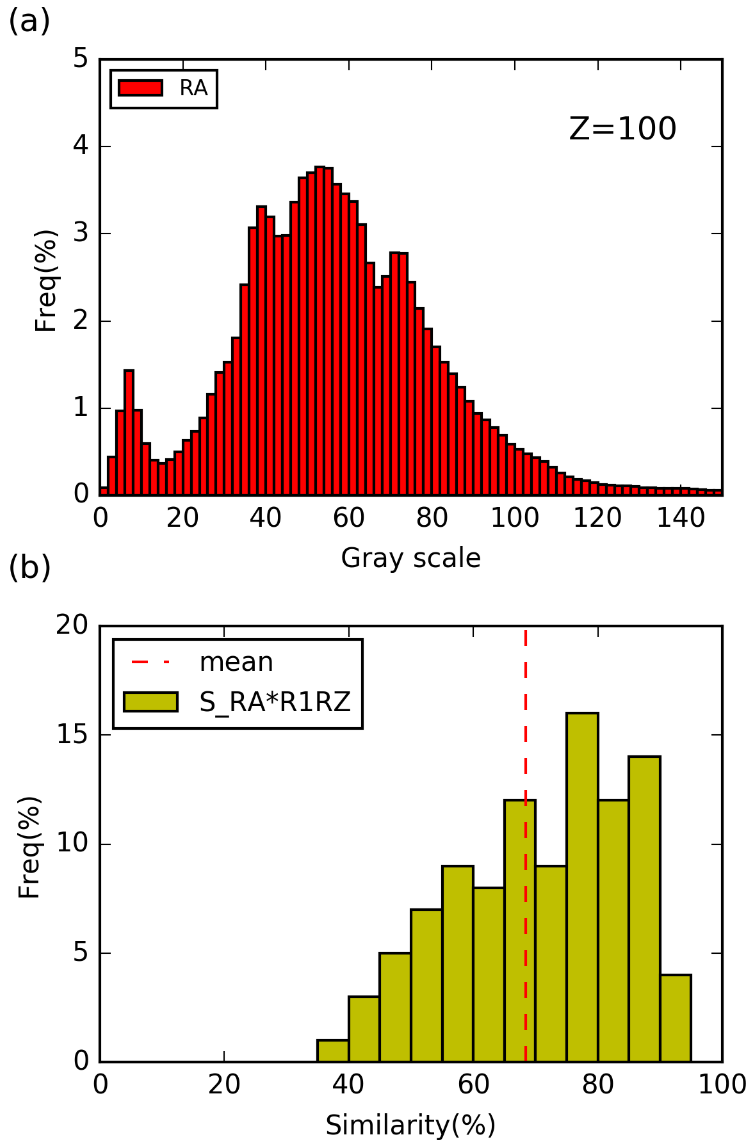
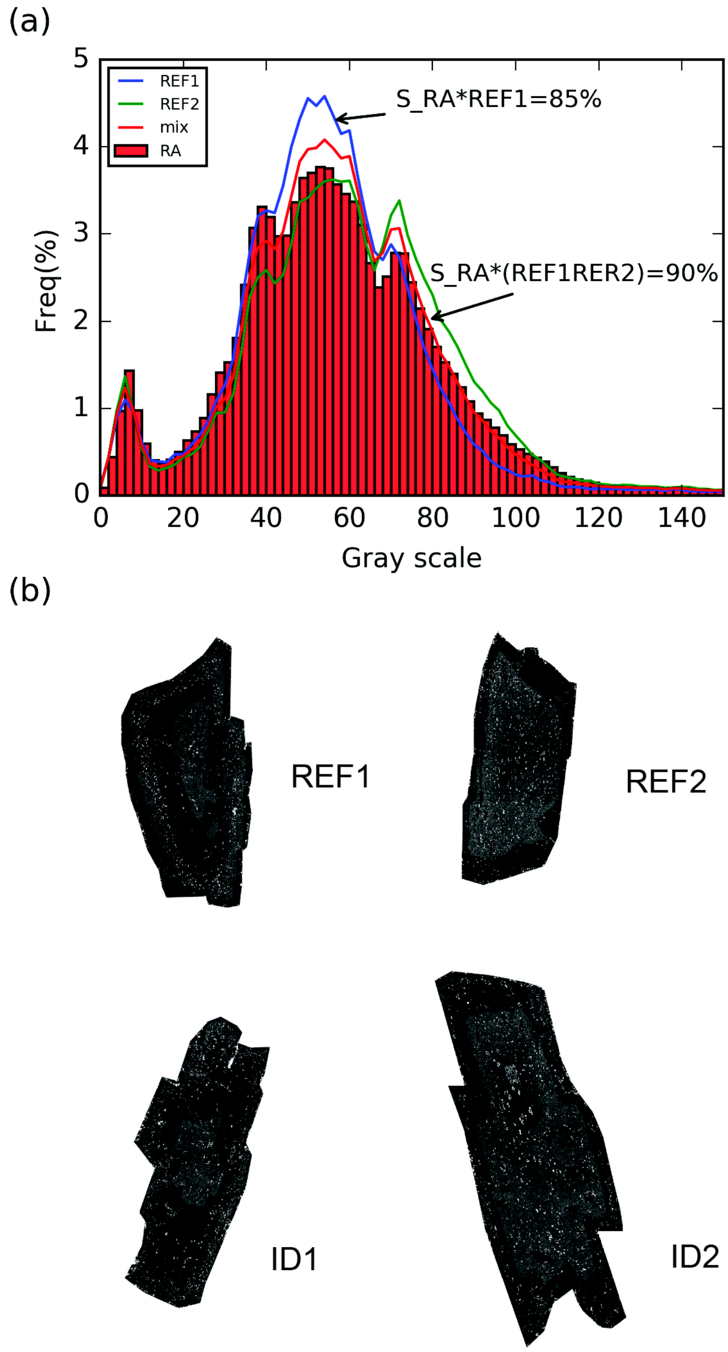
Supplementary appendix 3- Example using a thin section from Mayon volcano

As a case example for application of our method we investigated the zoning features of plagioclase from one thin section of a basaltic andesite from Mayon volcano (Philippines). From the BSE image of the whole thin section (Fig. 1) which contains about 750 crystals, we randomly chose 108 of them to do our analyses (Fig. S3_1). The crystal sections show a large variety of zoning patterns, with one to four chemical distinct zones and including sieve texture and resorptions. The large variety of 2D sections make it difficult to determine how many different crystal populations there are, and the extent to which such variety is due just to the random cut effect.

These plagioclase crystals are more akin to our Type C crystal the greyscale of plagioclase BSE images reflects the An content of plagioclase (Ginibre et al., 2002) and can be calibrated using electron microprobe analysis. Here, we used only the greyscale as a proxy for the An without direct calibration but we note that the image mosaic was obtained using the same contrast and brightness.

We calculated first the RA for all the sections and determine the similarity distribution of RA and all sections (Fig. S3_2) The RA distribution shows a broad peak that could correspond to crystal Type C. The similarity distribution also shows one large broad peak but which is different from the one of one single crystal population of Type C, and thus it is more likely due to more than one crystal population present in the sample. A first order comparison with our numerical simulations shows that it is actually similar to scenario 3: mixing of at least two crystal populations that are quite similar to each other (see Fig. 12l). We then calculated the threshold of similarities and took those sections that have values between 70 and 80 %, and we used the threshold of 78% to find a first reference section for one of the crystal populations. We found that with this section we already have a similarity of 85% with the RA. Nevertheless, we continued to search for another reference section and used different mixing proportions. Using least squares method we found another population and mixing proportions of 51-49, which increase the similarity with the overall RA to 90%. This means that with two populations we can explain 90% of the compositional distribution of all plagioclase crystals in the sample. There could still be other populations but they would have to be in little proportions and this implies that they are basically undetectable (see Section 7). In any case, we consider the ability to explain 90% of the compositional distribution a satisfactory result. In a similar manner, we can identify the associated ideal sections, with similarity thresholds around 92 %. Examples of the reference and ideal sections of the two populations (Fig. S3_3) shows that one corresponds to a crystal with two main zones, with a sieved part on its interior. The other crystal population is made of sections that contains four main zones and includes two sieved parts. Note that the similarity increase from one to two crystal populations is only of about 5 % although the proportions of the two populations is about 50 - 50. This is because the two populations are quite similar, and it is in fact an example of scenario case 3 that we investigated above.


(a)
RA
Z=100
Freq(%)
Gray scale
0
1
2
3
4
5
20
40
60
80
100
120
140
(b)
mean
S_RA*R1RZ
Freq(%)
Similarity(%)
0
5
10
15
20
20
40
60
80
100


(a)
REF1
REF2
mix
RA
S_RA*REF1=85%
S_RA*(REF1RER2)=90%
Freq(%)
Gray scale
0
20
40
60
80
100
120
140
1
2
3
4
5
(b)
REF1
REF2
ID1
ID2