in: *Journal of South American Earth Sciences*

Received Date: 21 February 2017

Accepted Date: 7 June 2017

Please cite this article as: Rodríguez, C., Aragón, E., Castro, A., Pedreira, R., Sánchez-Navas, A., Díaz-Alvarado, J., D'Eramo, F., Pinotti, L., Aguilera, Y., Cavarozzi, C., Demartis, M., Hernando, I.R., Fuentes, T., The Palaeocene Cerro Munro tonalite intrusion (Chubut Province, Argentina): A plutonic remnant of explosive volcanism?, *Journal of South American Earth Sciences* (2017), doi: 10.1016/j.jsames.2017.06.002.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.



1 The Palaeocene Cerro Munro tonalite intrusion
2 (Chubut Province, Argentina): a plutonic remnant of
3 explosive volcanism?

4 Rodríguez, C.⁽¹⁾, Aragón, E.^(2,5), Castro, A.⁽¹⁾, Pedreira, R.⁽³⁾, Sánchez-Navas,
5 A.⁽⁴⁾, Díaz-Alvarado, J.⁽⁶⁾, D'Eramo, F.⁽⁷⁾, Pinotti, L.⁽⁷⁾, Aguilera, Y.⁽⁵⁾, Cavarozzi, C.⁽⁵⁾,
6 Demartis, M.⁽⁷⁾, Hernando, .I. R.^(2,5), Fuentes, T.^(2,5)

7 ¹ *Departamento de Ciencias de la Tierra, Universidad de Huelva, Campus El Carmen, 21071*
8 *Huelva, Spain.*

9 ² *Facultad de Ciencias Naturales y Museo (UNLP). 122 y 60, s/n. (1900), La Plata, Buenos Aires.*
10 *Argentina.*

11 ³ *Département des sciences appliquées, Unité d'enseignement en sciences de la Terre, 555*
12 *Boulevard de l'Université (G7H 2B1), Chicoutimi, Québec, Canada.*

13 ⁴ *Departamento de Mineralogía y Petrología. Universidad de Granada, Spain.*

14 ⁵ *Centro de Investigaciones Geológicas, UNLP-CONICET, Calle 1 N° 644 (1900) La Plata,*
15 *Argentina.*

16 ⁶ *Departamento de Geología, Universidad de Atacama, Copayapu 485, Copiapó, Chile.*

17 ⁷ *Departamento de Ciencias Geológicas, UNRIV, Río Cuarto, Argentina.*

18

19 **KEYWORDS**

20 Calc-alkaline magmatism, tonalites, autoliths, fractionation,
21 cathodoluminescence

22

23 **ABSTRACT**

24 The Cerro Munro sub-volcanic intrusion is emplaced in the back-arc (400 km from the
25 trench) as small sub-circular tonalite-granodiorite plutons with abundant radial

26 porphyritic dikes. U-Pb zircon SHRIMP data give an age of crystallization of 57 Ma
27 ± 1.4 Ma. It is located to the east of the North Patagonian Batholith (NPB) that shows a
28 protracted and episodic magmatic history from Cretaceous to Miocene time. The NPB
29 Palaeogene episode is characterized by the lack of magmatic activity at the arc axis, as
30 small plutonic emplacements move to the fore-arc and back-arc. This Palaeogene
31 tectono-magmatic episode is ruled by the detachment of the Aluk plate during the Aluk-
32 Farallon-SAM triple junction, active at that time along northern Patagonia active
33 margin, changing the Cretaceous “NPB orogenic” setting to a Palaeogene “Munro
34 transitional” tectono-magmatic setting. Near the contacts, the tonalite contains abundant
35 enclaves of igneous appearance and variable size from several cm to dm, described as
36 autoliths. The study of autoliths and host tonalite reveals interesting results on the
37 processes of fractionation in a thermally zoned magma chamber. Autoliths, and in a
38 large extent the host tonalite, represent disguised cumulates from which a hydrous
39 silicic liquid was extracted. Barometry calculations from mineral chemistry in both
40 autoliths and tonalites record a shallow pressure of emplacement of 0.5 kbar. Rhyolite-
41 dacite flows and ignimbrites, surrounding the northern contact of the Cerro Munro
42 tonalite, may represent the exsolved liquid from the plutonic cumulates. The study by
43 cathodoluminescence and electron backscattered diffraction techniques from a rhyolite-
44 hosted quartz supports this protracted history of the Cerro Munro magma chamber.

45 **1. Introduction**

46 The connection between volcanic and plutonic rocks is nowadays subject of
47 discussion due to their implications in understanding deep-seated processes observed in
48 magmatic rocks (Bachmann and Bergantz, 2004; Bachmann and Bergantz, 2008;
49 Bachmann et al., 2007; Deering et al., 2016; Frost et al., 2016; Gelman et al., 2014;

50 Glazner et al., 2008; Lipman and Bachmann, 2015). Recently, granites have been
51 described as cumulate rocks formed by crystallization and expulsion of an interstitial
52 liquid (Lee and Morton, 2015; Vernon and Collins, 2011). Many felsic plutons have
53 been interpreted as the potential residues of rhyolitic eruptions (Bachmann and
54 Bergantz, 2004; Bachmann and Bergantz, 2008; Deering and Bachmann, 2010). The
55 retained liquid in the cumulate corresponds only to the terminal porosity (20-30%,
56 (Donev et al., 2004) and consequently, it can be difficult to recognize cumulate features
57 in these rocks, except for the textures (Lee and Morton, 2015). Because of the high
58 viscosity of silicic systems and its consequent inability to expel the interstitial liquid by
59 gravity forces (Glazner, 2014), the melt-segregation remains obscure. Water decreases
60 the viscosity of melts, and bubbles can favour its mobility allowing the residual liquid
61 expulsion in these silicic magma chambers or ascent conduits (Boudreau, 2016; Lee et
62 al., 2015; Pistone et al., 2015).

63 The North Patagonian Batholith (NPB) is an excellent example to study
64 magmatic processes regarding the volcanic-plutonic connection. The NPB shows a
65 protracted and episodic magmatic history from Cretaceous to Miocene time. The NPB
66 Palaeogene episode is characterized by the lack of magmatic activity at the arc axis, as
67 small plutonic emplacements move to the fore-arc and back-arc. This Palaeogene
68 episode is ruled by the detachment of the Aluk plate during the Aluk-Farallon-SAM
69 triple junction development along northern Patagonia, changing the “orogenic” setting
70 to a “transitional” tectono-magmatic one. The Cerro Munro tonalite is an 8 km
71 diameter, lens-shaped body intruding into Carboniferous-Permian sediments from the
72 Tepuel Group (Lower Jurassic) and is surrounded by silicic volcanic and volcanoclastic
73 rocks at its northern boundary. This tonalitic body is characterized by the presence of
74 abundant enclaves with variable shapes varying from irregular and angular to rounded,

75 the smallest ones showing the more rounded shape. The tonalite shows coarse-grained
76 texture and its enclaves have finer grain size.

77 Here we show a geochemical and petrological characterization for the Cerro
78 Munro magmatic system and we investigate the possible implications on calc-alkaline
79 magmatism. As a whole, the Cerro Munro intrusion is zoned and ranges from dioritic to
80 tonalitic compositions from east to west. Geochemical trends of the tonalite and
81 enclaves follow typical calc-alkaline patterns. Paired samples of enclaves and host
82 tonalites were collected in order to discriminate between local- and pluton-scale
83 processes of magma fractionation. The study of these rocks reveals interesting results on
84 the processes of magma differentiation in thermally zoned magma chambers or ascent
85 conduits. Enclaves and, to a large extent, the host tonalite, represent disguised
86 cumulates from which a hydrous silicic liquid was extracted, while rhyolite-dacite flows
87 and ignimbrites hosting the Cerro Munro tonalite, may represent the exsolved liquid
88 from the plutonic cumulates.

89 Detailed observation of igneous textures are key factors in recognizing the
90 “missing” cumulates, needed to generate silicic plutons (Lee and Morton, 2015).
91 Complementary tools to address this problem as geochemical modelling can be useful
92 to clarify the process accounting for silicic differentiation, as *in-situ* crystallization
93 (Langmuir, 1989; Lee and Morton, 2015).

94 On the other hand, cathodoluminescence techniques in quartz found in volcanic
95 and plutonic rocks have clearly proved to be useful in recording magmatic processes as
96 rejuvenation, mingling and recharge of magma chambers (Beane and Wiebe, 2012;
97 D'Lemos et al., 1997; Matthews et al., 2012; Matthews et al., 2011; Wiebe et al., 2007).
98 Here we show the recorded history in volcanic quartz of the Cerro Munro magma
99 chamber, directly related to the plutonic counterparts in this work.

100 2. Geological setting

101 Further east of the Patagonian Andes, several small size plutons (5 to 10 km
102 diameter) known as the Munro, Menucos, Tepuel and Kanquel plutons with upper
103 Cretaceous-Palaeocene K-Ar age, have been mapped as Aleusco Formation (Turner,
104 1982). The original work of Turner (1982) included the outcrops of the Aleusco locality,
105 which now are known to be of early Jurassic age (Haller et al., 1999; Rapela et al.,
106 2005). Since the denomination of Aleusco is now used to describe the early Jurassic
107 granitoids of the area (Haller et al., 1999; Rapela et al., 2005) and correlate this unit to
108 the Jurassic Subcordilleran plutonic belt, we preferred to use the denomination of Cerro
109 Munro system to describe the Palaeocene granitic rocks of this area, to avoid any
110 confusion.

111 The plutonic rocks from the Cerro Munro intrude Carboniferous-Permian
112 sediments of Tepuel Group, lower Jurassic sediments of the Lepá Formation, Granitoids
113 of the early Jurassic Subcordilleran plutonic belt (Haller et al., 1999; Rapela et al.,
114 2005), and Gabbros of the Tecka Formation (Turner, 1982). In turn, they are intruded
115 and covered by volcanic rocks of the Cautiva Complex (Spikermann, 1978; Turner,
116 1982). The age of La Cautiva Complex volcanic rocks that intrude the Menucos Pluton
117 have a K/Ar age of 54 ± 3 Ma (Turner, 1982). The Cautiva Complex on the regional
118 context is included in the Eastern Palaeocene Volcanic belt (EPEB) (Rapela et al., 1987).
119 Most radiometric K/Ar ages of the EPEB range from 60 to 42 Ma (Rapela et al., 1983).
120 The EPEB is a bimodal volcanism rhyolite-basalt, where rhyolites and dacites
121 predominate as large ignimbrite plateaux and subordinate domes and lava flows (Aragón
122 and Mazzoni, 1997; Rapela et al., 1987), suggesting an ignimbrite flare-up. The basalts
123 are tholeiitic and alkalic (Aragón et al., 2011). To the west of the EPEB a second and
124 younger volcanic belt known as Western Oligocene Volcanic belt (WOB) define a

125 typical calc-alkaline association (Fig. 1; Rapela et al., 1987; Rapela et al., 1983). The
126 WOB volcanic rocks also start as dacite-rhyolite flows and ignimbrites. The top of the
127 sequence is mostly andesitic to basaltic, and shows a range of K/Ar radiometric ages of
128 24 to 33 Ma (Rapela et al., 1987). Coeval to the WOB but on the former fore-arc is the
129 Coastal Volcanic belt (CVB; Muñoz et al., 2000) having basalts of primitive
130 composition.

131 Both volcanic belts (EPEB and WOB) have late basaltic flows with OIB affinity
132 (Aragón et al., 2005; Kay and Rapela, 1987), and are the eastern and western boundaries
133 of the Ñirihuau basin (Cazau et al., 1989; Spalletti, 1983). The extent of the extensional
134 tectonic setting with the development of fore-arc, arc and back-arc basins reached its
135 maximum in the Oligocene (Giacosa and Heredia, 2004; Jordan et al., 2001; Mancini
136 and Serna, 1989; Rapela et al., 1987; Rapela et al., 1983; Silvestro and Zubiri, 2008).

137 To the west of the Cerro Munro system, and running along the main cordillera of
138 the Patagonian Andes is the North Patagonian batholith (Fig. 1). This large magmatic
139 system shows a protracted and episodic plutonic activity with a complex distribution
140 (Pankhurst et al., 1999). These authors used detailed Rb-Sr geochronology to show that
141 plutonic emplacement spanned from 140 Ma to 9 Ma. The age's distribution show that
142 plutonism is episodic, having a severe decrease of plutonism during the Palaeogene,
143 besides, the few plutons are Eocene and migrated to the west of the main mid-
144 Cretaceous batholith axis, constrained to the major Liquiñe-Ofqui fault zone. Finally, the
145 continuous plutonic emplacement in the arc axis is recovered in the Miocene, but these
146 magmas are relatively primitive in terms of their isotopic composition.

147 The South Patagonian batholith (Hervé et al., 2007) has a similar time-space
148 zonation and geochemical evolution with respect to the North Patagonian batholith.

149 Aragon et al., 2011 showed that for the Palaeogene time, the southward
150 migration of the Farallon-Aluk-SAM triple junction with a highly oblique Farallon plate
151 convergence, has unzipped the subducted Aluk plate, developing a transform plate
152 margin with a slab-window as the Aluk plate was detached. This situation has also been
153 proposed to explain the NPB, EPEB, WOB and CVB time-space distribution changes.
154 From this perspective, the tectono-magmatic setting of the typical Cretaceous and
155 Miocene NPB magmatism is “*Orogenic*”. Instead the Palaeogene igneous episodes in
156 the NPB, EPEB, WOB and CVB are considered to be “*Transitional*” between the
157 “*Orogenic*” and “*Within Plate*” tectono-magmatic settings.

158 **3. The Cerro Munro tonalite**

159 The Cerro Munro body is made of Palaeocene epizonal granitic rocks. In the
160 original description, these palaeocene plutonic rocks are included in the Aleusco
161 batholith (Spikermann et al., 1988; Spikermann et al., 1989). These authors recognized
162 two plutonic episodes: a main phase to the north and a late phase to the south. Although
163 Spikermann et al. (1988), obtained a Jurassic age (K/Ar) for the northern Main plutonic
164 phase, they rejected this age in favour of the more frequent Palaeocene ages (K/Ar ages;
165 Spikermann, 1978; Turner, 1982) of the Late plutonic phase in the southern outcrops.
166 Recent K/Ar ages (Haller et al., 1999) and U/Pb SHRIMP zircon ages (Rapela et al.,
167 2005) have demonstrated the northern Main plutonic phase belongs to the Jurassic age
168 and these authors have reassigned the Aleusco Formation to the Jurassic and correlated
169 the granitoids to the Jurassic Subcordilleran belt. Therefore, in this paper we introduce
170 the denomination of Cerro Munro system for the Palaeocene southern granitoid
171 outcrops (Fig. 1).

172 The Cerro Munro tonalite has pale grey to pink medium grained rocks that
173 comprise granodiorites/quartz-monzodiorites with subordinate tonalites/diorites and
174 granites. The plutons have abundant round dark inclusions of a fine grain size (mafic-
175 rich enclaves), irregular patches and dikes of micro-leucogranites (graphic and
176 miarolitic), dikes of aplites, and abundant porphyritic dikes of andesitic and rhyolitic
177 composition arranged in radial geometry.

178 The detailed study of the example of Cerro Munro intrusion (listed as 1 in Fig.
179 1) is exposed in this work. The emplacement structure is well exposed. This is a sub-
180 circular body with a major axis trend of N 35° W, with a diameter of 8 km for the Cerro
181 Munro pluton (Fig. 2). Late stage porphyritic radial dikes are arranged towards the rims
182 of the bodies, but do not cut the surrounding country rocks. The Cerro Munro body
183 shows on the northern side an intrusion of Tertiary sub-volcanic rocks and is cut by
184 basaltic to trachyandesitic dikes. Abundant microgranular of igneous appearance and
185 variable size from several cm to dm and scarce leucocratic enclaves characterize Cerro
186 Munro intrusion (Fig. 3). Henceforth, enclaves are referred as autoliths because of its
187 igneous relation to the Cerro Munro tonalite and their common provenance of a unique
188 magmatic system.

189 **4. Sampling and analytical techniques**

190 Sampling on Cerro Munro body was arranged to cover a wide range of diverse
191 tonalites, its respective autoliths and the volcanic rocks. Autolith shapes vary from
192 irregular and angular to rounded, the smallest showing the more rounded shape (Fig. 3a
193 and b). The tonalite shows coarse-grained texture (Fig. 3c) increasing from the contact
194 inwards and its autoliths have finer grain size (Fig. 3d).

195 Approximately 3 kg of fresh rock was collected from tonalites and was crushed

196 and milled to a fine powder for whole-rock geochemistry. In the case of autoliths, the
197 entire sample was completely crushed, except fragments for the petrographic study.
198 Major elements were determined by X-ray fluorescence (XRF) at the CIC (University
199 of Granada, Spain). Precision for major elements is better than 1%. Trace elements were
200 obtained by inductively coupled plasma mass spectrometry (ICP-MS) at the University
201 of Granada, following the standard procedures described by Baedecker (1987). Analysis
202 of trace elements was carried out according to the method described by Bea et al.
203 (1996); the precision was approximately 2% and 5% error on concentrations of 50 and 5
204 ppm, respectively. Thin sections of intrusive samples were polished and subsequently
205 analysed in order to determine the composition of major elements in mineral phases
206 using a JEOL JXA-8200 Superprobe at the University of Huelva (Spain). A
207 combination of silicates and oxides were used for calibration. A defocused beam of 10-
208 μm diameter was used to analyse glasses to minimize Na migration. For the EBSD and
209 cathodoluminescence study, the sample was cut and polished with silica gel, and
210 subsequently analysed structurally.

211 **5. Whole-rock geochemistry of Cerro Munro intrusive and related volcanic** 212 **rocks**

213 Seventeen samples of tonalites, related autoliths, porphyry dykes and host rocks
214 were collected in fresh outcrops. Tonalites and autoliths show a silica range from $\text{SiO}_2 =$
215 57 to 65 wt% (Table 1 and Fig. 4). Both tonalites and autoliths are magnesian and calc-
216 alkalic according to the Peacock index (Fig. 4a and b). Autoliths are metaluminous (Fig.
217 4c) and have a narrow silica range (SiO_2 : 57-58 wt%, except autoliths from A312-36)
218 whilst tonalites are slightly peraluminous. A systematic correlation between autolith-
219 host pairs was found (Fig. 4). Considering the autolith-tonalite pairs separately, there is

220 a marked silica gap about 7 wt% SiO₂ (Fig. 4). The relation of molar ratio
221 K₂O/(K₂O+CaO) vs K₂O (Fig. 5a) of tonalites and autoliths coincides with a typical
222 calc-alkaline trend of Cordilleran batholith. However, Mg# maintains high values as
223 silica content increases (Fig. 5b), moving away from the calc-alkaline differentiation
224 pattern. Preferentially, autoliths have dioritic compositions while their host-rock
225 belongs to the grano-tonalite field (Fig. 5c). Also, in this diagram we can appreciate
226 enrichment in the molar ratio K₂O/(K₂O+CaO) regarding the fractionation trend of
227 Patagonian Batholith. In the Mg# vs MgO (wt%) diagram (Fig. 5d), it can be observed
228 that the flat pattern of the variation of Mg# should be explained by FeO depletion for
229 the Mg-poorer samples. This impoverishment is accompanied by a further depletion in
230 CaO (wt%), separating the Cerro Munro differentiation path from the cotectic line
231 marked by the Patagonian Batholith (Fig. 5e). Cpx and Fe-oxides fractionation can
232 explain this detachment from the calc-alkaline cotectic line, due to a FeO and CaO
233 impoverishment. More-depleted ends correspond to tonalites whereas autoliths show a
234 scattered pattern (Figs. 4 and 5).

235 REE diagrams (Fig. 6) show slight differences between autoliths and the host
236 tonalites, except for the case of the tonalite A312-36 (Fig. 6c), whose autoliths evidence
237 a wide range of compositional variation between themselves and regarding the host
238 tonalite. Autoliths A312-36b and c are the more primitive ends whereas the autolith 36a
239 and the tonalite A312-36 are the more evolved ends, showing an amphibole or
240 clinopyroxene fractionation pattern. For samples A312-33 and 33a the correlation is
241 similar, the autolith becoming richer in heavy REE and the tonalite following an Amp
242 or Cpx fractionation pattern (Fig. 6b). These REE pattern support a double fractionation
243 process resulting in autolith and tonalites from Cerro Munro intrusion.

244 **6. Petrography of the Cerro Munro tonalite and related autoliths**245 *Tonalites*

246 These are medium-grained, mesocratic and homogeneous rocks composed of Pl,
247 Amp, Kfs, Qz, Opaques, Bt, ± Cpx as essential minerals. Accessory minerals are Ap,
248 Zrn, Allantite and Sphene (Fig. 7).

249 Plagioclase appears as euhedral to subhedral crystals, complexly zoned with
250 patches and oscillatory bands (Fig. 7a), ranging in composition from An 0.5 at the cores
251 to An 0.18 near the rims (Table 2 and Fig. 8a). Plagioclase cores show patching zoning
252 and are surrounded by finely oscillatory layers in which resorption surfaces may be
253 present (Fig. 7a). Patching zoning cores may contain tiny inclusions of pyroxene (Fig.
254 7a). Plagioclase crystals form an interlocked framework and cumulate textures (Fig. 7b)
255 in which quartz and occasionally K-feldspar occupy the interstices giving rise to graphic
256 texture.

257 Amphiboles tend to form euhedral crystals, partially moulded by plagioclase
258 (Fig. 7c). Note that amphibole is not present as inclusion in tonalites, showing features
259 of an early phase precipitated from a water-rich magma (Fig. 7d). They range in
260 composition from Mg-hornblende to actinolite (Table 3 and Fig. 8b) and contain
261 inclusions of Ilm and Ti-Mt (Table S1). Actinolite occurs often at the rims of amphibole
262 crystals in autoliths (Table 6 and Fig. 8b). Amphibole also may appear forming
263 polycrystalline aggregates (Fig. 7d).

264 Clinopyroxene (Mg# = 0.75; Table 4 and Fig. 8c) is partially transformed to
265 amphibole and it occurs as both inclusion and relict cores (Fig. 7a and c).

266 Biotite (Mg# = 0.66, Table S2) appears as subhedral and anhedral crystals, in
267 some cases, partially chloritized, and with inclusions of apatite, zircon and opaques
268 (Fig. 7a and d). Fluorapatite, with up to 4.8 wt% of F, shows euhedral habit and also is

269 included in Amp and Pl crystals. Garnet (grossular) is present as an accessory mineral in
270 some samples of tonalites.

271 *Autoliths*

272 These are fine-grained rocks formed by the same similar assemblages than the
273 host tonalite, except for the presence of Opx and the greater abundance of Cpx. Subtle
274 differences in textures and modal abundances are found in comparison with the tonalite.
275 Plagioclase shows habit euhedral (Fig. 9) and zoning, ranging the composition from An
276 0.67 at the core to An 0.16 (Table 5, Fig. 8a). Amphibole (from Mg-Fe-hornblende to
277 actinolite; Table 6, Fig. 8b) tends to form acicular phenocrysts (Fig. 9a) and, together
278 with magnetite (Ti-Mt; Table S1), are slightly more abundant with respect to the host
279 tonalite. The early crystallization of amphibole can be evidenced by their preferential
280 growth regarding the plagioclase (Fig. 9a). Amphibole polycrystalline aggregates may
281 be present (Fig. 9b). Plagioclase and amphibole result in polycrystalline frameworks,
282 leaving the interstices occupied by Kfs and Qz (Fig. 9c and d). Fluorapatite has an
283 acicular habit (Fig. 9c). Clinopyroxene (Table 7, Fig. 8c) is present as inclusion in Pl, as
284 relict core in Amp and forming subhedral crystals with oxide inclusions (Fig. 9d).
285 Orthopyroxene (Table 7) appears as relict core in amphibole crystals and as inclusion in
286 Pl. Autoliths mineralogy suggests a greater pressure for the magmatic source, at which
287 the clinopyroxene and orthopyroxene can be stable.

288 Garnet (grossular) is only present in the autolith A312-36a, being the autolith
289 more similar to tonalites regarding its geochemistry and petrography.

290 **7. U-Pb SHRIMP zircon geochronology: sample description and results**

291 *5.1. Methodology*

292 One sample of the intrusive rocks was selected with caution to avoid the
293 marginal zones of the pluton and was analysed for zircon geochronology. Sample
294 C.2011-11 from the Cerro Munro tonalite (Location 43° 12.86'S 70° 16.64'W; Fig. 2) is
295 a fine-grained biotite-hornblende granodiorite. The texture is subidiomorphic and the
296 modal mineralogy includes zoned plagioclase, hornblende, biotite and interstitial quartz
297 and K-feldspar, with some cases of perthitic and graphic textures. The rock has abundant
298 inclusions of fine-grained mafic rich enclaves. Apatite, titanite, zircon and opaque
299 minerals are present as accessory minerals.

300 The sample (C.2011-11) selected for the geochronological study, was crushed
301 and milled to a medium and fine grain fraction at the National University of La Plata
302 (Argentina). Zircon separation was accomplished at the University of Huelva by
303 traditional techniques using dense liquids and magnetic separation (Frantz). Selected
304 crystals free of impurities and fractures were selected by hand-picking with a binocular
305 lens.

306 Analyses were carried out in the SHRIMP II microprobe at Beijing SHRIMP
307 Center. Analytical procedures are as follows. Zircon grains were mounted in epoxy,
308 together with reference standards SL13 (U=238) and TEMORA ($^{206}\text{Pb}/^{238}\text{U}=0.06683$),
309 and polished. Sectioned zircons were studied by CL imaging for selection of point
310 analyses. The mounts were then cleaned and coated with high-purity Au. Core and rims
311 were analysed in several grains of each individual sample with the aim of identifying
312 inherited cores. These selected points were target over the CL images and analysed for
313 U-Th-Pb isotopes with SHRIMP II at the Beijing-SHRIMP Center (Chinese Academy
314 of Geological Sciences, Beijing), following methods given in (Williams, 1998) and
315 references therein. A 10 kV negative O₂ primary beam was focused to c. 20 mm
316 diameter. Positive secondary ions were extracted at 10 kV and mass analysed at c.

317 R5000 on a single ETP multiplier by peak stepping through the isotopes of interest.
318 Analytical uncertainties are 1s precision estimates. All the analyses listed and plotted
319 were corrected for common Pb using the measured ^{204}Pb and a common Pb composition
320 appropriate to the age of each spot (Cumming and Richards, 1975). Concordia ages
321 have been calculated with ISOPLOT 3.0 software (Ludwig, 2003). Uncertainties are
322 95% confidence limits ($t\sigma$, where t is the student's t multiplier) and include the
323 uncertainty in the Pb/U calibration (ca. 0.3 – 0.5%). Ages were calculated with λ errors
324 and MSWD was determined using Concord. + Equiv. Ages were calculated using the
325 constants recommended by the IUGS Subcommittee on Geochronology (Steiger and
326 Jäger, 1977).

327 *5.2. U-Th-Pb geochronology results*

328 The sample from Cerro Munro (C.2011-11) intrusive body was analysed for U-
329 Th-Pb in the SHRIMP II microprobe at Beijing SHRIMP Center. Zircon populations
330 (Fig. 10) are euhedral to subhedral medium-large crystals (120-300 μm). CL images
331 show simple internal structures in zircons, with parallel-banded zoning in more
332 elongated crystals and concentric or absent zoning in less acicular zircons (Fig. 10a).
333 Th/U ratios are comprised between 0.6 and 1.56, mostly higher in C.2011-11 sample,
334 showing no relation with U-Pb ages. Location of sample is given in Fig. 2. Analytical
335 results are listed in Table 8. Analysed zircon crystals and spots from each sample are
336 shown in Fig. 10 together with concordia diagrams. We can distinguish between
337 acicular crystals, with parallel-banded zoning, and flattened zircons with a very weak or
338 absent zoning pattern (Fig. 10). Ten analyses with $^{206}\text{Pb}/^{238}\text{U}$ ages between 59.6 ± 2.7
339 and 53.8 ± 2.1 Ma, yield a concordia age of 57.1 ± 1.4 Ma (MSWD=0.7).

340 8. Cathodoluminescence and EBSD study in volcanic quartz

341 In order to know the volcanic process generating rhyolite dikes hosted in Cerro
342 Munro tonalite, textural analysis was performed in Qz phenocrysts from a rhyolitic
343 porphyry. This porphyry cut Cerro Munro intrusion but not the country rocks (sample
344 34 in Fig. 2).

345 Cathodoluminescence studies in Qz from a rhyolite porphyry was carried out by
346 an Environmental Scanning Electron Microscopy (ESEM, FEI Quanta 400) coupled
347 with a cathodoluminescence detector (ChromaCL, Gatan), at the CIC, University of
348 Granada (Spain). The Electron back-scattered diffraction (EBSD) was conducted by a
349 High-Resolution Scanning Electron Microscopy (HRSEM, AURIGA (FIB-FESEM)
350 from Carl Zeiss SMT), also at the CIC, University of Granada (Spain). The sample was
351 polished with colloidal silica of 0.01 μ m of grain size for the cathodoluminescence and
352 EBSD study.

353 Quartz crystals were selected from the rhyolitic porphyry (sample A312-34;
354 Table 1) for the cathodoluminescence and electron back-scattered diffraction study (Fig.
355 11). The Qz core is zoned showing a previous crystalline orientation within a spherical
356 crystal, giving rise to a circular shape of this previous crystal (Fig. 11b). Circular shapes
357 of magmatic crystals have been described in relation to melt-rich environments
358 (Kirkpatrick, 1981). Subsequently, Qz crystallization progresses following the same
359 crystal orientation (Fig. 11d) and according to well-developed crystal faces. This
360 development of euhedral shapes is related to fluid-rich regions where the ion mobility is
361 high (Sunagawa, 1981). The myrmekite rims around the main crystal (Fig. 11b), which
362 also follow the orientation along the c axis (Fig. 11d), evidence a final episode of Qz
363 growth. The cathodoluminescence image of Qz (Fig. 11) sheds light about the batch-
364 fractionation processes occurring in the magma chamber of the Cerro Munro body, in

365 two stages at least (double fractionation). During an early crystallization stage, the
366 quartz crystallizes in a melt-rich magma. However, during the late solidification stage,
367 the quartz is able to crystallize developing a euhedral shape, in equilibrium with fluid-
368 rich environments. Although the real colour of CL images is not considered a reliable
369 tool to identify the Qz origin, the blue colour in CL images of Qz (Fig. 11b) is usually
370 related to the volcanic origin (Boggs et al., 2002). Also, this blue luminescence has been
371 associated to high Al contents (Ramseyer and Mullis, 1990). However the red colour
372 occurring in the myrmekite rim (Fig. 11b) is linked to volcanic sills and dikes
373 (Ramseyer et al., 1988; Ramseyer and Mullis, 2000).

374 9. Discussion

375 Processes related to the cooling history of magma chambers are inferred through
376 the petrographic, geochemical and geochronological study of plutons and volcanic rocks
377 (Bachmann and Bergantz, 2004; Bellos et al., 2015; Deering and Bachmann, 2010;
378 Lipman and Bachmann, 2015). The relation between autoliths and hosting plutons can
379 provide useful information about processes generating silicic magmas. Petrographical
380 and geochemical tools are essential to understand the mechanisms connecting autoliths
381 and its plutonic host.

382 The Cerro Munro tonalite is a good example of calc-alkaline magmatism in
383 which the relation between tonalites and autoliths and dykes can address the cooling
384 history. Textures, mineralogical and geochemical signatures record the processes
385 occurring in a common magma chamber, such as cooling, recharge, recycling,
386 assimilation and/or fractionation.

387 The geochemical correlation between autolith-host pairs indicates a basicity
388 increase of the enclaves regarding the host tonalites from Cerro Munro intrusion (Figs.

389 4 and 5). The set of tonalites and autoliths can be expected to follow the typical
390 differentiation pattern of calc-alkaline series, where the autoliths correspond to residues
391 and the tonalites to more differentiated magmas. However, the fractionation pattern
392 from the Cerro Munro body is separated from a calc-alkaline evolution, characterized
393 by a constant Mg number (Fig. 5d) and CaO depletion (Fig. 5e). Given that the MgO
394 content evolves according the calc-alkaline trend (Fig.5d), only the FeO
395 impoverishment justifies the constant Mg number for more evolved terms (Fig. 4a). The
396 fractionation of mineral phases as Cpx and Fe-oxides can induce this FeO and CaO
397 depletion for the tonalites. Thus, the geochemical signatures of Cerro Munro tonalites
398 suggest a fractionation from a magma, which generated a residue rich in Cpx
399 fenocrystals with Fe-oxides inclusions. This Cpx rich in Fe-oxides inclusions, left
400 behind during the fractionation process, has been partially recorded in the mineralogy of
401 the autoliths (Fig. 9d). The fractionation of a metaluminous phase (amphibole and/or
402 clinopyroxene), preferentially subtracting Ca, also explains why autoliths are
403 metaluminous whereas tonalites have a peraluminous signature (Fig. 4c).

404 Non-cotectic relations from the CaO-MgO diagram indicate a Cpx and Fe oxides
405 fractionation, increasing their basicity and moving away the trend from the cotectic
406 CaO-MgO variation (Fig. 5e). The fractionation of Fe oxides, hosted as inclusions in
407 Cpx (Fig. 9d), maintains a high Mg# as magnesium decreases (Fig. 5d). At the same
408 time, the Cpx fractionation separates the geochemical trend of Cerro Munro samples
409 from the cotectic line, since the Ca content of the magma is less than what is expected,
410 due to the Cpx loss.

411 On the other hand, both tonalites and autoliths show cumulate textures (Figs. 7
412 and 9), which indicates the segregation of a potentially eruptible, residual liquid. We
413 deduce that these rocks can be the result of a double fractionation or fractionation by

414 batches of a hydrous magma, supported by the contribution of the successive
415 fractionated pulses of magma.

416 Other textural features as oscillatory zoning in Pl of tonalites (Fig. 7a) and Qz
417 from rhyolites (Fig. 11b) indicate different cooling episodes in the magmatic system.
418 Na-rich rim in Pl (Table 2) and graphic textures at the interstices (Fig. 7b and c) in both
419 tonalites and autoliths indicate final undercooling at near *solidus* stage. Also, textural
420 features of autoliths, such as grain size, acicular apatite and amphibole, are indicative of
421 undercooling. Pressure estimations in amphibole for both tonalites and autoliths
422 constrain the depths of emplacement at shallow crustal levels corresponding to 0.6 kbar
423 (Tables 3 and 6). The early growth of amphibole suggests a hydrous composition for the
424 initial magma from which the autoliths crystallized.

425 Cumulate textures in both tonalites and autoliths (Figs. 7 and 9) suggest a liquid
426 expulsion from a crystal mush. It is accompanied by the occurrence of amphibole
427 phenocrysts and textures, indicating their presence as an early phase (Fig. 7d and 9a).
428 This supports the theory that these rocks come from a water-rich magma. The
429 amphibole saturation as *liquidus* phase is expected in wet magmas, at higher pressures
430 and with high Na₂O contents (Fig. 4b and Table 1; Naney, 1983; Scaillet and Evans,
431 1999; Sisson and Grove, 1993). For this reason, it is not discarded that during the
432 crystallization course, water saturation can be reached and pressure changes are
433 considered during the magma ascent to the shallow level of emplacement.

434 Based on the features mentioned above, we can say that the enclaves may
435 represent autoliths: fragments of early chilled margins of the intrusion dragged by
436 mechanical erosion from the magma conduits or the walls of the early magma chamber.
437 We cannot discard the provenance from a different, deeper magma chamber.

438 In spite of the cumulate textures in both tonalites and autoliths, few samples
439 from Cerro Munro intrusion show REE enrichment patterns of cumulate rocks.
440 Nonetheless, the Cpx or Amp fractionation pattern is found in both autoliths and
441 tonalites (Fig. 6). The positive Eu anomaly (Fig. 6c; samples A312-36 and 36a) is only
442 present in tonalite A312-36 and its enclave A312-36a, and coincides with high values
443 for the Sr/Y ratio (Fig. 12) and the garnet occurrence. The Sr/Y ratio increases as Y
444 decreases indicating an inherited pattern from the source-melting process involving
445 garnet. The parental magma was fractionated at deeper levels, where the garnet was
446 stable. From the HREE concave pattern of these samples -in which the differentiation is
447 more evident- the amphibole and/or clinopyroxene role in the fractionation process can
448 be deduced (Fig. 6c; A312-36 and 36a).

449 The study of cathodoluminescence and electron back-scattered diffraction
450 (EBSD) of Qz, from a rhyolite porphyry cutting the Cerro Munro tonalite, reveals this
451 crystallization at different episodes, recording a first crystallization step disrupted by a
452 later stage during which the fluid concentration is higher (Fig. 11b). This increase in the
453 fluid content is explained by the segregation of the water-saturated melt, as a
454 consequence of the second boiling (see further explanation). A final crystallization stage
455 followed by a *subsolidus* solidification of Qz and Kfs is evidenced by CL images (Fig.
456 11b). Notes that the entire crystallization time frame of the Cerro Munro tonalite should
457 coincide with the dating error range since zircon crystallization ages gives an
458 homogenous age for the pluton (Fig. 11).

459 Zoned eruptive (Deering et al., 2011; Hildreth and Wilson, 2007) or intrusive
460 (Bateman and Chappell, 1979; Lee et al., 2015) products are usually found in nature but
461 also it is possible to find this zoning in volcanic and plutonic rocks which are related to
462 each other. The combined study of plutonic bodies and volcanic related rocks can help

463 us validate the hypothesis supported on petrological and geochemical evidences from a
464 fossil magma chamber.

465 Cumulate features of both tonalites and autoliths from Cerro Munro intrusive
466 body imply the expulsion of a differentiated liquid that can also increase the basicity. At
467 this point, the question is whether the tonalites represent a residue from which a
468 differentiate liquid is extracted. This is predicted by crystallization models within a
469 solidification front, in which the liquid is expelled when the water saturation is reached
470 (Rodríguez and Castro, 2017). The influence of water on the differentiation trend of
471 calc-alkaline series has been broadly discussed (Bachmann and Bergantz, 2004;
472 Kawamoto, 1996; Sisson and Grove, 1993). Here, we propose a crystallization model
473 for the Cerro Munro system, consisting of fractionation by batches induced by the water
474 saturation magma. Both at the sidewalls of a magmatic reservoir and at the ascent
475 conduits, the temperature interval between *solidus* and *liquidus* establishes a
476 solidification front (Marsh, 2002), in which the water saturation will be reached as the
477 crystallization proceeds by second boiling (Burnham, 1979). Cumulate features such as
478 textures and geochemical signatures, can be explained by the presence of a
479 solidification front, from which a residual liquid is expelled. This can potentially trigger
480 a further volcanic event recorded by late rhyolite porphyries, as a consequence of the
481 second boiling, favoured by the extensional tectonic setting. Simple variation diagrams
482 for incompatible elements as SiO₂ vs Rb or Li (Fig. 13) show that these differentiated
483 liquids are enriched in soluble elements. From this, we can also deduce that the
484 segregated liquid from this crystal mush was assisted by high water contents. The
485 successive water saturation in a magmatic system can develop different pulses of
486 fractionated magma, giving rise to the differentiation pattern of tonalites and autoliths of
487 Cerro Munro intrusion.

488 10. Conclusions

489 The integrated study of plutons and all its related rocks, such as enclaves and
490 dikes, is necessary to reconstruct the tectono-magmatic history of magma chambers.
491 The Cerro Munro tonalite has crystallized according to a modified calc-alkaline pattern
492 at shallow depths of emplacement. The role of water on the differentiation trend of this
493 pluton, as a promoter of the expulsion of different batches of magma, explains the
494 deviation from the traditional calc-alkaline pattern. The analysis of igneous textures
495 reveals the value of the second boiling as a precursor mechanism of the differentiation
496 in calc-alkaline magmas. Petrographical and geochemical tools are essential to take
497 advantage of the information registered in plutonic rocks. Plutonic enclaves are
498 ubiquitous in silicic plutons and can be used to define the relation to the host pluton,
499 which is expected to connect them both with a common magma chamber. The study of
500 volcanic rocks related to the fossil magma chamber supports this fractionation
501 mechanism by batches. The plutonic-volcanic connection is not only evidenced in the
502 case of the Cerro Munro magmatic system but also contributes to the knowledge about
503 processes governing the cooling and solidification of magmatic systems.

504 Acknowledgments

505 This work is supported by MINECO grant LITHOS project CGL2013-48408-
506 C3-1-P. C. R. is grateful for her AUIP grant (Asociación Universitaria Iberoamericana
507 de Postgrado) for the stay at the Universidad Nacional de La Plata (Argentina) and for
508 her postdoctoral contract from the University of Huelva (under the Estrategia Política
509 Científica de la UHU 2016/2017).

510

511 FIGURE CAPTIONS

512

513 **Fig. 1.** Location map of northern Patagonia, showing the major igneous units
514 related to the active margin from the Jurassic to the Cenozoic. Numbered circles
515 provide the location for post-tectonic Palaeocene plutons. The NPB time-space
516 distribution is modified from Pankhurst et al. (1999).

517 **Fig. 2.** Geological map of Cerro Munro tonalite with location of the collected
518 samples.

519 **Fig. 3.** Field relations between tonalites and autoliths from Cerro Munro body.
520 (a) Outcrop of autoliths within the tonalite A312-37. (b) Rounded microgranular
521 autolith of dm-size hosted in the coarse-grained tonalite A312-33. (c) Coarse-grained
522 texture of the tonalite A312-32. (d) Fine-grained texture of the autoliths.

523 **Fig. 4.** Classification diagrams for Cerro Munro tonalites and autoliths. (a) Fe^*
524 vs SiO_2 diagram shows the magnesian character of both tonalites and autoliths. (b)
525 MALI index indicates that Cerro Munro magmatic system have a calc-alkalic
526 composition. (c) The ASI index separates the autoliths as metaluminous and the
527 tonalites as peraluminous. Grey dots represent data from Patagonian Batholith
528 (California), taken as representative of calc-alkaline magmas.

529 **Fig. 5.** Variation diagrams for Cerro Munro tonalites and autoliths. (a) Molar
530 ratio K_2O/K_2O+CaO vs K_2O diagram indicated the calc-alkaline trend by which
531 tonalites and autoliths are differentiated. (b) Mg number maintains high values as the
532 silica content (wt%) increases, away from the trend marked by the Patagonian batholith.
533 (c) Molar ratio K_2O/K_2O+CaO vs K_2O plot classifies the autoliths as Qz-diorite and
534 host-rocks as grano-tonalites. The relation of Mg# (d) and CaO (e) with Mg denotes the
535 decoupling of the Cerro Munro samples from the calc-alkaline trend.

536 **Fig. 6.** REE spider diagrams, normalized to primitive mantle (Sun and
537 McDonough, 1989), showing the relation of the tonalites (red curves) with their
538 respective autoliths (black curves).

539 **Fig. 7.** BSE images of tonalites from Cerro Munro body. (a) Plagioclase
540 phenocrysts have zoning and inclusions of Fe-Ti oxides and Clinopyroxene. Plagioclase
541 is arranged forming cumulate texture and interstices filled by Qz and Kfs (b).
542 Amphibole is present as phenocryst and replacing Cpx rim (c). Amphibole clots also
543 occur (d). Mineral abbreviations after Whitney and Evans (2010).

544 **Fig. 8.** Classification diagrams for plagioclase according to anorthite (X_{An}) and
545 albite (X_{Ab}) molar fraction (a), for calcic amphiboles (b) and clinopyroxenes (c).
546 Amphibole classification after Leake et al. (1997). Tonalites are represented by blue
547 diamonds and autoliths by yellow squares. Si cation proportion is represented per
548 formula unit.

549 **Fig. 9.** BSE images of autoliths from Cerro Munro body. (a) Amphibole
550 phenocryst indicates their early growth and high initial water contents. (b) Amp and Pl
551 have smaller grain size in autoliths. (c) Acicular apatite also supports the high initial
552 water contents of the magma. (d) Interstices are occupied by Qz and Kfs, forming
553 graphic textures.

554 **Fig. 10.** Cathodoluminescence images of the analysed zircon sample. Spots
555 location and their resulting $^{206}\text{Pb}/^{238}\text{U}$ ages (Ma) are indicated. Data are given in Table
556 X. Scale bars are 100 μm . Concordia U-Pb diagrams for both studied samples are shown
557 beside CL images. Error ellipses for data points in the Concordia diagrams are 68.3%
558 confidence limits, including the error from the standard. Grey ovoids represent the
559 calculated concordia ages.

560 **Fig. 11.** (a) BSE image of Qz from rhyolitic porphyry A312-24. (b) Real colour
561 cathodoluminescence image of Qz from sample A312-24. (c) Image quality. (d)
562 Orientation map using Miller indices as orientation parameter. Red colour indicates the
563 occurrence of the *c* crystallographic axis of Qz parallel to the normal direction in the
564 sample (z). A certain grade of misorientation can be appreciated in the idiomorphic
565 crystal of the image. In addition, Qz occurring at the myrmekite rims maintains the
566 orientation of large central crystal.

567 **Fig. 12.** Sr/Y vs Y diagram showing tonalites and autoliths from Cerro Munro
568 body. Grey dots represent the Peninsular Range batholith (California, USA). Also,
569 experiments from Castro et al. (2010) are included for comparison. Red square
570 represents conditions of 1100 °C and 20 kbar. Green Square corresponds to 1050 °C and
571 15 kbar and the purple circle represents the melange melting at 1100 °C and 15 kbar.

572 **Fig. 13.** (a) Li vs SiO₂ diagram for tonalites, autoliths and dikes from Cerro
573 Munro magmatic system. (b) Rb vs SiO₂ diagram showing the geochemical trend for
574 the entire set of tonalites, autoliths and dikes.

575

576

- 578 Aragón, E., Aguilera, Y., Cavarozzi, C. and Ribot, A., 2005. Basaltos Alcalinos en el
579 Complejo Volcánico-Piroclástico del Río Chubut medio, Actas XVI Congreso
580 Geológico Argentino. Actas, pp. 485–486.
- 581 Aragón, E., D'Eramo, F., Castro, A., Pinotti, L., Brunelli, D., Rabbia, O., Rivalenti, G.,
582 Varela, R., Spakman, W., Demartis, M., Cavarozzi, C.E., Aguilera, Y.E.,
583 Mazzucchelli, M. and Ribot, A., 2011. Tectono-magmatic response to major
584 convergence changes in the North Patagonian suprasubduction system; the
585 Paleogene subduction–transcurrent plate margin transition. *Tectonophysics*,
586 509(3–4): 218-237.
- 587 Aragón, E. and Mazzoni, M.M., 1997. Geología y estratigrafía del complejo volcánico
588 piroclástico del río Chubut medio (Eoceno), Chubut, Argentina. *Revista de la*
589 *Asociación Geológica Argentina*, 52(3): 243–256.
- 590 Bachmann, O. and Bergantz, G.W., 2004. On the origin of crystal-poor rhyolites:
591 extracted from batholithic crystal mushes. *Journal of Petrology*, 45: 1565-1582.
- 592 Bachmann, O. and Bergantz, G.W., 2008. Rhyolites and their Source Mushes across
593 Tectonic Settings. *Journal of Petrology*, 49(12): 2277-2285.
- 594 Bachmann, O., Miller, C.F. and de Silva, S.L., 2007. The volcanic–plutonic connection
595 as a stage for understanding crustal magmatism. *Journal of Volcanology and*
596 *Geothermal Research*, 167(1–4): 1-23.
- 597 Baedeker, P.A., 1987. Methods for geological analysis. US Geological
598 Survey Bulletin. US Geological Survey Bulletin 1770, 187 pp.
- 599 Bateman, P.C. and Chappell, B.W., 1979. Crystallization, fractionation, and
600 solidification of the Tuolumne Intrusive Series, Yosemite National Park,
601 California. *Geological Society of America Bulletin*, 90: 465-482.
- 602 Bea, F., Montero, P., Stroh, A. and Baasner, J., 1996. Microanalysis of minerals by an
603 Excimer UV-LA-ICP-MS system. *Chemical Geology*, 133(1): 145-156.
- 604 Beane, R. and Wiebe, R.A., 2012. Origin of quartz clusters in Vinalhaven granite and
605 porphyry, coastal Maine. *Contributions to Mineralogy and Petrology*, 163(6):
606 1069-1082.
- 607 Bellos, L.I., Castro, A., Díaz-Alvarado, J. and Toselli, A., 2015. Multi-pulse cotectic
608 evolution and in-situ fractionation of calc-alkaline tonalite–granodiorite rocks,
609 Sierra de Velasco batholith, Famatinian belt, Argentina. *Gondwana Research*,
610 27(1): 258-280.
- 611 Boggs, S., Kwon, Y.-I., Goles, G.G., Rusk, B.G., Krinsley, D. and Seyedolali, A., 2002.
612 Is Quartz Cathodoluminescence Color a Reliable Provenance Tool? A
613 Quantitative Examination. *Journal of Sedimentary Research*, 72(3): 408-415.
- 614 Boudreau, A., 2016. Bubble migration in a compacting crystal-liquid mush.
615 *Contributions to Mineralogy and Petrology*, 171(4): 32.
- 616 Burnham, C.W., 1979. The importance of volatile constituents. In: H.S.J. Yoder
617 (Editor), *The evolution of the igneous rocks*. Princeton University Press,
618 Princeton, pp. 439-482.
- 619 Castro, A., Gerya, T., García-Casco, A., Fernández, C., Díaz Alvarado, J., Moreno-
620 Ventas, I. and Loew, I., 2010. Melting relations of MORB-sediment mélanges in
621 underplated mantle wedge plumes. Implications for the origin of cordilleran-
622 type batholiths. *Journal of Petrology*, 51(6): 1267-1295.
- 623 Cazau, L., Mancini, D., Cangini, J. and Spalletti, L., 1989. Cuenca Ñirihuau. In: G.
624 Chebli and I. Spalletti (Editors), *Cuencas Sedimentarias de Argentina*.
625 *Correlación Geológica* 6, pp. 299–318.

- 626 Cumming, G.L. and Richards, J.R., 1975. Ore lead isotope ratios in a continuously
627 changing earth. *Earth and planetary science letters*, 28(2): 155-171.
- 628 D'Lemos, R.S., Kearsley, A.T., Pembroke, J.W., Watt, G.R. and Wright, P., 1997.
629 Complex quartz growth histories in granite revealed by scanning
630 cathodoluminescence techniques. *Geological Magazine*, 134(4): 549-552.
- 631 Deering, C.D. and Bachmann, O., 2010. Trace element indicators of crystal
632 accumulation in silicic igneous rocks. *Earth and Planetary Science Letters*,
633 297(1-2): 324-331.
- 634 Deering, C.D., Cole, J.W. and Vogel, T.A., 2011. Extraction of crystal-poor rhyolite
635 from a hornblende-bearing intermediate mush: a case study of the caldera-
636 forming Matahina eruption, Okataina volcanic complex. *Contributions to
637 Mineralogy and Petrology*, 161(1): 129-151.
- 638 Deering, C.D., Keller, B., Schoene, B., Bachmann, O., Beane, R. and Ovtcharova, M.,
639 2016. Zircon record of the plutonic-volcanic connection and protracted rhyolite
640 melt evolution. *Geology*.
- 641 Donev, A., Cisse, I., Sachs, D., Variano, E.A., Stillinger, F.H., Connelly, R., Torquato,
642 S. and Chaikin, P.M., 2004. Improving the Density of Jammed Disordered
643 Packings Using Ellipsoids. *Science*, 303(5660): 990-993.
- 644 Frost, C.D., Frost, B.R. and Beard, J.S., 2016. On silica-rich granitoids and their
645 eruptive equivalents. *American Mineralogist*, 101(6): 1268-1284.
- 646 Gelman, S.E., Deering, C.D., Bachmann, O., Huber, C. and Gutiérrez, F.J., 2014.
647 Identifying the crystal graveyards remaining after large silicic eruptions. *Earth
648 and Planetary Science Letters*, 403: 299-306.
- 649 Giacosa, R. and Heredia, N., 2004. Structure of the North Patagonian thick-skinned
650 fold-and-thrust belt, southern central Andes, Argentina (41°–42° S). *Journal of
651 South American Earth Sciences*, 18: 61–72.
- 652 Glazner, A.F., 2014. Magmatic life at low Reynolds number. *Geology*, 42(11): 935-938.
- 653 Glazner, A.F., Coleman, D.S. and Bartley, J.M., 2008. The tenuous connection between
654 high-silica rhyolites and granodiorite plutons. *Geology*, 36(2): 183-186.
- 655 Haller, M.J., Linares, M., Osters, H.A. and Page, S.M., 1999. Petrology and
656 Geochronology of the Sub-Cordilleran Plutonic Belt of Patagonia, Argentina, II
657 South American Symposium on Isotope Geology, Carlos Paz, Argentina, pp.
658 210-214.
- 659 Hervé, F., Pankhurst, R.J., Fanning, C.M., Calderon, M. and Yaxley, G.M., 2007. The
660 South Patagonian batholith: 150 my of granite magmatism on a plate margin.
661 *Lithos*, 97(3-4): 373-394.
- 662 Hildreth, W. and Wilson, C.J.N., 2007. Compositional Zoning of the Bishop Tuff.
663 *Journal of Petrology*, 48(5): 951-999.
- 664 Jordan, T.E., Burns, W.M., Veiga, R., Pángaro, F., Copeland, P., Kelley, S. and
665 Mpodozis, C., 2001. Extension and basin formation in the southern Andes
666 caused by increased convergence rate: A mid-Cenozoic trigger for the Andes.
667 *Tectonics*, 20(3): 308-324.
- 668 Kawamoto, T., 1996. Experimental constraints on differentiation and H₂O abundance
669 of calc-alkaline magmas. *Earth and Planetary Science Letters*, 144(3-4): 577-
670 589.
- 671 Kay, S.M. and Rapela, C.W., 1987. El volcanismo del Terciario inferior y medio en los
672 Andes Norpatagónicos (40°–42° 30'S): Origen de los magmas y su relación con
673 variaciones en la oblicuidad de la zona de subducción, 10° Congreso Geológico
674 Argentino. *Actas*, pp. 192–194.

- 675 Kirkpatrick, R.J., 1981. Kinetics of crystallization of igneous rocks. *Rev. Mineral.*;
676 (United States): Medium: X; Size: Pages: 321-395.
- 677 Leake, B.E., Woolley, A.R., Arps, C.E.S., Birch, W.D., Gilbert, M.C., Grice, J.D.,
678 Hawthorne, F.C., Kato, A., Kisch, H.J., Krivovichev, V.G., Linthout, K., Laird,
679 J., Mandarino, J.A., Maresch, W.V., Nickel, E.H., Rock, N.M.S., Schumacher,
680 J.C., Smith, D.C., Stephenson, N.C.N., Ungaretti, L., Whittaker, E.J.W. and Guo
681 Youzhi, 1997. Nomenclature of amphiboles; Report of the Subcommittee on
682 Amphiboles of the International Mineralogical Association, Commission on
683 New Minerals and Mineral Names. *American Mineralogist*, 82(9-10): 1019-
684 1037.
- 685 Lee, C.-T.A., Morton, D.M., Farner, M.J. and Moitra, P., 2015. Field and model
686 constraints on silicic melt segregation by compaction/hindered settling: The role
687 of water and its effect on latent heat release. *American Mineralogist*, 100(8-9):
688 1762-1777.
- 689 Lee, C.T.A. and Morton, D.M., 2015. High silica granites: Terminal porosity and crystal
690 settling in shallow magma chambers. *Earth and Planetary Science Letters*, 409:
691 23-31.
- 692 Lipman, P.W. and Bachmann, O., 2015. Ignimbrites to batholiths: Integrating
693 perspectives from geological, geophysical, and geochronological data.
694 *Geosphere*, 11(3): 705-743.
- 695 Locock, A.J., 2014. An Excel spreadsheet to classify chemical analyses of amphiboles
696 following the IMA 2012 recommendations. *Computers & Geosciences*, 62: 1-
697 11.
- 698 Ludwig, K.R., 2003. Mathematical–Statistical Treatment of Data and Errors for
699 ²³⁰Th/U Geochronology. *Reviews in Mineralogy and Geochemistry*, 52(1):
700 631-656.
- 701 Mancini, C.D. and Serna, M.J., 1989. Evaluación petrolera de la cuenca de Ñirihuau,
702 Sudoeste de la Argentina, I Congreso Nacional de Hidrocarburos, pp. 739–762.
- 703 Marsh, B.D., 2002. On bimodal differentiation by solidification front instability in
704 basaltic magmas, part 1: Basic mechanics. *Geochimica et Cosmochimica Acta*,
705 66: 2211-2229.
- 706 Matthews, N.E., Huber, C., Pyle, D.M. and Smith, V.C., 2012. Timescales of Magma
707 Recharge and Reactivation of Large Silicic Systems from Ti Diffusion in
708 Quartz. *Journal of Petrology*, 53(7): 1385-1416.
- 709 Matthews, N.E., Pyle, D.M., Smith, V.C., Wilson, C.J.N., Huber, C. and Hinsberg, V.,
710 2011. Quartz zoning and the pre-eruptive evolution of the ~340-ka Whakamaru
711 magma systems, New Zealand. *Contributions to Mineralogy and Petrology*,
712 163(1): 87-107.
- 713 Muñoz, J., Troncoso, R., Duhart, P., Crignola, P., Farmer, L. and Stern, C.R., 2000. The
714 relation of the mid-Tertiary coastal magmatic belt in south-central Chile to the
715 late Oligocene increase in plate convergence rate. *Revista geológica de Chile*,
716 27: 177-203.
- 717 Naney, M.T., 1983. Phase equilibria of rock-forming ferromagnesian silicates in
718 granitic systems. *American Journal of Science*, 283: 993-1033.
- 719 Pankhurst, R.J., Weaver, S.D., Hervé, F. and Larrondo, P., 1999. Mesozoic-Cenozoic
720 evolution of the North Patagonian Batholith in Aysen, southern Chile. *Journal of*
721 *the Geological Society*, 156(4): 673-694.
- 722 Pistone, M., Arzilli, F., Dobson, K.J., Cordonnier, B., Reusser, E., Ulmer, P., Marone,
723 F., Whittington, A.G., Mancini, L., Fife, J.L. and Blundy, J.D., 2015. Gas-driven

- 724 filter pressing in magmas: Insights into in-situ melt segregation from crystal
725 mushes. *Geology*.
- 726 Ramseyer, K., Baumann, J., Matter, A. and Mullis, J., 1988. Cathodoluminescence
727 colours of a-quartz. *American Mineralogist*, 52: 669-677.
- 728 Ramseyer, K. and Mullis, J., 1990. Factors influencing short-lived blue
729 cathodoluminescence of a-quartz. *American Mineralogist*, 75: 791-800.
- 730 Ramseyer, K. and Mullis, J., 2000. Geologic Application of Cathodoluminescence of
731 Silicates. In: M. Pagel, V. Barbin, P. Blanc and D. Ohnenstetter (Editors),
732 Cathodoluminescence in Geosciences. Springer Berlin Heidelberg, Berlin,
733 Heidelberg, pp. 177-191.
- 734 Rapela, C.W., Pankhurst, R.J., Fanning, C.M. and Hervé, F., 2005. Pacific subduction
735 coeval with the Karoo mantle plume: The Early Jurassic Subcordilleran belt of
736 northwestern Patagonia, *Geological Society Special Publication*, pp. 217-239.
- 737 Rapela, C.W., Spalletti, L., J.C., M. and Aragón E., 1987. Temporal evolution and
738 spatial variation of the lower tertiary Andean volcanism (40-42 30'S). *Journal of*
739 *South American Earth Sciences*, 1: 1-14.
- 740 Rapela, C.W., Spalletti, L. and Merodio, J.C., 1983. Evolución magmática y
741 geotectónica de la Serie Andesítica andina (Paleoceno–Eoceno) en la cordillera
742 norpatagónica. *Revista de la Asociación Geológica Argentina*, 38(3-4): 469–
743 484.
- 744 Ridolfi, F., Renzulli, A. and Puerini, M., 2010. Stability and chemical equilibrium of
745 amphibole in calc-alkaline magmas: an overview, new thermobarometric
746 formulations and application to subduction-related volcanoes. *Contributions to*
747 *Mineralogy and Petrology*, 160(1): 45-66.
- 748 Rodríguez, C. and Castro, A., 2017. Silicic magma differentiation in ascent conduits.
749 Experimental constraints. *LITHOS*, 272–273: 261-277.
- 750 Scaillet, B. and Evans, B.W., 1999. The 15 June 1991 eruption of Mount Pinatubo. I.
751 Phase equilibria and pre-eruption P-T-fO₂-fH₂O conditions of the dacite
752 magma. *Journal of Petrology*, 40(3): 381-411.
- 753 Silvestro, J. and Zubiri, M., 2008. Convergencia oblicua: Modelo estructural alternativo
754 para la dorsal Neuquina (39°S)- Neuquén. *Revista de la Asociación Geológica*
755 *Argentina*, 63(1): 49–64.
- 756 Sisson, T.W. and Grove, T.L., 1993. Experimental investigations of the role of H₂O in
757 calc-alkaline differentiation and subduction zone magmatism. *Contributions to*
758 *Mineralogy and Petrology*, 113(2): 143-166.
- 759 Spalletti, L.A., 1983. Paleogeografía de la Formación Ñirihuau y sus equivalentes en la
760 región occidental de Neuquén, Río Negro y Chubut. *Revista de la Asociación*
761 *Geológica Argentina*, 38(3-4): 454–468.
- 762 Spikermann, J.P., 1978. Contribución al conocimiento de la intrusividad en el
763 Paleozoico de la región extraandina del Chubut. *Revista de la Asociación*
764 *Geológica Argentina* 33(1).
- 765 Spikermann, J.P., Sterlin, J., Marshall, P., Carrillo, R., Montenegro, T., Lago, M.,
766 Villalba, E. and Perez, A., 1988. Geología del área del batolito Aleusco,
767 Departamento de Languiño, Provincia de Chubut. *Revista de la Asociación*
768 *Argentina de Mineralogía, Petrología y Sedimentología* 19(1/4): 39-48.
- 769 Spikermann, J.P., Sterlin, J., Marshall, P., Carrillo, R., Montenegro, T., Lago, M.,
770 Villalba, E. and Perez, A., 1989. Caracterización geológica y petrológica del
771 batolito Aleusco, Departamento de Languiño, Provincia de Chubut. *Revista de*
772 *la Asociación Argentina de Mineralogía, Petrología y Sedimentología* 20(1/4):
773 33-42.

- 774 Steiger, R.H. and Jäger, E., 1977. Subcommission on geochronology: Convention on
775 the use of decay constants in geo- and cosmochronology. *Earth and Planetary*
776 *Science Letters*, 36(3): 359-362.
- 777 Sun, S.s. and McDonough, W.F., 1989. Chemical and isotopic systematics of oceanic
778 basalts: implications for mantle composition and processes. Geological Society,
779 London, Special Publications, 42(1): 313-345.
- 780 Sunagawa, I., 1981. Characteristics of crystal growth in nature as seen from the
781 morphology of mineral crystals. *Bulletin of Mineralogy*, 104: 81-87.
- 782 Turner, J.S., 1982. Descripción Geológica de la Hoja 44c, Tecka, Provincia de Chubut.
783 Servicio Geológico Nacional Boletín 180 92.
- 784 Vernon, R.H. and Collins, W.J., 2011. Structural Criteria for Identifying Granitic
785 Cumulates. *The Journal of Geology*, 119(2): 127-142.
- 786 Whitney, D.L. and Evans, B.W., 2010. Abbreviations for names of rock-forming
787 minerals. *American Mineralogist*, 95(1): 185-187.
- 788 Wiebe, R.A., Wark, D.A. and Hawkins, D.P., 2007. Insights from quartz
789 cathodoluminescence zoning into crystallization of the Vinalhaven granite,
790 coastal Maine. *Contributions to Mineralogy and Petrology*, 154(4): 439-453.
- 791 Williams, I.S., 1998. U-Th-Pb Geochronology by Ion Microprobe. In: M.A. McKibben,
792 W.C. Shanks III and W.I. Ridley (Editors), *Applications of microanalytical*
793 *techniques to understanding mineralizing processes. Reviews in Economic*
794 *Geology* pp. 1-35.

Table 1

Whole-rock analyses of major and trace elements of Cerro Munro pluton and related host-rocks.

Sample	A312-29	A312-29b	A312-32	A312-33	A312-33a-g	A312-36	A312-36a	A312-36b	A312-36c	A312-37	A312-37a	A312-38	C.2011-11	A312-30	A312-31	A312-34	A312-35
Rock Type	Tonalite	Autolith	Tonalite	Tonalite	Autolith	Tonalite	Autolith	Autolith	Autolith	Tonalite	Autolith	Autolith	Tonalite	Andesite tuff (host rock)	Dacite tuff (host rock)	Rhyolite porphyry	Andesite porphyry dyke
<i>Major elements (wt%)</i>																	
SiO ₂	63.19	57.21	61.95	63.07	57.81	64.21	64.32	61.10	57.86	65.37	57.73	58.31	63.19	60.13	66.44	76.58	61.59
TiO ₂	0.80	1.13	0.88	0.79	1.05	0.37	0.43	0.88	0.80	0.69	1.03	0.92	0.80	1.01	0.81	0.04	0.87
Al ₂ O ₃	16.36	16.50	16.51	16.66	16.78	18.92	18.54	16.78	16.81	15.90	16.39	16.73	16.36	17.63	15.55	13.57	16.14
FeOt	4.45	6.68	4.84	4.28	6.35	2.22	2.29	4.98	6.37	3.77	6.27	6.23	4.49	7.43	5.92	0.50	4.60
MgO	2.44	3.44	2.63	2.13	3.77	1.15	1.14	2.93	4.07	1.92	3.60	3.70	2.44	3.35	2.46	0.26	2.44
MnO	0.09	0.14	0.09	0.09	0.17	0.04	0.05	0.09	0.13	0.07	0.15	0.11	0.09	0.19	0.07	0.02	0.08
CaO	4.05	6.24	4.46	3.99	5.50	4.10	3.98	5.17	6.12	3.14	5.62	6.64	4.05	3.66	1.05	0.20	3.84
Na ₂ O	4.05	4.10	4.00	4.19	4.24	4.57	4.58	3.93	4.09	4.17	4.44	4.39	4.05	1.95	2.35	1.19	4.13
K ₂ O	2.01	1.61	1.96	2.20	1.82	2.58	2.56	1.73	1.10	2.56	1.57	1.04	2.01	3.05	2.63	5.61	1.92
P ₂ O ₅	0.28	0.39	0.31	0.26	0.30	0.14	0.14	0.30	0.24	0.22	0.34	0.33	0.28	0.35	0.11	0.06	0.38
Loi	1.19	1.16	1.47	1.36	0.98	0.77	0.98	0.92	1.19	1.13	1.42	0.34	1.19	0.00	1.21	1.65	2.98
Total	98.91	98.60	99.10	99.02	98.77	99.07	99.00	98.81	98.77	98.94	98.56	98.74	98.95	98.75	98.60	99.68	98.97
ASI ⁽¹⁾	1.05	0.87	1.03	1.05	0.92	1.08	1.08	0.99	0.91	1.07	0.89	0.85	1.05	1.43	1.86	1.64	1.08
K/K+Ca ⁽²⁾	0.23	0.13	0.21	0.25	0.16	0.27	0.28	0.17	0.10	0.33	0.14	0.09	0.23	0.33	0.60	0.94	0.23
#Mg ⁽³⁾	0.49	0.48	0.49	0.47	0.51	0.48	0.47	0.51	0.53	0.48	0.51	0.51	0.49	0.45	0.43	0.48	0.49
Fe* ⁽⁴⁾	0.65	0.66	0.65	0.67	0.63	0.66	0.67	0.63	0.61	0.66	0.64	0.63	0.65	0.69	0.71	0.66	0.65
<i>Trace elements (ppm)</i>																	
Li	36.40	32.78	29.93	28.44	36.37	24.80	17.72	27.80	28.23	29.34	40.45	9.08	36.00	103.75	68.84	75.96	54.44
Sc	12.09	20.62	11.93	10.13	21.48	6.54	5.31	12.47	20.56	9.68	20.45	20.33	12.10	21.32	14.56	2.83	11.37
V	92.62	150.53	93.99	78.76	129.16	66.60	47.74	93.84	137.73	72.19	124.08	147.78	92.60	151.52	101.54	3.37	98.74
Cr	51.77	33.38	46.29	25.21	77.57	34.42	17.98	41.99	87.05	26.67	62.10	64.30	51.80	105.11	75.76	1.86	62.86
Co	30.58	26.81	25.46	25.81	29.66	42.46	21.08	27.48	32.19	25.61	27.88	32.63	30.60	34.92	30.11	15.29	23.51
Ni	34.69	31.77	34.13	20.74	43.68	31.93	19.55	38.84	67.27	26.55	32.44	40.00	34.70	53.17	40.33	4.61	27.24
Cu	37.44	197.13	29.02	22.56	44.75	26.94	18.27	33.34	41.05	18.99	28.65	73.09	37.40	31.34	17.81	1.98	34.62
Zn	73.75	89.21	75.39	73.97	129.04	46.85	34.13	69.10	92.06	64.92	110.63	90.03	73.70	112.41	89.76	19.00	88.34
Ga	18.54	17.89	18.10	18.35	18.99	25.78	18.45	17.81	18.07	18.22	18.40	17.64	18.50	23.13	18.86	17.61	18.61
Rb	58.71	49.07	50.14	58.72	57.79	79.96	58.62	44.81	25.32	60.60	51.81	17.62	58.70	128.95	106.50	158.56	42.67

Sr	384.5	389.3	402.0	345.4	352.9	611.7	462.1	420.5	425.7	281.9	369.9	430.8	384.0	168.8	205.1	21.0	484.7
Y	21.25	26.48	20.74	21.76	40.08	11.17	9.34	18.90	22.15	24.96	30.09	21.93	21.20	38.44	14.56	11.55	17.49
Zr	20.31	21.13	37.60	14.67	21.13	32.70	16.54	18.71	27.11	28.75	20.27	30.16	20.00	63.95	16.57	28.02	143.54
Nb	13.77	17.31	14.29	14.97	21.85	9.52	7.75	12.66	10.32	15.50	15.52	10.63	13.80	14.78	13.86	24.44	11.21
Cs	1.92	1.82	1.71	1.96	2.97	2.03	1.33	1.66	0.86	1.21	2.39	0.90	1.90	11.17	6.64	3.16	3.05
Ba	316.2	202.1	316.4	324.7	266.7	379.3	323.8	258.0	196.1	354.0	192.8	258.2	316.0	536.1	394.2	196.9	401.7
La	27.60	33.45	26.53	29.85	33.42	21.05	16.40	23.42	21.10	30.10	31.05	22.74	27.60	41.38	29.44	4.21	25.68
Ce	59.55	73.22	57.26	61.33	81.08	37.45	31.07	50.18	46.79	67.10	68.37	50.05	59.60	86.23	61.90	10.00	55.47
Pr	7.11	8.70	6.80	7.09	10.51	4.17	3.44	6.06	5.90	8.12	8.35	6.19	7.10	10.43	7.19	1.27	6.71
Nd	26.67	32.88	25.53	26.64	41.01	15.16	12.36	22.97	23.03	31.11	32.05	24.44	26.70	41.80	27.81	4.28	25.56
Sm	5.18	6.43	5.02	5.05	8.54	2.74	2.28	4.52	4.84	6.15	6.67	5.11	5.20	9.14	5.47	1.53	4.97
Eu	1.35	1.55	1.30	1.39	1.74	1.57	1.17	1.24	1.44	1.27	1.62	1.50	1.40	2.01	1.26	0.22	1.37
Gd	4.79	5.89	4.41	4.63	7.89	2.32	1.96	4.06	4.59	5.49	6.13	4.72	4.80	8.50	4.54	1.59	4.41
Tb	0.70	0.87	0.66	0.63	1.25	0.34	0.28	0.60	0.68	0.76	0.94	0.69	0.70	1.20	0.57	0.30	0.63
Dy	3.96	4.91	3.71	3.65	7.16	1.79	1.68	3.38	4.08	4.49	5.36	4.00	4.00	6.74	3.06	2.01	3.39
Ho	0.80	1.02	0.75	0.76	1.55	0.38	0.31	0.67	0.86	0.91	1.12	0.82	0.80	1.38	0.56	0.37	0.66
Er	2.04	2.57	1.98	1.95	4.03	1.01	0.81	1.75	2.18	2.33	2.91	2.11	2.00	3.56	1.32	0.99	1.58
Tm	0.31	0.40	0.31	0.30	0.66	0.18	0.13	0.27	0.34	0.35	0.45	0.32	0.30	0.57	0.21	0.16	0.24
Yb	1.93	2.52	1.85	1.91	4.20	1.02	0.82	1.67	2.10	2.05	2.82	1.99	1.90	3.54	1.31	1.05	1.49
Lu	0.27	0.36	0.27	0.28	0.60	0.15	0.12	0.23	0.29	0.30	0.40	0.28	0.30	0.52	0.20	0.15	0.21
Hf	0.35	0.74	0.98	0.00	0.80	-0.37	0.15	0.34	0.77	0.00	0.59	0.67	0.40	0.00	0.00	0.95	3.07
Ta	1.67	1.56	1.36	1.42	2.15	3.27	1.51	1.41	1.28	1.62	1.53	1.30	1.70	1.78	1.86	3.20	1.21
Pb	7.81	10.66	6.15	8.03	20.38	8.54	7.48	7.18	9.44	9.75	12.18	7.53	7.80	27.84	17.64	7.58	8.76
Th	6.68	6.52	6.91	9.44	7.57	9.80	7.61	6.23	4.81	8.73	6.59	3.57	7.60	11.20	8.89	2.92	5.55
U	0.57	0.61	0.76	0.75	1.36	0.97	0.68	0.69	0.71	0.75	0.83	0.87	0.60	2.94	1.59	1.95	1.38

LOI: Loss of ignition

⁽¹⁾ $ASI = [Al_2O_3 / (Na_2O + K_2O + (CaO - 1.67 * P_2O_5))]$

⁽²⁾ $K / (K + Ca) = \text{molar } K_2O / [K_2O + CaO]$

⁽³⁾ $Mg\# = \text{molar } MgO / [MgO + FeO]$

⁽⁴⁾ $Fe^* = \text{wt\% } FeO / [FeO + MgO]$

Table 2

Microprobe analyses of plagioclases from the Cerro Munro tonalites

Sample	29	29	29	29	29	29	29	29	32	32	32	32	32	33	33	33	33	33	33	36	36	36	36	36	36	37	37	37	37	37	37	37
Run	29-4	29-5	29-6	29-7	29-12	29-13	29-14	29-15	32-4	32-7	32-11	32-12	32-13	33-2	33-3	33-4	33-5	33-6	33-7	36-1	36-17	36-18	36-24	36-25	36-27	37-5	37-17	37-18	37-19	37-26	37-27	
Position ⁽¹⁾	inc	core	int	rim	core	int	int	rim	core	rim	core	int	rim	core	int	int	int	int	int	rim	int	int	rim	core	int	rim	int	rim	int	core	rim	core
SiO ₂	65.81	58.94	57.59	63.83	59.31	56.71	60.49	62.96	58.67	65.51	61.14	56.44	60.34	56.22	59.49	59.11	58.15	58.94	58.47	59.35	58.93	64.57	60.65	55.33	62.78	62.49	63.39	54.93	56.41	64.11	55.57	
Al ₂ O ₃	21.61	25.87	26.79	22.39	25.66	27.55	25.02	23.40	25.79	21.56	23.79	26.98	24.22	27.60	25.30	25.71	26.43	25.67	25.99	25.59	25.64	22.21	24.75	28.08	22.85	23.24	22.74	28.61	27.29	21.96	27.16	
FeO	0.31	0.26	0.21	0.14	0.38	0.28	0.31	0.25	0.35	0.12	0.34	0.41	0.32	0.35	0.28	0.37	0.33	0.30	0.27	0.32	0.24		0.30	0.29	0.20	0.21	0.30	0.32	0.30	0.19	0.36	
CaO	2.36	7.20	8.28	3.09	7.06	9.08	6.31	4.38	7.47	2.27	5.17	8.71	5.48	9.33	6.77	7.13	7.91	7.17	7.50	6.46	6.75	2.11	5.55	9.44	3.35	4.34	3.86	10.42	9.11	2.52	9.23	
Na ₂ O	9.77	7.15	6.71	9.33	7.36	6.08	7.47	8.72	7.02	9.87	8.37	6.69	8.26	5.89	7.22	6.93	6.60	6.86	6.67	7.48	7.13	9.53	7.60	5.61	9.59	8.85	9.23	5.53	6.18	9.84	6.05	
K ₂ O	0.62	0.45	0.31	0.78	0.54	0.32	0.58	0.59	0.43	0.71	0.87	0.38	0.48	0.36	0.60	0.52	0.44	0.50	0.40	0.45	0.33	0.14	0.61	0.29	0.43	0.67	0.47	0.25	0.35	0.72	0.28	
BaO	0.01		0.08	0.04	0.02	0.03	0.06	0.22		0.06	0.06	0.09	0.08	0.04	0.06	0.06	0.01	0.05	0.06	0.07	0.07	0.04		0.12	0.09	0.06	0.09	0.12	0.06	0.13	0.03	
Total	100.6	99.97	100.2	99.67	100.5	100.2	100.4	100.8	99.95	100.2	100.0	99.88	99.36	99.98	99.89	100.1	100.1	99.73	99.52	100.0	99.34	98.74	99.82	99.49	99.43	100.0	100.2	100.3	99.88	99.65	98.83	
X _{An}	0.11	0.35	0.40	0.15	0.34	0.44	0.31	0.21	0.36	0.11	0.24	0.41	0.26	0.46	0.33	0.35	0.39	0.36	0.37	0.31	0.34	0.11	0.28	0.47	0.16	0.21	0.18	0.50	0.44	0.12	0.45	
X _{Ab}	0.85	0.63	0.58	0.81	0.63	0.54	0.66	0.76	0.61	0.85	0.71	0.57	0.71	0.52	0.64	0.62	0.59	0.62	0.60	0.66	0.64	0.88	0.69	0.51	0.82	0.76	0.79	0.48	0.54	0.84	0.53	
X _{Or}	0.04	0.03	0.02	0.04	0.03	0.02	0.03	0.03	0.02	0.04	0.05	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.01	0.04	0.02	0.02	0.04	0.03	0.01	0.02	0.04	0.02	

¹ Position represent the relative position of spot analyses within the crystal: int — intermediate between core and border

inc: phase included in Amp

Table 3

Microprobe analyses of amphiboles from the Cerro Munro tonalites

Sample	29	29	29	29	29	32	32	32	32	32	32	36	36	36	36	36	36	
Run	291	293	298	2911	2917	321	329	3210	3217	3222	3223	362	367	368	369	3612	3613	3621
Position ⁽¹⁾	int	int	core	core	core	int	core	rim	core	core	int	core	rim	core	int	core	rim	int
SiO ₂	49.30	49.60	49.07	50.35	49.81	50.19	48.97	52.36	47.79	47.56	51.78	47.12	52.32	49.28	49.29	47.54	51.90	49.22
TiO ₂	1.51	1.31	1.38	1.11	1.29	1.24	1.36	0.68	1.66	1.87	0.71	1.67	0.80	1.08	1.06	1.57	0.72	1.35
Al ₂ O ₃	5.59	5.29	5.74	4.57	5.01	4.74	5.13	3.42	6.52	6.62	3.48	6.19	3.27	4.57	4.38	5.95	3.54	4.94
Cr ₂ O ₃		0.00		0.06	0.08	0.09	0.03	0.09	0.02	0.07		0.03	0.06			0.03	0.04	
FeO	11.73	11.48	10.97	12.91	12.55	11.49	12.62	9.86	11.37	12.58	9.84	12.31	9.04	12.72	13.45	11.95	8.91	12.42
MnO	0.20	0.20	0.23	0.27	0.30	0.26	0.32	0.11	0.16	0.29	0.14	0.19	0.21	0.31	0.34	0.21	0.09	0.29
MgO	16.21	16.59	16.43	15.98	15.97	16.60	15.45	18.49	16.07	15.28	18.01	15.80	18.73	15.75	15.39	15.94	19.00	15.58
NiO	0.04	0.05	0.03	0.12	0.02	0.02	0.04	0.09		0.06	0.10	0.03	0.04	0.05		0.01	0.05	0.06
CaO	11.31	11.22	11.15	11.05	11.06	11.12	10.83	11.43	10.94	11.00	11.68	11.00	11.78	11.10	11.04	11.07	11.69	11.18
Na ₂ O	1.63	1.54	1.65	1.40	1.43	1.58	1.51	1.25	2.02	2.03	1.31	1.59	1.01	1.31	1.12	1.58	1.06	1.22
K ₂ O	0.51	0.49	0.52	0.41	0.50	0.45	0.48	0.38	0.60	0.64	0.38	0.57	0.34	0.43	0.43	0.52	0.40	0.45
F	0.09	0.36	0.31	0.27	0.23	0.57	0.69	1.15	0.73	1.32	1.20	0.75	0.61	0.78	0.83	0.45	1.01	0.69
Total	98.10	98.13	97.48	98.5	98.24	98.34	97.42	99.29	97.87	99.33	98.63	97.25	98.20	97.38	97.30	96.82	98.41	97.4
Si (T)	7.10	7.12	7.10	7.22	7.16	7.20	7.14	7.39	6.95	6.91	7.39	6.97	7.41	7.19	7.21	6.96	7.35	7.17
Al (T)	0.90	0.88	0.90	0.77	0.84	0.80	0.86	0.57	1.05	1.09	0.59	1.03	0.55	0.79	0.75	1.03	0.59	0.83
Ti (T)				0.01				0.04				0.02		0.02	0.03	0.02	0.06	
Ti (C)	0.16	0.14	0.15	0.11	0.14	0.13	0.15	0.03	0.18	0.20	0.05	0.19	0.04	0.10	0.08	0.15	0.02	0.15
Al (C)	0.05	0.01	0.08		0.01	0.00	0.02	0.07	0.04	0.04		0.05						0.02
Cr (C)				0.01	0.01	0.01	0.00	0.01	0.00	0.01		0.00	0.01			0.00	0.01	
Fe ³⁺ (C)	0.23	0.39	0.23	0.44	0.42	0.37	0.40	0.40	0.24	0.24	0.30		0.35	0.42	0.48	0.45	0.42	0.38
Ni (C)	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01		0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01
Fe ²⁺ (C)	1.08	0.90	0.99	1.02	1.01	0.93	1.06	0.66	1.02	1.19	0.80	1.27	0.65	1.05	1.09	0.91	0.54	1.06
Mg (C)	3.48	3.55	3.54	3.42	3.42	3.55	3.36	3.89	3.48	3.31	3.83	3.48	3.95	3.43	3.36	3.48	4.01	3.39
Mn ²⁺ (B)	0.02	0.02	0.03	0.03	0.04	0.03	0.04	0.01	0.02	0.04	0.02	0.02	0.03	0.04	0.04	0.03	0.01	0.04
Fe ²⁺ (B)	0.11	0.09	0.11	0.09	0.08	0.08	0.08	0.10	0.12	0.10	0.07	0.25	0.08	0.08	0.08	0.10	0.10	0.07
Ca (B)	1.75	1.73	1.73	1.70	1.70	1.71	1.69	1.73	1.71	1.71	1.79	1.73	1.79	1.74	1.73	1.74	1.77	1.75
Na (B)	0.12	0.16	0.14	0.18	0.18	0.19	0.19	0.16	0.16	0.15	0.13		0.11	0.14	0.14	0.14	0.12	0.15
Na (A)	0.33	0.27	0.33	0.21	0.22	0.26	0.23	0.19	0.41	0.42	0.23	0.46	0.16	0.23	0.18	0.31	0.17	0.20
K (A)	0.09	0.09	0.10	0.08	0.09	0.08	0.09	0.07	0.11	0.12	0.07	0.11	0.06	0.08	0.08	0.10	0.07	0.08
OH (W)	1.96	1.84	1.86	1.88	1.90	1.74	1.68	1.49	1.67	1.39	1.46	1.65	1.73	1.64	1.62	1.79	1.55	1.68
F (W)	0.04	0.16	0.14	0.12	0.10	0.26	0.32	0.51	0.34	0.61	0.54	0.35	0.28	0.36	0.38	0.21	0.45	0.32
Cl (W)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sum																		
T,C,B,A	15.42	15.36	15.42	15.29	15.31	15.34	15.32	15.25	15.52	15.54	15.31	15.58	15.23	15.31	15.26	15.40	15.25	15.28
#Mg	0.75	0.78	0.76	0.75	0.76	0.78	0.75	0.84	0.75	0.72	0.81	0.70	0.85	0.75	0.74	0.77	0.86	0.75
P (kbar) ⁽³⁾	0.64	0.69	0.77	0.58	0.64	0.60	0.68	0.44	0.94	0.96	0.44	0.88	0.42	0.59	0.56	0.83	0.45	0.64

¹ Position represent the relative position of spot analyses within the crystal: int — intermediate between core and border

² Structural amphibole formula was calculated according to Locock A- J. (2014)

³ Pressure obtained by Amp barometry from Ridolfi et al. (2010).

ACCEPTED MANUSCRIPT

Table 3 (continued)

Microprobe analyses of amphiboles from the Cerro Munro tonalites

Sample	37	37	37	37	37	37	37	37	37	37	37	37	37
Run	371	374	378	379	3710	3711	3715	3716	3721	3722	3725	3729	3731
Position ⁽¹⁾	int	int	core	int	rim	core	rim	int	core	rim	rim	int	int
SiO ₂	48.55	48.64	50.81	47.40	52.27	48.89	48.36	47.99	48.16	50.92	49.30	48.89	48.09
TiO ₂	1.36	1.54	1.08	1.55	0.61	1.50	1.53	1.72	1.39	0.79	1.18	1.54	1.65
Al ₂ O ₃	5.30	5.57	3.80	6.33	3.01	5.33	5.64	6.03	5.19	3.98	4.71	5.55	5.88
Cr ₂ O ₃				0.11	0.03		0.15	0.00		0.07			0.04
FeO	13.35	12.82	11.63	13.57	10.35	13.56	13.91	12.27	13.85	9.43	14.35	13.32	12.35
MnO	0.29	0.21	0.27	0.26	0.31	0.29	0.34	0.30	0.31	0.24	0.37	0.30	0.24
MgO	15.27	15.63	16.86	14.97	17.63	15.19	14.90	15.70	14.89	18.09	14.94	15.23	15.85
NiO	0.04	0.01	0.01	0.03		0.07	0.06				0.00	0.00	0.08
CaO	10.87	10.93	11.07	10.89	11.55	10.73	10.79	10.84	10.83	11.56	10.76	10.82	10.98
Na ₂ O	1.78	1.96	1.40	2.05	1.20	1.81	1.79	2.02	1.82	1.59	1.74	1.78	2.00
K ₂ O	0.51	0.54	0.40	0.59	0.30	0.50	0.53	0.54	0.50	0.52	0.49	0.51	0.50
F	1.33	1.20	1.53	1.30	1.14	1.54	1.26	0.81	1.26	2.03	1.19	1.21	0.76
Total	98.62	99.06	98.86	99.04	98.39	99.41	99.25	98.21	98.19	99.22	99.03	99.14	98.4
Si (T)	7.10	7.06	7.31	6.93	7.48	7.10	7.04	6.99	7.09	7.31	7.19	7.09	6.99
Al (T)	0.90	0.94	0.64	1.07	0.51	0.90	0.96	1.01	0.90	0.67	0.81	0.91	1.01
Ti (T)			0.05		0.02				0.01	0.01	0.01		0.00
Ti (C)	0.15	0.17	0.07	0.17	0.05	0.16	0.17	0.19	0.15	0.07	0.12	0.17	0.18
Al (C)	0.01	0.01		0.02		0.02	0.01	0.02				0.04	
Cr (C)				0.01	0.00		0.02			0.01			0.00
Fe ³⁺ (C)	0.28	0.25	0.40	0.28	0.30	0.28	0.29	0.26	0.27	0.20	0.29	0.27	0.27
Ni (C)	0.00	0.00	0.00	0.00		0.01	0.01						0.01
Fe ²⁺ (C)	1.24	1.19	0.92	1.26	0.89	1.24	1.28	1.12	1.32	0.85	1.34	1.23	1.11
Mg (C)	3.33	3.38	3.61	3.26	3.76	3.29	3.23	3.41	3.27	3.87	3.25	3.29	3.43
Mn ²⁺ (B)	0.04	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.03	0.05	0.04	0.03
Fe ²⁺ (B)	0.12	0.12	0.08	0.13	0.05	0.13	0.13	0.11	0.12	0.08	0.12	0.12	0.13
Ca (B)	1.70	1.70	1.71	1.71	1.77	1.67	1.68	1.69	1.71	1.78	1.68	1.68	1.71
Na (B)	0.14	0.15	0.18	0.14	0.14	0.17	0.15	0.16	0.14	0.11	0.15	0.16	0.14
Na (A)	0.36	0.40	0.21	0.45	0.19	0.34	0.36	0.41	0.38	0.34	0.34	0.34	0.43
K (A)	0.09	0.10	0.07	0.11	0.06	0.09	0.10	0.10	0.09	0.10	0.09	0.09	0.09
OH (W)	1.38	1.45	1.30	1.40	1.48	1.29	1.42	1.63	1.42	1.08	1.45	1.44	1.65
F (W)	0.62	0.55	0.70	0.60	0.52	0.71	0.58	0.37	0.58	0.92	0.55	0.56	0.35
Cl (W)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sum													
T,C,B,A	15.46	15.50	15.29	15.55	15.24	15.43	15.46	15.51	15.47	15.43	15.43	15.43	15.52
#Mg	0.71	0.72	0.78	0.70	0.80	0.71	0.70	0.73	0.69	0.81	0.69	0.71	0.74
P (kbar) ⁽³⁾	0.70	0.75	0.49	0.90	0.40	0.70	0.76	0.84	0.69	0.50	0.61	0.74	0.80

¹ Position represent the relative position of spot analyses within the crystal: int — intermediate between core and border

² Structural amphibole formula was calculated according to Locock A- J. (2014)

³ Pressure obtained by Amp barometry from Ridolfi et al. (2010).

ACCEPTED MANUSCRIPT

Table 4

Microprobe analyses of pyroxenes of the Cerro Munro tonalites

Phase	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx
Sample	32 (relict core)	33 (inc)	33 (inc)	33 (inc)	36 (relict core)	36 (relict core)	37 (relict core)
Run	32-21	33-8	33-9	33-11	36-20	36-33	37-13
SiO ₂	52.29	51.96	52.61	52.60	53.85	52.64	52.99
TiO ₂	0.27	0.32	0.20	0.27	0.02	0.11	0.17
Al ₂ O ₃	0.75	1.25	0.93	1.14	0.36	0.46	0.81
Cr ₂ O ₃	0.06	0.09	0.05	n.d.	0.15	n.d.	0.03
FeO	8.79	8.91	8.98	9.42	6.45	10.62	8.22
MnO	0.39	0.33	0.34	0.35	0.32	0.33	0.51
MgO	14.62	14.60	14.37	14.48	15.32	13.33	15.21
NiO	0.00	n.d.	n.d.	0.02	n.d.	n.d.	0.02
CaO	21.54	21.48	21.76	21.67	23.08	21.94	21.49
Na ₂ O	0.49	0.42	0.44	0.43	0.21	0.37	0.38
K ₂ O	0.01	n.d.	0.01	0.00	0.02	n.d.	0.00
F	n.d.	0.15	n.d.	n.d.	0.17	0.13	0.03
Total	99.27	99.59	99.82	100.43	99.95	99.96	99.88
#Mg ⁽¹⁾	0.75	0.74	0.74	0.73	0.81	0.69	0.77

inc: phase included in Pl

¹ Mg# = molar MgO/[MgO+ FeO]

n.d.: not determined

Table 5

Microprobe analyses of plagioclases from the Cerro Munro autoliths

Sample	29b	29b	29b	29b	29b	29b	29b	29b	29b	33a	33a	36A	36a	36a	36a	36a	36B	36B	36B	36B	36B	36B	36B	
Run	29b-6	29b-7	29b-8	29b-9	29b-10	29b-19	29b-20	29b-25	29b-26	33a-12	33a-13	36A-2	36A-4	36A-8	36A-44	36A-46	36B-5	36B-6	36B-14	36B-15	36B-16	36B-17	36B-23	
Position ⁽¹⁾	core	rim	core	int	rim	int	int	int	rim	core	rim	int	core	rim	inc	core	rim	core	rim	core	rim	core	rim	inc
SiO ₂	56.97	64.23	54.58	62.84	65.63	62.57	55.38	57.69	61.33	53.08	62.33	57.14	55.92	63.51	64.07	54.92	56.47	63.16	57.33	65.12	54.79	60.97	59.87	
Al ₂ O ₃	27.30	22.29	29.14	23.63	21.96	24.04	28.78	26.79	24.32	29.39	22.96	26.39	27.93	22.70	23.32	28.75	26.85	22.24	26.38	21.75	28.24	24.34	25.11	
FeO	0.27	0.23	0.30	0.18	0.07	0.36	0.27	0.30	0.33	0.20	0.21	0.44	0.28	0.35	0.27	0.38	0.29	0.19	0.24	0.12	0.24	0.22	0.28	
CaO	8.82	3.21	11.00	4.32	2.28	4.90	10.46	8.18	5.40	11.27	4.18	7.61	9.24	3.07	3.20	10.18	8.55	3.23	7.88	2.45	10.08	5.28	6.36	
Na ₂ O	6.44	9.27	5.23	8.90	10.01	8.49	5.37	6.66	8.35	5.07	8.78	7.07	5.97	9.38	9.38	5.83	6.45	9.45	6.80	9.77	5.69	8.13	7.51	
K ₂ O	0.28	0.85	0.19	0.55	0.18	0.38	0.24	0.31	0.47	0.19	0.55	0.39	0.32	0.56	0.66	0.15	0.31	0.40	0.40	0.61	0.24	0.46	0.42	
BaO		0.09	0.02	0.05			0.12	0.06	0.16	0.04			0.05	0.06	0.02		0.08		0.05	0.06	0.07		0.03	
Total	100.3	100.3	100.8	100.7	100.4	101.1	100.9	100.1	100.5	99.40	99.09	99.15	99.90	99.81	101.1	100.5	99.18	98.86	99.38	100.2	99.51	99.92	99.66	
X _{An}	0.42	0.15	0.53	0.21	0.11	0.24	0.51	0.40	0.26	0.55	0.20	0.36	0.45	0.15	0.15	0.49	0.42	0.16	0.38	0.12	0.49	0.26	0.31	
X _{Ab}	0.56	0.80	0.46	0.76	0.88	0.74	0.47	0.58	0.72	0.44	0.77	0.61	0.53	0.82	0.81	0.50	0.57	0.82	0.60	0.85	0.50	0.72	0.66	
X _{Or}	0.02	0.05	0.01	0.03	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.02	0.02	0.03	0.04	0.01	0.02	0.02	0.02	0.03	0.01	0.03	0.02	

¹ Position represent the relative position of spot analyses within the crystal: int — intermediate between core and border
inc: phase included in Cpx or Amp

Table 5 (continued)

Microprobe analyses of plagioclases from the Cerro Munro autoliths

Sample	37a	37a	37a	37a	37a	37a	38	38	38	38	38	38
Run	37a-3	37a-4	37a-5	37a-6	37a-13	37a-16	38-9	38-10	38-14	38-18	38-19	38-23
Position ⁽¹⁾	int	core	int	rim	int	core	core	rim	inc	core	rim	
SiO ₂	57.90	54.80	58.20	64.38	59.06	58.52	56.50	63.61	61.06	50.40	61.55	60.78
Al ₂ O ₃	26.31	27.88	26.10	21.80	25.56	26.00	27.59	22.83	24.82	31.53	23.90	24.64
FeO	0.25	0.33	0.30	0.41	0.36	0.36	0.31	0.26	0.37	0.30	0.34	0.32
CaO	7.88	9.55	7.83	2.59	7.00	7.65	8.85	3.63	5.71	13.76	5.15	5.80
Na ₂ O	7.27	5.90	7.04	10.03	7.44	7.08	6.38	9.92	7.99	3.61	8.11	7.87
K ₂ O	0.34	0.32	0.38	0.43	0.39	0.49	0.27	0.58	0.56	0.11	0.36	0.66
BaO			0.13	0.03	0.12	0.07	0.02	0.09	0.05	0.06		0.01
Total	100.2	99.06	100.1	99.83	100.2	100.4	100.2	101.3	100.8	99.90	99.60	100.4
X _{An}	0.37	0.46	0.37	0.12	0.33	0.36	0.43	0.16	0.27	0.67	0.25	0.28
X _{Ab}	0.61	0.52	0.61	0.85	0.64	0.61	0.56	0.81	0.69	0.32	0.72	0.68
X _{Or}	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.01	0.02	0.04

¹ Position represent the relative position of spot analyses within the crystal: int — intermediate between core and border

inc: phase included in Cpx or Amp

Table 6

Microprobe analyses of amphiboles from the Cerro Munro autoliths

Sample Position ⁽¹⁾	29b int	29b int	29b int	29b int	29b rim	29b core	29b rim	29b core	29b int	29b rim	29b rim	29b int	33a core	33a rim	33a rim	33a int	33a int	33a int	33a int	33a int	33a core	33a rim	33a int
Run	29b1	29b3	29b4	29b11	29b12	29b14	29b17 (inc)	29b21 (inc)	29b22	29b23	29b24 (inc)	29b27	33a1	33a2	33a4	33a5	33a11	33a14	33a15	33a17	33a18	33a19	33a23
SiO ₂	49.40	49.11	50.27	50.70	53.84	49.58	49.17	53.84	49.55	52.83	51.18	50.39	53.67	53.88	55.06	47.32	52.30	52.42	52.93	53.06	54.31	52.11	49.06
TiO ₂	1.11	1.13	1.25	0.99	0.35	1.35	1.26	0.23	1.49	0.62	0.26	1.04	0.16	0.23	0.06	1.62	0.14	0.33	0.07	0.17	0.29	0.13	1.32
Al ₂ O ₃	4.64	4.85	4.40	4.04	2.08	5.03	5.24	1.50	5.17	2.84	3.86	4.48	1.40	1.75	0.47	5.99	1.27	2.12	1.51	1.33	1.74	1.76	5.29
Cr ₂ O ₃	0.08	0.09	0.01	0.02			0.02	0.00		0.05	0.03	0.13	0.04	0.03	0.09	0.12	0.06	0.11	0.04	0.09			0.05
FeO	14.06	14.35	13.92	14.08	10.70	12.15	14.01	12.14	12.35	11.14	13.50	13.08	14.90	10.57	10.05	14.32	18.11	13.59	16.20	18.71	7.86	15.83	13.07
MnO	0.33	0.31	0.33	0.42	0.51	0.31	0.41	0.43	0.27	0.21	0.41	0.21	0.64	0.30	0.38	0.51	0.66	0.42	0.54	0.70	0.18	0.49	0.30
MgO	15.06	14.74	15.23	15.24	18.14	16.15	14.88	17.45	16.12	17.16	16.12	15.76	14.37	17.67	18.03	14.04	12.16	15.06	14.03	11.74	19.37	14.14	15.77
NiO	0.05		0.01							0.04			0.04	0.08	0.03	0.04	0.00	0.03			0.02	0.03	
CaO	11.06	10.96	10.99	11.08	11.26	11.08	11.16	11.53	11.14	12.12	10.84	11.14	12.16	12.13	12.48	11.15	11.89	12.55	11.53	11.81	12.22	12.04	11.15
Na ₂ O	1.20	1.46	1.35	1.19	0.58	1.42	1.47	0.35	1.49	0.71	0.96	1.30	0.18	0.40	0.07	1.55	0.25	0.27	0.23	0.24	0.45	0.29	1.49
K ₂ O	0.41	0.43	0.37	0.33	0.12	0.50	0.47	0.11	0.48	0.23	0.28	0.39	0.07	0.08	0.03	0.54	0.08	0.08	0.07	0.05	0.15	0.10	0.56
F	0.25	0.33	0.40	0.34	0.45	0.55	0.40	0.13	0.25	0.26	0.04	0.25	0.08	0.27		0.58	0.17	0.16		0.03	0.45	0.10	0.67
Total	97.63	97.75	98.53	98.43	98.03	98.12	98.48	97.70	98.29	98.21	97.49	98.17	97.70	97.38	96.73	97.78	97.07	97.13	97.15	97.94	97.03	97.01	98.73
Si (T)	7.18	7.16	7.24	7.30	7.65	7.14	7.12	7.69	7.12	7.52	7.37	7.25	7.81	7.70	7.88	6.98	7.79	7.63	7.76	7.84	7.71	7.65	7.10
Al (T)	0.80	0.83	0.75	0.69	0.35	0.85	0.88	0.25	0.87	0.48	0.63	0.75	0.19	0.30	0.08	1.02	0.21	0.36	0.24	0.16	0.29	0.31	0.90
Ti (T)	0.02	0.01	0.01	0.01	0.00			0.03	0.01	0.00				0.01	0.01			0.01			0.00	0.01	0.00
Ti (C)	0.10	0.12	0.13	0.10	0.03	0.15	0.14		0.15	0.07	0.03	0.11	0.02	0.02		0.18	0.02	0.03	0.01	0.02	0.03		0.14
Al (C)							0.02			0.02	0.03	0.01	0.05			0.03	0.01		0.02	0.07			
Cr (C)	0.01	0.01	0.00	0.00			0.00			0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01			0.01
Fe ³⁺ (C)	0.47	0.42	0.41	0.42	0.26	0.41	0.40	0.26	0.41	0.26	0.49	0.40	0.09	0.24	0.10	0.25	0.15	0.24	0.18	0.06	0.21	0.32	0.29
Ni (C)	0.01		0.00							0.01			0.01	0.01	0.00	0.01		0.00			0.00	0.00	
Fe ²⁺ (C)	1.15	1.25	1.18	1.20	0.87	0.97	1.24	1.02	0.99	1.02	0.99	1.08	1.72	0.97	1.05	1.43	2.11	1.41	1.72	2.25	0.66	1.59	1.16
Mg (C)	3.27	3.20	3.27	3.27	3.84	3.47	3.21	3.72	3.45	3.64	3.46	3.38	3.12	3.76	3.85	3.09	2.70	3.27	3.07	2.59	4.10	3.09	3.40
Mn ²⁺ (B)	0.04	0.04	0.04	0.05	0.06	0.04	0.05	0.05	0.03	0.03	0.05	0.03	0.08	0.04	0.05	0.06	0.07	0.02	0.07	0.08	0.02	0.06	0.04
Fe ²⁺ (B)	0.09	0.08	0.08	0.07	0.14	0.08	0.06	0.14	0.08	0.04	0.14	0.09	0.00	0.05	0.03	0.08		0.09			0.06	0.01	0.13
Ca (B)	1.72	1.71	1.70	1.71	1.71	1.71	1.73	1.77	1.71	1.85	1.67	1.72	1.89	1.86	1.91	1.76	1.90	1.96	1.81	1.87	1.86	1.89	1.73
Na (B)	0.15	0.16	0.18	0.17	0.08	0.17	0.16	0.05	0.17	0.08	0.13	0.17	0.03	0.06	0.01	0.09	0.04	0.02	0.03	0.05	0.06	0.04	0.10
Na (A)	0.19	0.25	0.19	0.17	0.08	0.23	0.26	0.05	0.25	0.12	0.13	0.19	0.03	0.06	0.01	0.35	0.04	0.06	0.03	0.02	0.06	0.04	0.32
K (A)	0.08	0.08	0.07	0.06	0.02	0.09	0.09	0.02	0.09	0.04	0.05	0.07	0.01	0.02	0.01	0.10	0.02	0.01	0.01	0.01	0.03	0.02	0.10
OH (W)	1.89	1.85	1.82	1.85	1.80	1.75	1.82	1.94	1.89	1.88	1.98	1.89	1.96	1.88	2.00	1.73	1.92	1.93	2.00	1.99	1.80	1.96	1.70
F (W)	0.11	0.15	0.18	0.15	0.20	0.25	0.18	0.06	0.11	0.12	0.02	0.11	0.04	0.12		0.27	0.08	0.07		0.01	0.20	0.05	0.30
Cl (W)	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Sum T,C,B,A	15.27	15.33	15.26	15.23	15.10	15.32	15.35	15.07	15.33	15.16	15.19	15.27	15.04	15.07	15.01	15.45	15.05	15.07	15.05	15.03	15.09	15.06	15.42
#Mg	0.72	0.71	0.72	0.72	0.79	0.77	0.71	0.76	0.76	0.77	0.75	0.74	0.64	0.79	0.78	0.67	n.d.	n.d.	0.63	n.d.	0.85	0.66	0.72

P (kbar)⁽³⁾ 0.60 0.63 0.56 0.51 0.32 0.65 0.69 0.28 0.67 0.38 0.50 0.57 0.27 0.29 0.22 0.85 0.26 0.32 0.28 0.27 0.29 0.30 0.69

inc: phase included in Pl or Fe-Ti oxide

¹ Position represent the relative position of spot analyses within the crystal: int — intermediate between core and border

² Structural amphibole formula was calculated according to Locock (2014)

³ Pressure obtained by Amp barometry from Ridolfi et al. (2010)

Table 6 (continued)

Microprobe analyses of amphiboles from the Cerro Munro autoliths

Sample Position ⁽¹⁾	36a core	36a rim	36a rim	36a int	36a int	36a rim	36a core	36a core	36B rim	36B rim	36B core	36B int	36B rim	36B int	36B rim	36B int	38 int	38 int	38 core	38 rim	38 int	38 int	38 rim	38 int	38 int	38 rim	38 core	
Run	36A10	36A11	36A16	36A32 (inc)	36A38 (inc)	36A40	36A4 2	36A43 (inc)	36B2	36B4	36B1 2	36B1 8	36B1 9	36B2 4	37a rim	37a int	38 385	38 386	38 387	38 388	38 3812	38 3813	38 3817	38 3820	38 3826	38 3828	38 3829	
SiO ₂	49.35	51.50	51.85	50.05	50.25	49.36	54.59	50.00	46.72	52.52	47.74	47.76	48.80	48.57	53.51	49.78	50.88	49.90	49.77	54.04	47.01	49.25	49.67	49.85	50.28	50.91	49.03	
TiO ₂	1.16	0.76	0.61	0.76	0.92	1.10	0.29	0.82	1.75	0.67	1.84	1.70	1.45	1.50	0.32	0.93	0.71	0.98	1.01	0.35	1.86	1.27	0.79	1.05	1.03	0.64	1.06	
Al ₂ O ₃	4.97	3.51	3.54	4.20	4.13	4.67	1.34	4.55	6.54	2.84	6.63	6.04	5.72	5.52	1.39	3.89	3.72	4.04	4.04	2.02	7.01	4.80	3.98	4.50	4.27	4.02	5.13	
Cr ₂ O ₃		0.09		0.06	0.01		0.10	0.10	0.05	0.01	0.06	0.11		0.10		0.10	0.02	0.09	0.05	0.07	0.04	0.07		0.03		0.00		
FeO	13.99	10.60	9.98	14.21	14.95	14.29	9.24	14.24	12.39	8.11	11.48	12.68	12.37	13.13	12.14	14.16	13.94	13.69	14.29	9.43	11.50	12.19	13.83	12.52	13.71	13.49	14.56	
MnO	0.30	0.17	0.27	0.31	0.34	0.30	0.21	0.32	0.26	0.13	0.20	0.16	0.26	0.25	0.14	0.38	0.29	0.33	0.37	0.29	0.11	0.22	0.37	0.16	0.27	0.34	0.28	
MgO	14.88	17.27	18.05	15.08	15.55	15.41	19.35	15.50	15.76	19.15	16.20	15.32	15.65	15.42	17.01	15.09	15.08	15.17	14.72	18.84	15.55	16.19	15.08	15.77	15.18	15.66	14.28	
NiO	0.07		0.07	0.04		0.10			0.01	0.04			0.04		0.05		0.02	0.04	0.05	0.04	0.03	0.04	0.05	0.05	0.09		0.00	
CaO	11.01	11.67	11.27	11.03	10.94	10.80	11.73	10.90	11.07	12.12	10.98	11.00	11.19	11.09	11.70	10.90	10.93	10.81	10.81	12.25	10.99	11.02	10.81	11.04	10.91	10.78	10.99	
Na ₂ O	1.20	0.82	0.81	0.90	0.94	1.20	0.45	1.11	1.78	0.71	1.83	1.67	1.54	1.44	0.53	1.38	1.06	1.16	1.13	0.55	1.99	1.36	0.94	1.20	1.14	1.05	1.43	
K ₂ O	0.43	0.36	0.26	0.38	0.36	0.41	0.13	0.37	0.56	0.23	0.52	0.51	0.50	0.49	0.19	0.34	0.27	0.35	0.34	0.12	0.63	0.46	0.30	0.39	0.31	0.29	0.46	
F	0.49	0.93	0.65	0.25	0.08	0.43	0.38	0.49	0.55	0.56	0.55	0.85	0.38	0.67	0.77	1.38	0.07	0.22	0.23	0.07	0.16	0.36	0.16	0.04	0.07	0.34	0.15	
Total	97.85	97.68	97.36	97.27	98.46	98.06	97.81	98.38	97.43	97.10	98.02	97.79	97.90	98.17	97.74	98.32	96.99	96.78	96.80	98.06	96.87	97.23	96.03	96.57	97.29	97.53	97.37	
Si (T)	7.18	7.41	7.42	7.29	7.22	7.14	7.71	7.21	6.82	7.47	6.91	6.99	7.06	7.05	7.71	7.28	7.40	7.27	7.27	7.60	6.89	7.15	7.31	7.26	7.27	7.37	7.18	
Al (T)	0.82	0.59	0.58	0.71	0.70	0.80	0.22	0.77	1.13	0.48	1.09	1.01	0.94	0.94	0.24	0.67	0.60	0.69	0.70	0.33	1.11	0.82	0.69	0.74	0.73	0.64	0.83	
Ti (T)					0.08	0.06	0.03	0.02	0.05	0.05				0.01	0.03	0.05		0.04	0.03	0.04				0.03		0.00		
Ti (C)	0.13	0.08	0.07	0.08	0.02	0.06		0.07	0.14	0.02	0.20	0.19	0.16	0.15		0.05	0.08	0.07	0.08		0.21	0.11	0.09	0.12	0.11	0.07	0.12	
Al (C)	0.03	0.00	0.01	0.01							0.05	0.04	0.04				0.04			0.10			0.00	0.03		0.05	0.06	
Cr (C)		0.01		0.01	0.00		0.01	0.01	0.01	0.00	0.01	0.01		0.01		0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01		0.00			
Fe ³⁺ (C)	0.44	0.34	0.39	0.45	0.59	0.60	0.23	0.55	0.51	0.35	0.29	0.26	0.37	0.43	0.22	0.44	0.39	0.61	0.59	0.33	0.22	0.45	0.44	0.40	0.58	0.41	0.38	
Ni (C)	0.01		0.01	0.01		0.01			0.00	0.01			0.01		0.01		0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01		
Fe ²⁺ (C)	1.17	0.87	0.67	1.17	1.06	1.01	0.69	1.04	0.91	0.56	0.97	1.16	1.05	1.07	1.12	1.21	1.22	1.02	1.11	0.71	1.08	0.93	1.14	1.03	1.03	1.09	1.33	
Mg (C)	3.23	3.70	3.85	3.27	3.33	3.32	4.07	3.33	3.43	4.06	3.50	3.34	3.38	3.33	3.65	3.29	3.27	3.29	3.20	3.95	3.40	3.50	3.31	3.42	3.27	3.38	3.12	
Mn ²⁺ (B)	0.04	0.02	0.03	0.04	0.04	0.04	0.03	0.04	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.05	0.04	0.04	0.05	0.04	0.01	0.03	0.05	0.02	0.03	0.04	0.03	
Fe ²⁺ (B)	0.09	0.07	0.13	0.12	0.15	0.12	0.14	0.13	0.09	0.06	0.14	0.13	0.07	0.09	0.10	0.08	0.09	0.04	0.04	0.04	0.11	0.10	0.12	0.10	0.05	0.13	0.07	
Ca (B)	1.72	1.80	1.73	1.72	1.68	1.68	1.78	1.68	1.73	1.85	1.70	1.73	1.73	1.72	1.81	1.71	1.70	1.69	1.69	1.85	1.72	1.71	1.70	1.72	1.69	1.67	1.72	
Na (B)	0.16	0.11	0.11	0.13	0.13	0.17	0.06	0.15	0.14	0.08	0.13	0.12	0.16	0.15	0.07	0.17	0.17	0.23	0.22	0.08	0.15	0.16	0.13	0.16	0.22	0.16	0.17	
Na (A)	0.18	0.12	0.11	0.13	0.13	0.17	0.06	0.16	0.36	0.12	0.38	0.35	0.28	0.25	0.08	0.22	0.13	0.10	0.10	0.08	0.42	0.23	0.14	0.18	0.09	0.14	0.24	
K (A)	0.08	0.07	0.05	0.07	0.07	0.08	0.02	0.07	0.10	0.04	0.10	0.10	0.09	0.09	0.03	0.06	0.05	0.07	0.06	0.02	0.12	0.09	0.06	0.07	0.06	0.05	0.09	
OH (W)	1.77	1.58	1.71	1.88	1.96	1.80	1.83	1.78	1.75	1.75	1.75	1.61	1.83	1.69	1.65	1.36	1.97	1.90	1.89	1.97	1.93	1.83	1.93	1.98	1.97	1.85	1.93	
F (W)	0.23	0.42	0.29	0.12	0.04	0.20	0.17	0.23	0.25	0.25	0.25	0.40	0.17	0.31	0.35	0.64	0.03	0.10	0.11	0.03	0.08	0.17	0.07	0.02	0.03	0.16	0.07	
Cl (W)	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Sum T,C,B ₂ A	15.26	15.19	15.16	15.20	15.20	15.25	15.09	15.22	15.47	15.16	15.48	15.44	15.37	15.34	15.11	15.29	15.18	15.17	15.16	15.10	15.53	15.31	15.19	15.25	15.15	15.19	15.32	
#Mg	0.72	0.80	0.83	0.72	0.73	0.75	0.83	0.74	0.77	0.87	0.76	0.72	0.75	0.74	0.75	0.72	0.71	0.76	0.74	0.84	0.74	0.77	0.72	0.75	0.75	0.73	0.69	

P (kbar)⁽³⁾ 0.65 0.45 0.46 0.54 0.53 0.61 0.26 0.59 0.96 0.38 0.96 0.84 0.77 0.74 0.27 0.51 0.48 0.52 0.52 0.31 1.08 0.62 0.52 0.58 0.54 0.51 0.68

inc: phase included in Pl or Fe-Ti oxide

¹ Position represent the relative position of spot analyses within the crystal: int — intermediate between core and border

² Structural amphibole formula was calculated according to Locock A- J., (2014)

³ Pressure obtained by Amp barometry from Ridolfi et al. (2010)

Table 7
Microprobe analyses of pyroxenes from the Cerro Munro autoliths

Phase	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Cpx	Opx	
Sample	36a	36a	36a	36a	36a	36a	36a	36a	36a	36a	36a	36a	36a	36a	36B	36B	36B	37a	37a	37a	37a	37a	37a	37a	
Run	36A-3	36A-13	36A-14	36A-15	36A-22	36A-23	36A-24	36A-25	36A-28	36A-29	36A-30	36A-31	36A-39	36A-47	36B-1	36B-10	36B-11	37a-2	37a-7	37a-10	37a-11	37a-15	37a-19	37a-20	37a-12
Position ⁽¹⁾	inc	core	rim	core	core					core			core, inc	rim, inc	core			inc	core	rim	inc	core	rim	inc	
SiO ₂	51.29	52.99	51.93	53.11	52.56	52.56	51.96	53.21	53.30	52.58	52.64	52.15	52.43	51.60	51.94	52.64	52.28	53.54	51.97	52.07	53.47	52.82	53.38	52.40	52.70
TiO ₂	0.65	0.03	0.16	0.06	0.13	0.10	0.21	0.08	0.09	0.12	0.13	0.21	0.09	0.41	0.21	0.15	0.16	0.06	0.33	0.12	0.05	0.30	0.09	0.21	0.21
Al ₂ O ₃	1.84	0.40	0.74	0.17	0.75	0.14	1.12	0.44	0.37	0.96	0.81	0.94	0.48	1.91	0.78	1.16	0.98	0.34	1.17	0.85	0.33	1.09	0.38	1.11	0.57
Cr ₂ O ₃	0.09	0.01	n.d.	0.10	n.d.	0.01	0.08	0.10	0.02	0.04	0.05	0.06	0.05	0.12	0.10	n.d.	0.16	n.d.	0.03	n.d.	n.d.	n.d.	n.d.	0.09	0.07
FeO	9.50	6.65	10.44	8.32	10.22	10.20	9.92	6.20	6.34	7.99	8.40	9.06	10.02	7.64	8.77	7.06	8.06	7.37	9.41	8.83	7.32	9.49	7.47	9.18	21.86
MnO	0.34	0.22	0.32	0.29	0.35	0.34	0.29	0.27	0.14	0.13	0.31	0.28	0.38	0.21	0.27	0.23	0.35	0.24	0.30	0.30	0.32	0.36	0.27	0.26	0.71
MgO	14.22	15.51	13.95	14.60	13.71	13.59	13.38	15.50	15.45	14.30	14.50	14.68	14.35	15.47	14.90	14.92	15.29	15.05	14.78	14.48	15.53	14.47	15.16	13.88	22.60
NiO	0.11	0.03	0.02	0.06	0.05	0.01	0.10	0.01	n.d.	0.01	0.09	0.04	0.08	0.06	0.03	0.05	0.03	n.d.	0.04	0.07	0.04	n.d.	0.02	n.d.	0.02
CaO	21.07	23.20	21.47	22.95	21.67	22.30	22.06	23.46	23.55	23.09	22.20	21.30	21.66	21.93	21.60	23.04	21.95	22.89	20.90	21.56	22.76	21.30	22.82	22.21	1.09
Na ₂ O	0.46	0.28	0.28	0.14	0.21	0.13	0.31	0.23	0.23	0.31	0.32	0.26	0.34	0.31	0.40	0.31	0.39	0.28	0.46	0.44	0.31	0.43	0.36	0.50	0.03
K ₂ O	0.02	0.02	n.d.	0.02	0.01	0.01	n.d.	0.01	0.00	n.d.	n.d.	0.02	0.01	0.01	n.d.	0.01	0.01	0.01	n.d.	0.01	0.01	0.00	0.01	0.00	0.00
F	n.d.	0.03	0.06	n.d.	0.07	n.d.	0.19	n.d.	n.d.	n.d.	0.09	0.24	n.d.	n.d.	0.22	0.02	n.d.	0.11	0.03	0.10	0.03	0.06	n.d.	0.08	n.d.
Total	99.61	99.51	99.38	99.85	99.76	99.40	99.61	99.55	99.55	99.61	99.53	99.26	99.91	99.79	99.27	99.60	99.72	99.98	99.50	98.91	100.16	100.37	99.99	99.96	99.95
#Mg ⁽²⁾	0.73	0.81	0.70	0.76	0.71	0.70	0.71	0.82	0.81	0.76	0.75	0.74	0.72	0.78	0.75	0.79	0.77	0.78	0.74	0.75	0.79	0.73	0.78	0.73	0.65

inc: phase included in Pl

¹ Position represent the relative position of spot analyses within the crystal: inc — inclusion

² Mg# = molar MgO/[MgO+ FeO]

n.d.: not determined

Table 7 (continued)

Microprobe analyses of pyroxenes from the Cerro Munro autoliths

Phase	Cpx	Cpx	Cpx	Cpx	Cpx	Opx	Opx	Opx	Opx
Sample	37	38	38	38	38	38	38	38	38
Run	38-1	38-11	38-16	38-22	38-25	38-2	38-15	38-21	38-27
Position ⁽¹⁾	int	relic core		inc		inc		inc	relic core
SiO ₂	51.80	53.14	52.42	52.81	52.43	52.56	52.87	53.04	53.60
TiO ₂	0.26	0.09	0.35	0.26	0.41	0.23	0.19	0.21	0.14
Al ₂ O ₃	1.10	0.43	1.18	0.87	1.45	0.61	0.66	0.63	0.45
Cr ₂ O ₃	n.d.	0.03	0.13	0.01	0.08	0.01	0.03	0.02	n.d.
FeO	8.80	8.25	9.65	9.02	8.75	23.34	22.76	21.89	21.57
MnO	0.41	0.26	0.29	0.31	0.29	0.84	0.67	0.55	0.57
MgO	14.67	14.15	13.70	14.25	14.56	21.50	21.81	22.28	22.65
NiO	0.01	0.02	0.04	n.d.	0.02	0.04	n.d.	n.d.	0.02
CaO	21.18	22.96	21.73	21.33	21.60	1.11	1.24	1.40	1.13
Na ₂ O	0.48	0.34	0.43	0.37	0.44	0.03	0.03	0.03	0.03
K ₂ O	n.d.	0.02	n.d.	n.d.	n.d.	0.00	0.01	0.01	0.02
F	0.07	n.d.	n.d.	0.07	n.d.	n.d.	n.d.	n.d.	0.17
Total	98.82	99.73	99.94	99.33	100.1	100.3	100.3	100.1	100.5
#Mg ⁽²⁾	0.75	0.75	0.72	0.74	0.75	0.62	0.63	0.64	0.65

inc: phase included in Pl

¹ Position represent the relative position of spot analyses within the crystal: int — intermediate between core and border; inc — inclusion² Mg# = molar MgO/[MgO+ FeO]

n.d.: not determined

Table 8
Summary of SHRIMP U-Pb zircon data for Cerro Munro tonalite

Id	ppm				⁽¹⁾ Isotope ratios						⁽¹⁾ Age (Ma)			⁽²⁾ Age (Ma)			
	U	Th	²⁰⁶ Pb	%Pb _c	Th/U	²⁰⁷ Pb/ ²⁰⁶ Pb	±%	²⁰⁶ Pb/ ²³⁸ U	±%	²⁰⁷ Pb/ ²³⁵ U	±%	²⁰⁸ Pb/ ²³² Th	±err	²⁰⁶ Pb/ ²³⁸ U	±err	²⁰⁶ Pb/ ²³⁸ U	±err
<i>C.2011-11</i>																	
1.1	169	255	1.35	4.65	1.56	0.052	22	0.0089	2.1	0.063	22	47.1	3.8	56.9	1.2	56.6	1.3
2.1	130	181	1.01	6.85	1.44	0.043	73	0.0084	4	0.050	73	41.9	8.8	53.8	2.1	54.1	1.6
3.1	80	99	0.69	7.67	1.27	0.060	54	0.0092	5.5	0.076	54	53.0	12	59.0	3.2	58.0	2.4
4.1	67	68	0.57	6.70	1.06	0.088	38	0.0092	4.8	0.113	39	60.0	13	59.3	2.8	56.2	2.8
5.1	55	45	0.47	7.39	0.85	0.055	64	0.0093	4.5	0.070	64	63.0	18	59.6	2.7	59.1	2.2
6.1	94	125	0.78	4.78	1.38	0.077	25	0.0091	3.9	0.097	25	61.6	6.1	58.7	2.2	56.5	2.2
7.1	85	87	0.66	4.33	1.06	0.082	40	0.0086	4.3	0.097	40	74.0	13	55.2	2.4	52.8	1.9
8.1	56	61	0.50	15.9	1.13	0.038	98	0.0088	5.3	0.046	98	35.0	13	56.6	3.0	57.3	2.7
9.1	50	55	0.43	8.90	1.14	0.111	39	0.0092	5	0.140	40	75.0	16	58.9	3.0	54.2	2.9
10.1	86	112	0.71	6.86	1.34	0.066	39	0.0090	3.2	0.082	39	52.8	7.4	57.7	1.9	56.3	1.9

Errors are 1-sigma; Pb_c and ²⁰⁶Pb indicate the common and radiogenic portions, respectively.

Error in Standard calibration was 0.31% (not included in above errors but required when comparing data from different mounts).

¹ Common Pb corrected using measured ²⁰⁴Pb.

² Common Pb corrected by assuming ²⁰⁶Pb/²³⁸U-²⁰⁷Pb/²³⁵U age-concordance