Magmatic processes under Osorno Volcano (Southern Volcanic Zone, Chile)

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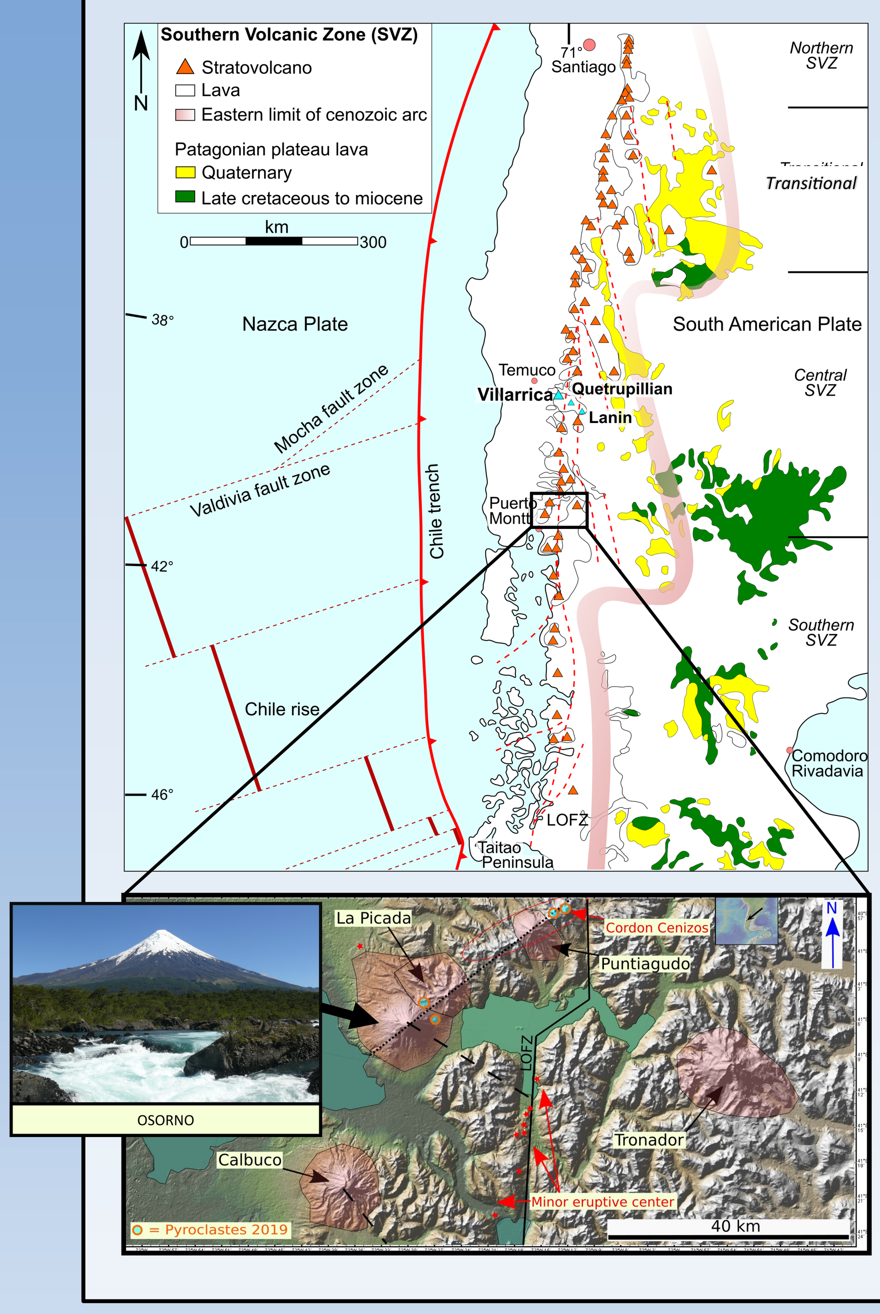
I. Introduction

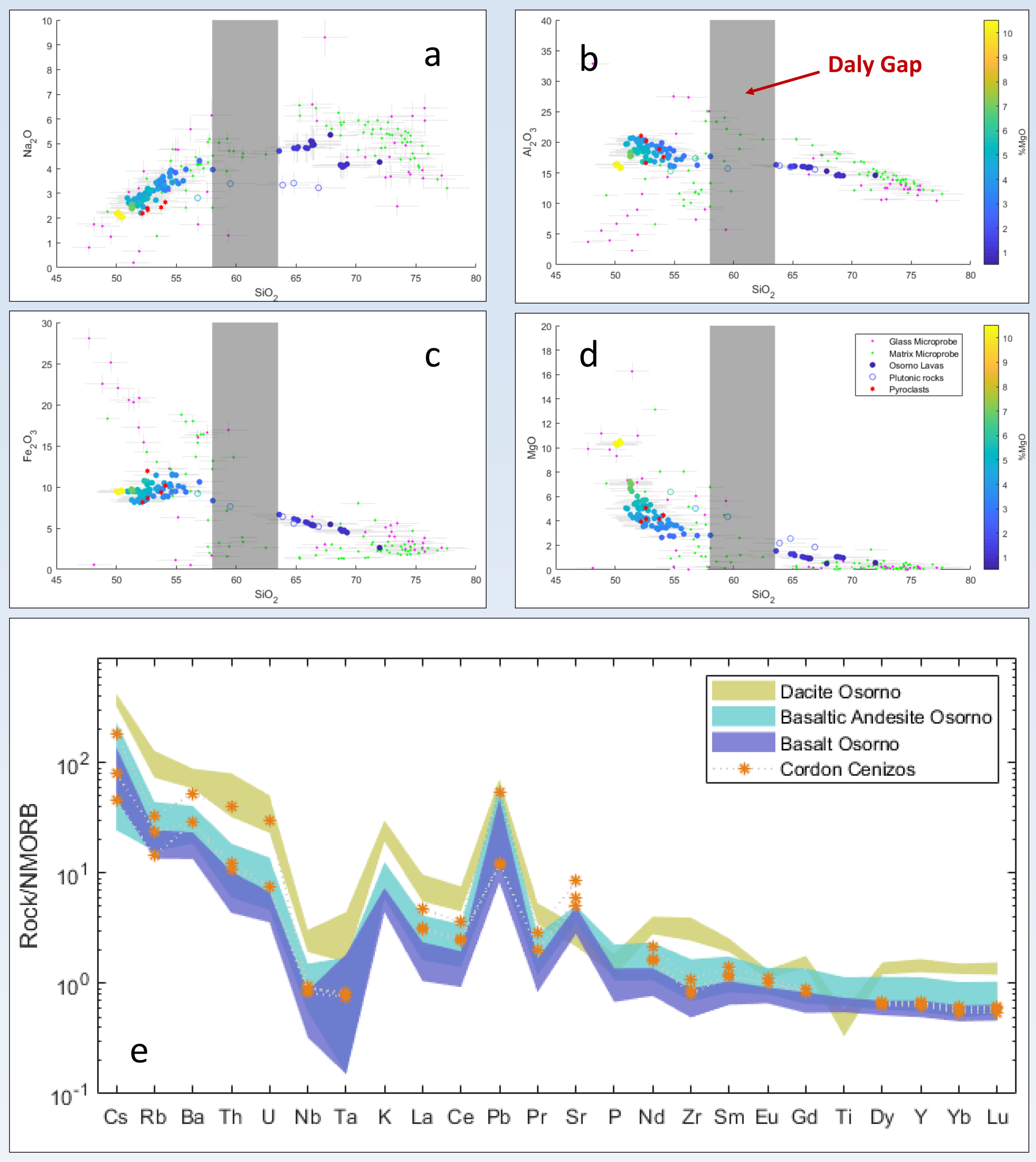


In the Central Southern Volcanic Zone (CSVZ) of Chile, magma ascent is likely facilitated by (1) the thin thickness of the **continental crust (30-40 km)**[5] and (2) by the presence of the **Linquiñe Ofqui Fault Zone**[2,5] (LOFZ) that increases crustal permeability. (3) This part of the Andean arc includes some of the **most active volcanoes (Llaima, Villarica)**[9]. (4) It is characterized by **mafic lavas** (basalts,basaltic andesites) that are commonly lacking in the NSVZ and (5) unlike most arc magmas hydrous phases (amphibole, biotite) are absent, except in a few volcanoes (e.g. Calbuco ; Fig 0), **suggestive of lower water contents**.

Osorno is a typical stratovolcano of the CSVZ located nearby Calbuco that recently erupted (April 2015). Osorno contains some very mafic basalts ($Mg\#^{ol}$ >0.8 and chromite-rich) and displays a well-defined Daly gap (58%-64% SiO_2). A comprehensive petrologic study of the volcano has been undertaken in order to :

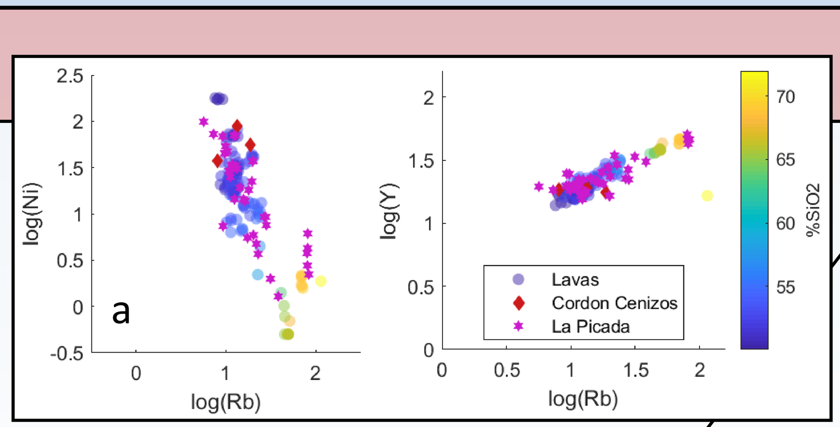
- ***constrain the level(s) of prolonged magma storage and the potential processes that produced the observed Daly gap;***
- constrain mantle melting using the most mafic samples that have probably not been modified by crustal interaction;
- study magmatic processes on the long term by combining Osorno's results with those from a recent study[1] of the older neighboring volcanic system (La Picada, 500-60ky) that is partly overlapped by Osorno (Fig 0).

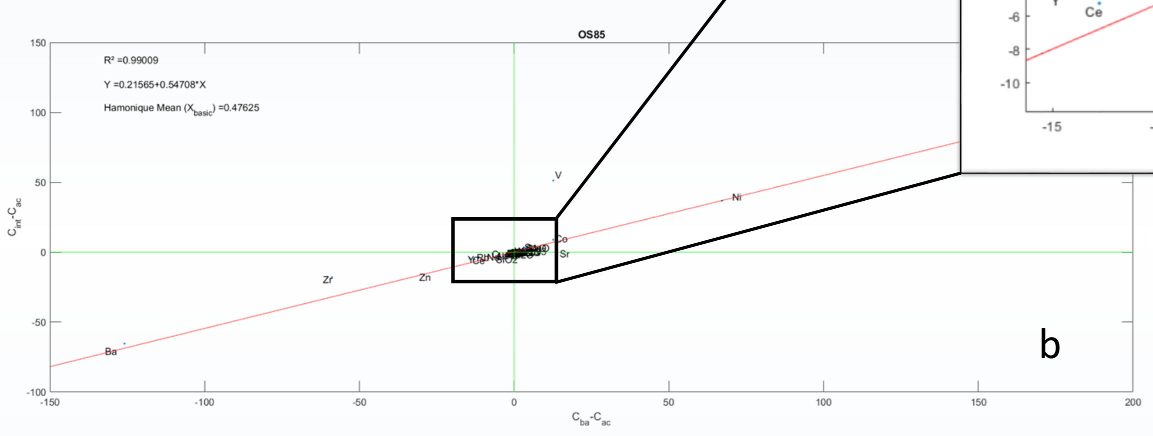
← Fig 0—Maps of the area plus picture of Osorno. See references 7, 8, 9 for credits.

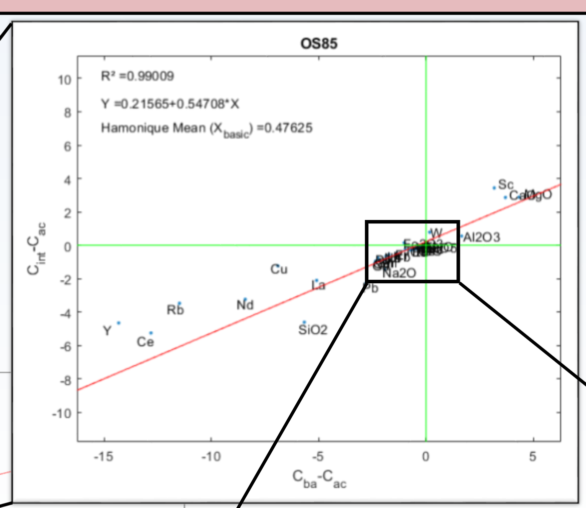


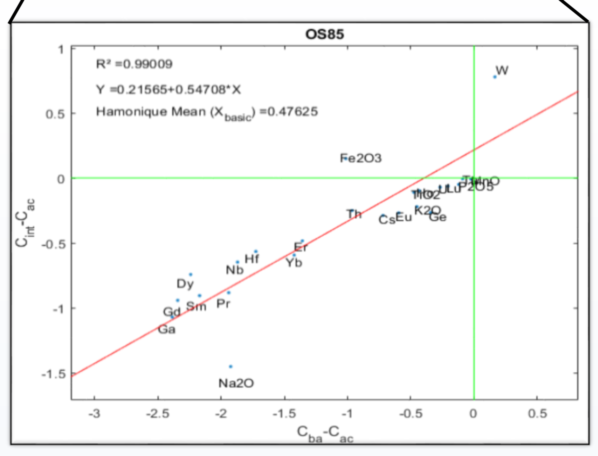
→ Fig 1 — Results from chemical analysis : (a, b, c, d) Some major elements Harker diagrams (XRF) with the Daly gap emphasized by the grey patch and (e) trace elements N-MORB normalized Spider plot (ICPMS) .

II. Magmatic Source and Differentiation









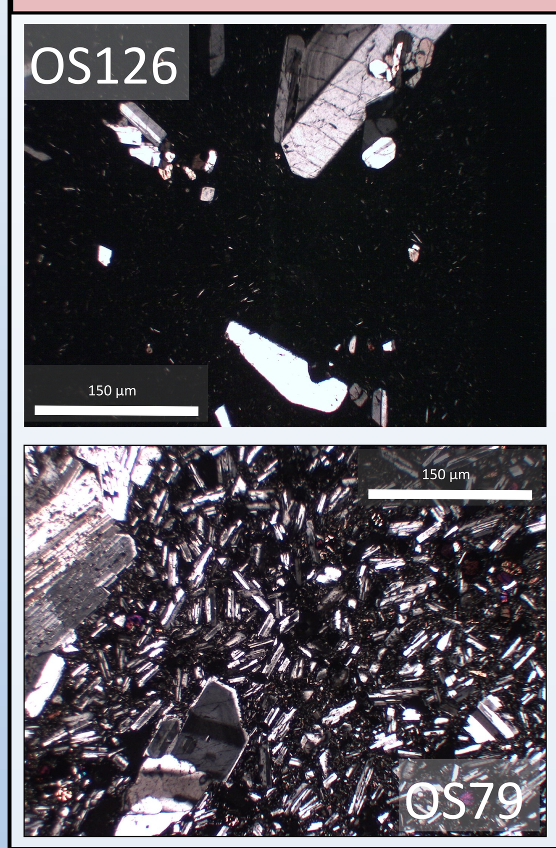
↑→ Fig 2 —Differentiation test: (a) Log(Ni) vs Log(Rb) or Log (y) vs Log(Rb) are tests for fractional crystallization which are positive if a steep negative slope or a slightly positive slope respectively appears. (b) C_{int}-C_{ac} vs C_{ba}-C_{ac} (with two zoom) is the test for mixing which is positive if all the elements are clearly aligned.

A collection of >120 samples have been analyzed for major (XRF) and trace elements (ICPMS). Mineral phases (ol, cpx, plag, ox) were analyzed with the microprobe. Results show :

- a defined differentiation trend from MgO-rich samples (>10%wt) to SiO2-rich ones (~70%wt) (See Fig 1);
- differentiation is mainly **the result of fractional crystallization** (trace elements test, least square modelling with Rayleigh distillation law) (Fig 2a);
- crystallization occurred mostly at **low pressure**[1] (Fig 1a);
- **mixing between 2 endmembers was tested and revealed itself to be inconclusive** (the dilution factor is inconsistent from one element to another) (Fig2b).

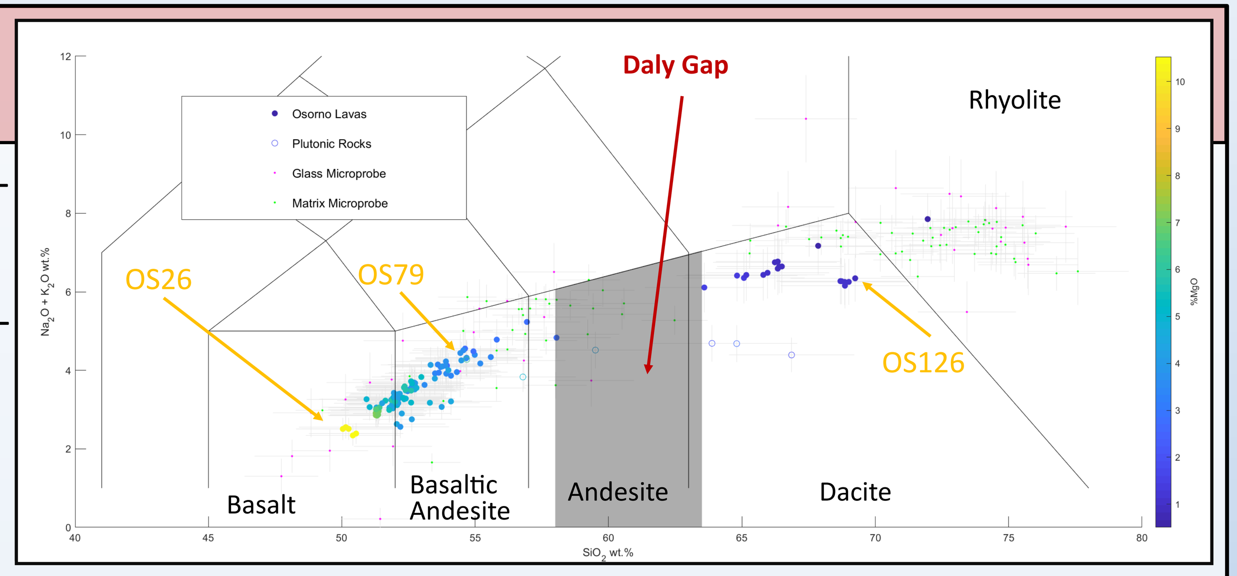
Current work focus on the Melt Inclusion analysis, source analysis and thermobarometry estimation through the study of mafic glassy pyroclasts, MgO-rich samples and analysis of previously collected data respectively.

III. Daly gap and critical crystallinity



Several processes have been proposed to explain the occurrence of a Daly Gap in many differentiation trends:

- presence at depth of mafic and felsic end-members that mix to create the andesite[6] in the upper crust;
- rapid variation in liquid composition for small temperature decrease[4];
- immiscibility of liquids along the line of descent that produces the two end members[3];
- fractional crystallization that reach a critical crystallinity threshold preventing the magma from moving forward except for the interstitial liquid.[1]



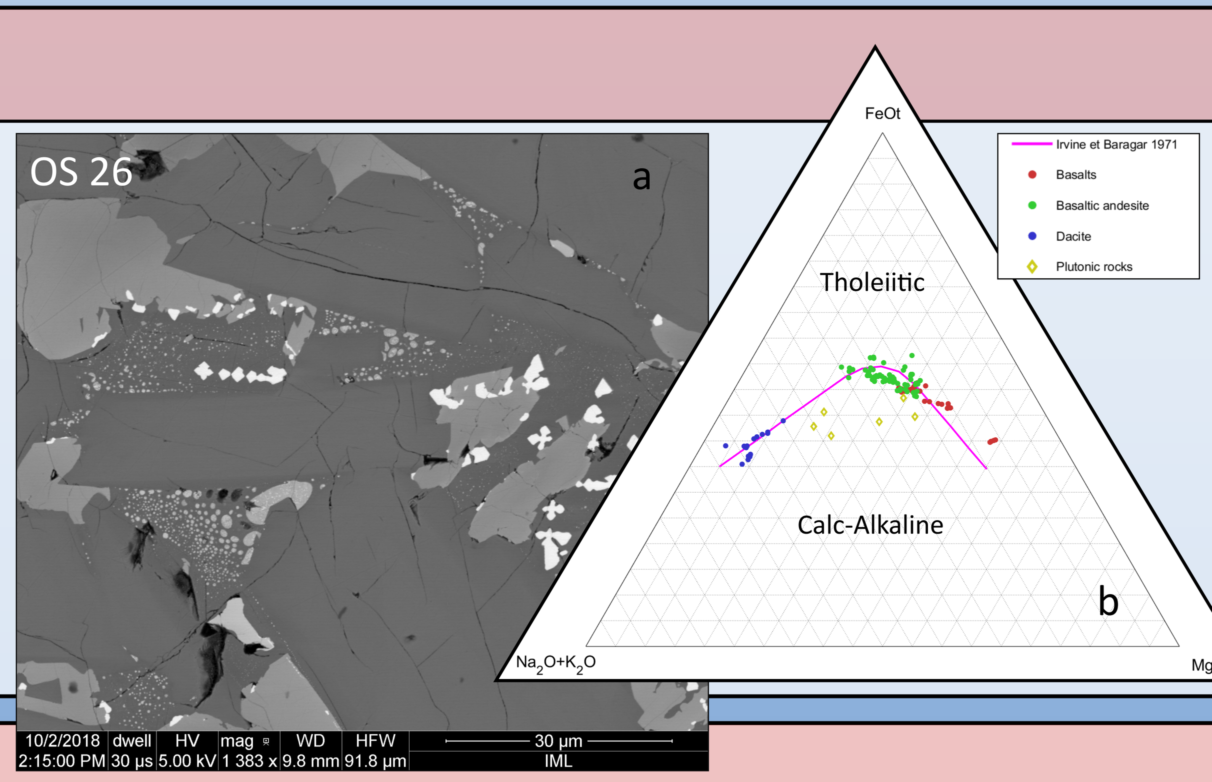
Osorno lavas are either **crystal-rich** (Fig3 OS79) **before the gap** or **crystal-poor** (Fig 3: OS126) **after the gap**. Furthermore **dacitic dome alignment on Osorno** and **dacitic dykes** measured at La Picada volcano (Fig 0) have a **NW direction** (⊥ to σ_{hmax} meaning that faults to the NW are under a compressive regime[2]).

Further work will investigate the possibility of creating the Daly Gap by compression of a crystal mush and compare results with the observed lavas.

← Fig 3— Cross polarized light of two sample OS126 and OS79 that are located after and before the gap respectively (see Fig 4)

↑ Fig 4— Total Alkali Silica (TAS) diagram showing the magmatic trend and the location of Fig 3 and fig 5 samples.

IV. Immiscibility



Several observations suggest that an immiscibility process may have occurred at some point along the differentiation trend : (1) Most of the lavas studied show very small immiscibility bubbles in the matrix (Fig 5), (2) immiscibility was evidenced in some tholeiitic lavas[3], (3) Osorno's most mafic lavas plot on the limit of the tholeiitic field (Fig 5).

- Checking first **whether or not immiscibility bubbles are due to quench or metastable reasons.**
- **If not**, the studied trend **may have step in an immiscibility field**. **Experimental petrology is the best tool to find the conditions** (P°, T°, fO2) at which it is stable.

← Fig 5 — (a) SEM picture of OS26 one of the most mafic sample (see Fig 4) in which small sized immiscible bubbles clearly appear. (b) AFM diagram showing that Osorno trend is in between tholeiitic and Calc-alkaline magmatic series.

V. References / Funding

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9. **Picture of Osorno : credit Helène Foucart.**

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