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# La Palma Earthquakes

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10 **Abstract**

11 In September 2021, a significant jump in seismic activity on the island of La Palma  
 12 (Canary Islands, Spain) signaled the start of a volcanic crisis that still continues at  
 13 the time of writing. Earthquake data is continually collected and published by the  
 14 Instituto Geográfico Nacional (IGN). We have created an accessible dataset from  
 15 this and completed preliminary data analysis which shows seismicity originating at  
 16 two distinct depths, consistent with the model of a two reservoir system feeding the  
 17 currently very active volcano.

18 **0.1 Introduction**

19 La Palma is one of the west most islands in the Volcanic Archipelago of the Canary  
 20 Islands, a Spanish territory situated in the Atlantic Ocean where at their closest  
 21 point are 100km from the African coast Figure 1. The island is one of the youngest,  
 22 remains active and is still in the island forming stage.



Figure 1: Map of La Palma in the Canary Islands. Image credit [NordNordWest](#)

23 La Palma has been constructed by various phases of volcanism, the most recent and  
 24 currently active being the *Cumbre Vieja* volcano, a north-south volcanic ridge that  
 25 constitutes the southern half of the island.

26 **0.1.1 Eruption History**

27 A number of eruptions were recorded since the colonization of the islands by Euro-  
 28 peans in the late 1400s, these are summarised in Table 1.

Table 1: Recent historic eruptions on La Palma

Name	Year
Current	2021
Teneguía	1971
Nambroque	1949
El Charco	1712
Volcán San Antonio	1677
Volcán San Martin	1646
Tajuya near El Paso	1585

Name	Year
Montaña Quemada	1492

29 This equates to an eruption on average every 79 years up until the 1971 event. The  
 30 probability of a future eruption can be modeled by a Poisson distribution Equa-  
 31 tion 1.

$$p(x) = \frac{e^{-\lambda} \lambda^x}{x!} \quad (1)$$

32 Where  $\lambda$  is the number of eruptions per year,  $\lambda = \frac{1}{79}$  in this case. The probability of  
 33 a future eruption in the next  $t$  years can be calculated by:

$$p_e = 1 - e^{-t\lambda} \quad (2)$$

34 So following the 1971 eruption the probability of an eruption in the following 50  
 35 years — the period ending this year — was 0.469. After the event, the number of  
 36 eruptions per year moves to  $\lambda = \frac{1}{75}$  and the probability of a further eruption within  
 37 the next 50 years (2022-2071) rises to 0.487 and in the next 100 years, this rises  
 38 again to 0.736.

### 39 0.1.2 Magma Reservoirs

40 Studies of the magma systems feeding the volcano, such as Marrero et al. (2019) has  
 41 proposed that there are two main magma reservoirs feeding the Cumbre Vieja vol-  
 42 cano; one in the mantle (30-40km depth) which charges and in turn feeds a shallower  
 43 crustal reservoir (10-20km depth).

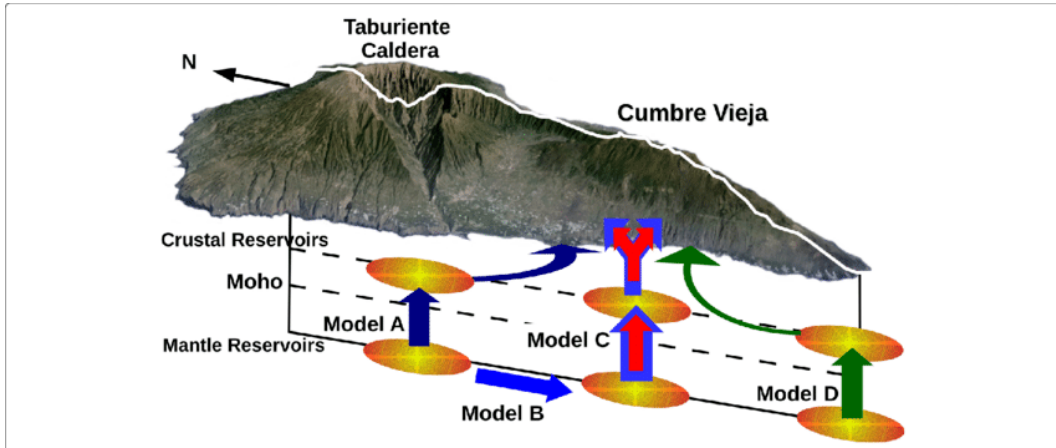


Figure 2: Proposed model from Marrero et al

44 In this paper, we look at recent seismicity data to see if we can see evidence of such  
 45 a system action, see Figure 2.

### 46 0.2 Dataset

47 The earthquake dataset used in our analysis was generated from the [IGN web portal](#)  
 48 this is public data released under a permissive license. Data recorded using the net-  
 49 work of [Seismic Monitoring](#) on the island. A web scraping script was developed to

50 pull data into a machine-readable form for analysis. That code tool [is available on](#)  
 51 [GitHub](#) along with a copy of recently updated data.

### 52 0.3 Results

53 The dataset was loaded into a Jupyter notebook [visualization](#) and filtered down to  
 54 La Palma events only. This results in 5465 data points which we then visualized to  
 55 understand their distributions spatially, by depth, by magnitude and in time.

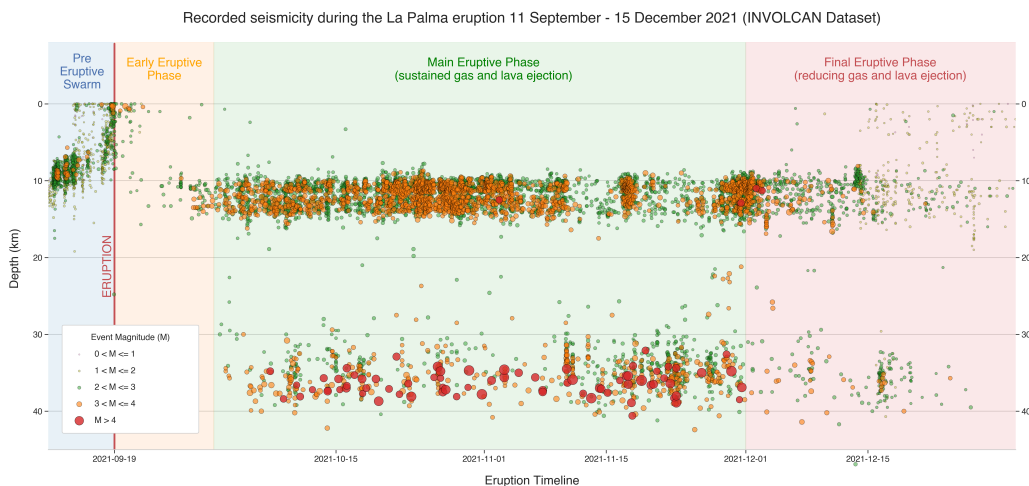


Figure 3: Earthquake data over time ( $n=5465$ ) to understand their distributions spatially, by depth, by magnitude and in time.

56 Source: [Visualization & Figure Creation](#)

57 From our analysis in Figure 3, we can see 3 different systems in play.

58 Firstly, the shallow earthquake swarm leading up to the eruption on 19th September,  
 59 related to significant surface deformation and shallow magma intrusion.

60 After the eruption, continuous shallow seismicity started at 10-15km corresponding  
 61 to magma movement in the crustal reservoir.

62 Subsequently, high magnitude events begin occurring at 30-40km depths correspond-  
 63 ing to changes in the mantle reservoir. These are also continuous but occur with a  
 64 lower frequency than in the crustal reservoir.

### 65 0.4 Conclusions

66 From the analysis of the earthquake data collected and published by IGN for the  
 67 period of 11 September through to 9 November 2021. Visualization of the earth-  
 68 quake events at different depths appears to confirm the presence of both mantle and  
 69 crustal reservoirs as proposed by Marrero et al. (2019).

#### 70 Availability

71 A web scraping script was developed to pull data into a machine-readable form  
 72 for analysis. That code tool [is available on GitHub](#) along with a copy of recently  
 73 updated data.

74 Marrero, J., García, A., Berrocoso, M., Llinares, Á., Rodríguez-Losada, A., & Ortiz,  
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77 *Applied Volcanology*, 8. <https://doi.org/10.1186/s13617-019-0085-5>