Reviewers’ comments

Review Details: The rupture plane of the February 2022 Mw 6.2 Guatemala, intermediate depth earthquake

Reviewer 1

Completed: 2023-05-23 04:12 PM
Recommendation: Resubmit for Review
Reviewer Comments
For author and editor
Review of:

The rupture plane of the February 2022 Mw 6.2 3

Guatemala, intermediate depth earthquake

By Yani-Quiyuch, Asturias and Castro

The aim of this paper is to relocate some of the aftershocks of the 16 February 2022 Guatemala earthquake and to obtain fault-plane solutions for as many of the aftershocks. With this information, the authors draw conclusions about the subduction process of the Cocos plate, offshore Guatemala.

In general, the paper is worthy of publication, but several issues should be first addressed.

My biggest concern is with the presentation of data and results. Figures are not clear (the use of some color is recommended, Seismica permitting). Most of the symbols are small and hence, confusing. For example, Figure 1 should show the background seismicity of the area (not only focal mechanisms) and leave station locations for an inset. By the way, detphs for isodeth curves are missing.

Most of the readers will not be that familiar with local Geography (for example, show on map where the Department of Escuintla is), or culture (what does the acronym INSIVUMEH stand for, anyway?)

Department of Escuintla is mentioned several times. For those of us not familiar with Guatemalan geography, it would be useful to locate the Department on a map.

The English language also requires some brushing-up. One extreme example is in line 131: "…it is possible que such effects …"

In a section-by-section examination:

The introduction does not clearly address what the aim and objectives of the paper are.

Section 2 should be called something like "Subduction of the Cocos plate in Guatemala". In this section, contradictory data about the dip of the subducted slab are given: in the text, it is stated that dip gradually changes from 20 to 60 degrees, while the caption of Figure 2 sayas that the geomtry is uniform. The speed of convergence is, within error limits, constant in the area of study. Historical seismicity is mentioned in the text. It would be helpful to show main epicenters for intermediate-depth shocks on a map (both historical and recent, 1964 onwards). The authors talk about the trigger mechanism for intermediate-depth earthquakes; as far as I know, the most accepted idea is slab-pull, which is not mentioned.

Section 3. Ok, in general. Except, take out subsection 3.3 Conclusions and discussion and make it Section 4. Discussion and conclusions.

I recommend resubmission after review.

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Resubmit for Review

Review Details: The rupture plane of the February 2022 Mw 6.2 Guatemala, intermediate depth earthquake

Xyoli Pérez

Completed: 2023-05-13 03:10 PM
Recommendation: Revisions Required
Reviewer Comments
For author and editor
The manuscript "The rupture plane of the February 2022 Mw 6.2 3 Guatemala, intermediate depth earthquake" by Yani-Quiyuch et al. presents an analysis of the 16 February 2022, Mw 6.2, earthquake. They performed a hypocenter relocation using HypoDD, obtaining a fault plane of ~350 km^2. In this relocation, they can delimitate the main fault and some seismicity in the upper layer of the slab. This seismicity contrast with the one at the fault by having an inverse mechanism. Furthermore, this event presented a relatively high number of aftershocks compare with other similar earthquakes in the region. The authors post the possibility of a relation to hydration but decide not to explore further.

The manuscript is in general well written but the introduction needs some review in the writing. I include all my comments, suggestions and questions in the attached document.

On a personal note, I am please that the exchange of data between countries has prooved it usefullness and it has been fruitful.

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Revisions Required

Review Details: The rupture plane of the February 2022 Mw 6.2 Guatemala, intermediate depth earthquake

Beatriz Cosenza

Completed: 2023-05-12 03:59 AM
Recommendation: Revisions Required
Reviewer Comments
For author and editor
Dear R. Yani-Quiyuch and co-authors:

Your manuscript “The rupture plane of the February 2022 Mw 6.2 Guatemala, intermediate depth earthquake” presents the analysis of the mainshock-aftershock sequence for the Mw 6.2 subduction earthquake in the segment of the Middle America Trench offshore Guatemala. This is the first time such an analysis is performed for an intra-slab, intermediate depth earthquake in this region. The relocalization of all the events in the sequence and the estimation of focal mechanisms for the mainshock and several aftershocks, allowed to establish the rupture plane, which was a subvertical plane cutting through the lower seismicity zone of the subduction slab, in which extensional events were produced. This activity also triggered aftershocks with compressional events in the upper seismicity zone, near the top of the slab. The size of the estimated rupture area, its location in with respect to the double seismicity zone and similarities with other subduction zones around the world allowed the authors to hypothesize this seismic activity occurred at a pre-existing fault, reactivated by dehydration embrittlement processes on the down going slab. Since extensional, intermediate depth, intra-slab earthquakes occur often in the region, they represent an important hazard which needs to be characterized and understood. This work is an important step towards that goal.

The manuscript is very well written and is a pleasure to read through. I found Figures 5, 6, and 7 particularly striking. If not for a few details, the paper could be ready for publication as is. However, I noted a few places where the discussion could be refined and a few figures could be improved slightly. Also, some final copy-editing to remove a few typos and grammatical errors would improve the clarity of the manuscript.

Find my comments in an attached file.

Also, I am not a native English speaker but, if it is useful, I have included a file with copy-editing suggestiosn which you can use as you see fit. There is no obligation to consider those suggestions.

Apart from these minor comments, please accept my congratulations on a very interesting paper.

Best wishes,

Beatriz Cosenza-Muralles

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Revisions Required

Revision by the authors

Dear Reviewers,
It is a pleasure to greet you once again as the authors of the work titled "The rupture plane of the 16 February 2022 Mw 6.2 Guatemala, intermediate depth earthquake."
We express our sincere gratitude for your valuable observations and suggestions aimed at improving the manuscript. Enclosed, you will find our response to each of your comments, which have played a crucial role in aligning the manuscript with the necessary requirements for potential publication.
As a general guideline, we have attached the original manuscript with the most significant changes highlighted, as well as those implemented in response to your meticulous feedback.
It is pertinent to note the following notable alterations:

- The title of the work now includes the day of the earthquake occurrence.
- Extensive revisions have been made to the wording to enhance the organization of ideas and achieve greater readability.
- The first two figures of the original manuscript have been merged, with the first figure now containing information regarding the focal mechanisms from the ISC-GEM catalog.
- The introduction has been expanded to provide a more comprehensive context.
- Some subheadings have been slightly modified to improve clarity and cohesion.
- A focal mechanism associated with aftershocks has been removed due to its absence in the relocated aftershock catalog.
- A portion of the text pertaining to the use of the HypoDD algorithm has been modified for improved coherence.
- The majority of the section "Rupture plane and temporal evolution of seismicity" has been appropriately relocated to the "Discussion and Conclusions" section.
- We have decided to eliminate the comparison of the seismic sequence analyzed in this work with that resulting from other intermediate-depth earthquakes, as it has been concluded that the catalogs are not equivalent.

We hope that these modifications meet your expectations and requirements. We hereby present a revised version of the manuscript for your consideration.
We extend our gratitude once again for your time and dedication in reviewing our work.
Sincerely,
The Authors.

The rupture plane of the February 2022 Mw 6.2 Guatemala, intermediate depth earthquake

R. Yani-Quiyuch * [1], **L. Asturias** [1], **D. Castro** [1]

[1]Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología, INSIVUMEH, Guatemala.

Author contributions: *Conceptualization*: R. Yani-Quiyuch, L. Asturias. *Software*: L. Asturias, D. Castro. *Formal Analysis*: R. Yani-Quiyuch, L. Asturias, D. Castro. *Writing - original draft*: R. Yani-Quiyuch, L. Asturias.

Abstract An intermediate depth intraplate earthquake with Mw 6.2 was generated in the Guatemalan subduction zone on 16 February 2022 with epicenter to Southwest of the department of Escuintla. More than 275 aftershocks were registered, which were relocated with the HypoDD algorithm, being able to identify a fault with an area of $\sim$350 km^2, which is considerably higher than expected for an earthquake of that magnitude. The moment tensor at the centroid of the main earthquake and the estimation of other focal mechanisms of the largest aftershocks, allowed us to identify extension earthquakes, related to the fault plane, and compression earthquakes that were associated with seismicity on the upper part of the slab. The region of the sequence has presented high seismic activity in recent years. It is proposed that the mainshock nucleated in the lower seismicity layer (LSL) of the double seismicity zone proposed for the region, triggering seismic activity on a pre-existing active fault, also triggering seismic activity in the upper seismicity layer (USL). The separation between these seismicity layers was estimated to be 12.2 ± 5.0 km.

Resumen Un sismo intraplaca de profundidad intermedia con Mw 6.2 se generó en la zona de subducción guatemalteca el 16 de febrero de 2022 con epicentro en el suroeste del departamento de Escuintla. Se registraron más de 275 réplicas, las cuales fueron relocalizadas con el algoritmo HypoDD, pudiendo identificar una falla con un área de $\sim$350 km^2, la cual es considerablemente superior a la esperada para un sismo de esa magnitud. El tensor de momento en el centroide del sismo principal y la estimación de otros mecanismos focales de las réplicas más grandes, permitieron identificar sismos de extensión, relacionados al plano de falla y sismos de compresión que fueron asociados a sismicidad en la zona superior del slab. La región de la secuencia ha presentado actividad sísmica alta en años recientes. Se propone que el sismo principal nucleó en la capa inferior de sismicidad (CIS) de la zona doble de sismicidad propuesta para la región disparando actividad sísmica en una falla activa pre-existente, disparando además, actividad sísmica en la capa superior de sismicidad (CSS). La separación entre estas capas de sismicidad se estimó en 12.2 ± 5.0 km.

Non-technical summary On 16 February 2022, an earthquake of magnitude 6.2 was generated with an epicenter in the department of Escuintla, located at a depth of approximately 70 km, corresponding to an earthquake inside the Cocos plate that is introduced below the Caribbean plate. The earthquake caused alarm among the population and slight damage to some buildings. Thanks to recent improvements in the National Seismological Network (RSN, by its acronym in spanish), a high number of aftershocks was registered, which made it possible to identify the fault plane related to the earthquake and the activation of another type of seismicity in the upper region of that same plate. The size of the identified fault area is twice that expected for an earthquake of this magnitude and given that the region has been seismically active in recent years, it is proposed that the generation of said seismicity took place on a pre-existing seismic fault. The knowledge of this seismic source, which is detailed for the first time in an instrumental way, allows to expand the knowledge of the hazard and the seismic risk in Guatemala due to subduction earthquakes.

*Corresponding author: royani@insivumeh.gob.gt

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Page 1 4

robin 17 Sep

Below you will find two types of annotations:

Green, means your suggestions were completed.
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xyoli 28 Jun

Include the day.

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I consider better to refer as normal and inverse earthquakes than to extension and compression earthquakes.

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XPC 28 Jun

The seismic waves travel all through and around the world. Maybe you are trying to say that they were felt in a large part of the country.

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Spell it out.

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I suggested the following change:
Due to the location of the hypocenter and its normal focal mechanism, it was classified as an intraslab earthquake

1 Introduction

On 16 February 2022 at 07:12 (UTC) an earthquake of magnitude Mw 6.2 was generated in the subduction zone. The epicenter was located in the department of Escuintla, near the department of Suchitepéquez, on the southern coast of Guatemala (Figure 1). The seismic event had a depth of approximately 70 km, the seismic waves generated reached a large part of the country, being reported in several departments of the country. According to INSIVUMEH instrumental measurements, seismic intensities of VI were reached on the Modified Mercalli Intensities scale (MMI). Due to the location of the hypocenter, it was classified as an intra-slab earthquake with a normal focal mechanism, characteristic of that seismogenic zone. (Güendel and Protti, 1998; Alvarez, 2009; Guzmán-Speziale and Zúñiga, 2016; Guzmán-Speziale and Molina, 2022).

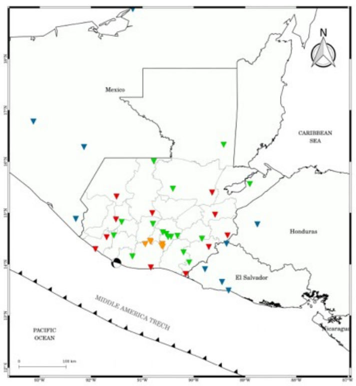

Figure 1 Seismic stations used for the characterization of the 16 February 2022 earthquake (black focal mechanism) and its sequence of aftershocks. The Red Sismologica Nacional (RSN) (doi: 10.7914/SN/GI) is represented by green, red and orange inverted triangles (aquired by INSIVUMEH, ATTAC project and VDAP, respectively, see description in text), while seismic stations from México, El Salvador and Honduras are represented by blue inverted triangles. Due the mainshock and aftershocks occured close to the coastline, it was possible to achieve good locations and re-locations hypocentrals.

The main earthquake and the sequence of aftershocks were characterized through the stations of the RSN operated by INSIVUMEH (see Figure 1). In recent years, the RSN has considerably increased its number of seismic stations with velocity and acceleration sensors. In addition, there is instrumentation provided by the Swiss Agency for Development and Cooperation (SDC) in the project Earthquake Early Warning in Central America (ATTAC, for its acronym in Spanish) led by the Swiss Seismological Service (SED) in ETH Zurich and the Central American seismological agencies. This network includes also stations donated by the Volcano Disaster Assistance Program of the US Geological Survey (USGS) for volcanic monitoring. On the other hand, waveforms are received at INSIVUMEH in real time from the Servicio Sismológico Nacional (SSN) of Mexico (doi: 10.21766/SSNMX/SN/MX) , from the Ministerio de Ambiente y Recursos Naturales (MARN) of El Salvador and from the Comisión Permanente de Contingencias (COPECO) of Honduras. All this has made it possible to achieve good hypocentral locations and opens the possibility of carrying out more detailed analyzes of the seismicity in Guatemala and its surrounding regions, such as the characterization of the seismic source presented in this paper, located within the plate that subducts under Guatemalan territory.

2 Slab description

On the southern coast of Guatemala, the Cocos plate subducts under the Caribbean plate; this subduction zone being the source that produces the most seismicity per year in the country. From Southeastern Mexico to Northwestern El Salvador (México-Guatemala-El Salvador Subduction Zone or MGESZ), the slab dip angle gradually changes from 20 to 60 degrees from the Mesoamerican Trench to a depth of 280 km (Hayes et al., 2018) with a substantially uniform geometry (Hayes et al., 2018; Guzmán-Speziale and Zúñiga, 2016). The velocity of the Cocos plate with respect to the Central America forearc sliver to the northwest of MGESZ is 76.4±2.5 mm/year, while to the southeast it is 75.0±1.2

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annotations:

Green, means your suggestions were completed.
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xyoli 28 Jun

Include the day.

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seismic intensities of VI on the Modified Mercalli Intensities scale (MMI) were reached.

mm/year (Ellis et al., 2019) (Figure 2).

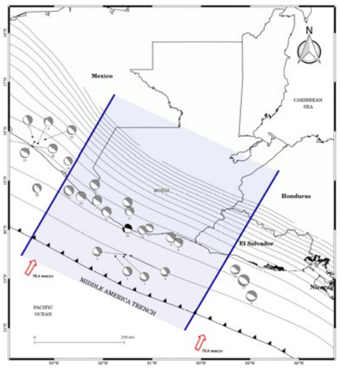

Figure 2 Subduction region between the Cocos and Caribbean plates that includes the border with Mexico, Guatemala and part of El Salvador (MGESZ), the geometry of the slab (Hayes et al., 2018) is relatively uniform. The focal mechanism of the 16 February 2022 earthquake is shown in black (this work) and the focal mechanisms of historical intermediate-depth (>50 km) down dip extension earthquakes with Mw>6 obtained from the Global Centroid-Moment-Tensor (gCMT) Project (Dziewonski et al., 1981; Ekström et al., 2012) and the Advanced National Seismic System (ANSS) of the USGS catalogs, are shown in grey. The convergence velocity of the Cocos plate decreases slightly from Mexico to El Salvador (Ellis et al., 2019).

Historically several destructive earthquakes have been generated in this subduction zone (e.g., Ambraseys and Adams, 1996; White et al., 2004; Ye et al., 2013; Ellis et al., 2018), through instrumental and macroseismic information, several of them have been identified, both in the interplate and intraplate regions (Ambraseys and Adams, 1996; White et al., 2004). On the other hand, information about the centroid moment tensors (CMTs), indicate that in the entire subduction process there are reverse (or compression) as well as normal (or extension) focal mechanisms. In the outer rise, where the bending of the Cocos plate occurs at the beginning of subduction, the focal mechanisms are mostly normal, in the interplate region (to depths between 50-60 km) are predominantly inverse, while at greater depths both types of focal mechanisms are found (Güendel and Protti, 1998; Alvarez, 2009; Guzmán-Speziale and Zúñiga, 2016; Guzmán-Speziale and Molina, 2022). This is consistent with other subduction zones in the world with relatively simple geometries (Craig et al., 2022).

The trigger mechanism of intermediate depth earthquakes is still a matter of debate. Among the most accepted explanations is the dehydration embrittlement and the reactivation of faults previously created in the outer rise region in the bending of the plate and its subsequent unbending during subduction (e.g., Ranero et al., 2005; Brudzinski et al., 2007; Kiser et al., 2011; Marot et al., 2012; Cabrera et al., 2021).

As in other regions of the world, for earthquakes of intermediate depth, detailed studies have revealed the presence of a double seismicity zone (DSZ) on the MGESZ slab, with an observed separation between the upper seismicity layer (USL) and the lower seismicity layer (LSL) (Brudzinski et al., 2007; Florez and Prieto, 2019). For the region close to the 16 February 2022 earthquake Brudzinski et al. (2007) found a separation of 8±6.6 km betwen USL and LSL while for Florez and Prieto (2019) this distance was 11.3±4 km. This little separation compared to other subduction regions is closely related to the young age of the subducting plate (Brudzinski et al., 2007; Florez and Prieto, 2019), which is estimated to be 24±2 million years old (Nishikawa and Ide, 2014).

Brudzinski et al. (2007) found that the focal mechanisms of the LSL in the analyzed subduction zones (he does not report information on MGESZ) are of extension. On the other hand, at intermediate depths the earthquakes in the USL are usually compressional (Craig et al., 2022; Chu and Beroza, 2022). At these depths in MGESZ it has been estimated that extensional earthquakes release more seismic moment than compressional earthquakes (Alvarez, 2009; Guzmán-Speziale and Zúñiga, 2016) as in many other subduction zones (Craig et al., 2022).

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inverse earthquakes than to extension and compression earthquakes.

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Spell it out.

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XPC 16 Sep

Add an inset global map for reference. Not all the readers are familiar with the region.

XPC 16 Sep

Fonts in figures are too small, enlarge them.

3

3 Seismicity associated with the Mw 6.2 earthquake

More than 275 aftershocks were registered and located with the SeisAn software (Havskov and Ottemoller, 1999), with magnitudes between 2.4 and 4.7, distributed in the region close to the mainshock. The epicenters showed a NNE-SSW orientation. The depth of the mainshock hypocenter was estimated at 70±7 km, deeper than the approximately 50 km of the Slab2 model at that location (Hayes et al., 2018). The initial distribution (before the relocation procedure) of aftershock depths ranged from 40 to 80 km (Figure 3).

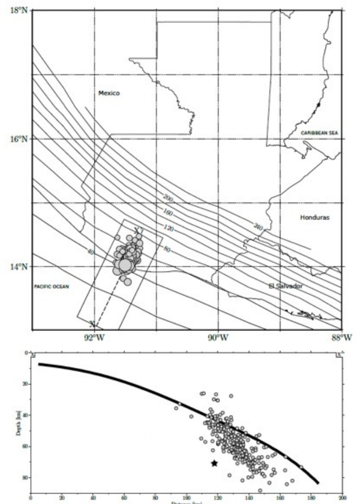

Figure 3 Geographic distribution and profile of the preliminary location of the main earthquake (black star in profile) and the sequence of aftershocks. The model of the slab in region is shown (Hayes et al., 2018). Most earthquakes are found at depths between 40 and 80 km.

The CMT of the Mw 6.2 earthquake was obtained using the W phase algorithm (Kanamori and Rivera, 2008; Hayes et al., 2018; Duputel et al., 2012), with records from the seismic agencies mentioned above and from waveforms obtained through the Wilber 3 platform of the Incorporated Research Institutions for Seismology (Newman et al., 2013). The depth of the centroid was 60.5 km (Figure 5). Table 1 shows some results of the inversion in comparison with the solutions of the Global Centroid-Moment-Tensor Project (Dziewonski et al., 1981; Ekström et al., 2012) and the Advanced National Seismic System (ANSS) of the USGS.

Agency	NP1	NP2	Mw	Depth (km)	Moment (N-m)
INSIVUMEH	182.6/ 34.0/ -14.9	285.1/ 81.7/ -123.1	6.24	60.5	2.85e+18
GCMT	189.2/ 49.2/ -10.6	286.2/ 82.0/ -138.7	6.2	63.5	2.41e+18
USGS	190.0/ 49.0/ -14.0	289.0/ 79.0/ -138.0	6.17	60.5	2.30e+18

Table 1 Comparison of the moment tensor's elements obtained in the present work with those of gCMT and USGS.

In addition, 13 focal mechanisms were estimated using the P-wave first-arrival polarity method for the largest magnitude aftershocks, obtaining focal mechanisms with larger extension and compression components. For this, the FOCMEC (Snoke, 2003) and FPFIT (Reasenberg and Oppenheimer, 1985) algorithms were used within the SeisAn software (Havskov and Ottemoller, 1999) (Figure 4).

Add a comment

inverse earthquakes than to extension and compression earthquakes.

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Spell it out.

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XPC 16 Sep

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Fonts in figures are too small, enlarge them.

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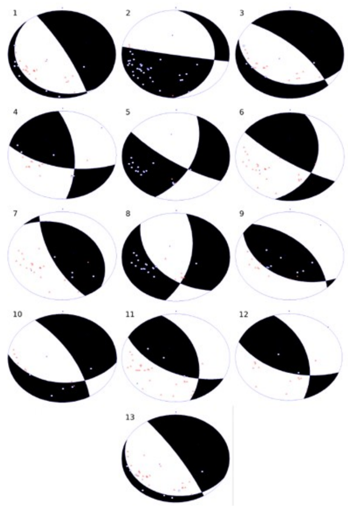

Figure 4 Focal mechanisms of the largest aftershocks of the seismic sequence related to the Mw 6.2 earthquake obtained by the first-arrival polarities method. The circles represent the polarities of compression and the triangles those of dilatation. 1,2,3,5,8,10 and 13 have larger normal focal mechanism components, while 4,6,7,9,11 and 12 have inverse focal mechanism components. P and T are the pressure and tension axes, respectively.

3.1 Earthquake relocation

To obtain a catalog of relocated seismic events, the HypoDD v1.3 program was used (Waldhauser and Ellsworth, 2000; Waldhauser, 2001), a simultaneous relocation algorithm that minimizes the residual between observed and theoretical travel time differences (or double differences) for pairs of earthquakes recorded at each station while linking all observed event-station pairs (Waldhauser and Ellsworth, 2000). The Double-Differences technique takes advantage of the fact that if the hypocentral separation between two earthquakes is small compared to the event-station distance, then the ray paths between the source region and a common station are similar over almost the entire path (Fréchet, 1985; Got et al., 1994). In this case, the difference in travel times for two events observed at one station can be attributed to spatial shifting between the events with high precision. This approach is especially useful in regions with a dense seismicity distribution (Waldhauser, 2001).

To build the initial network of event pairs, neighborhoods were defined in which the maximum separation distance between hypocenters was 8.0 km and that each earthquake formed at least six links within this region. In addition, each pair of events within the network was required to have at least six pairs of observations, resulting in an average separation of 4.8 km between strongly linked events. With the network of pairs of events thus formed and using the local velocity model, a relocated catalog with 234 events was obtained. Although the local velocity model is a 1D parallel layer model, HypoDD reduces the bias in locating individual events.

The results observed in Figure 5 show that the earthquakes clustered remarkably below the top of the slab proposed by Hayes et al. (2018), limiting the depth of most earthquakes between approximately 50 and 65 km, with a few events reaching depths close to 70 km including the mainshock. The latter was grouped with the rest of the sequence after relocation, although the depth was only reduced to 69 km. The dimensions of the fault according to the relocated catalog were ~16 km×22 km, which is equivalent to an area of 350 km^2 approximately.

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Fonts in figures are too small, enlarge them.

Page 3 2

xyoli 16 Sep

I don't think there is a need of the number below the beachballs since they are not referenced anywhere else in the manuscript.

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Page 5 2

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Also, it is impossible to distinguish the

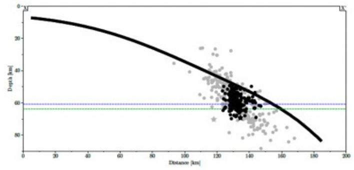

Figure 5 Comparison of the preliminary location of the mainshock (gray star) and aftershock sequence (grey dots) and their relocation (black star and dots) using HypoDD (Waldhauser and Ellsworth, 2000; Waldhauser, 2001). The model of the slab in the region is shown (Hayes et al., 2018) and the horizontal dotted lines show the depth of the centroid reported by different agencies (blue line: INSIVUMEH, USGS; green line: gCMT).

3.2 Rupture plane and temporal evolution

According to the catalog of relocated earthquakes, during the first days the seismicity was concentrated in a limited region with a subvertical orientation. As the seismic activity evolved, in addition to recording earthquakes in this same area, earthquakes were recorded further away, near the top of the slab, as shown in Figure 6. According to the estimated moment tensor, NP2 in Table 1 represents the rupture plane, where most of the seismicity is distributed, as shown in Figure 7. On the other hand, the focal mechanisms with the highest normal component were located in the region of said fault plane (blue dots in Figure 6), while the focal mechanisms with the highest inverse components were in the upper seismicity region (red dots in Figure 6).

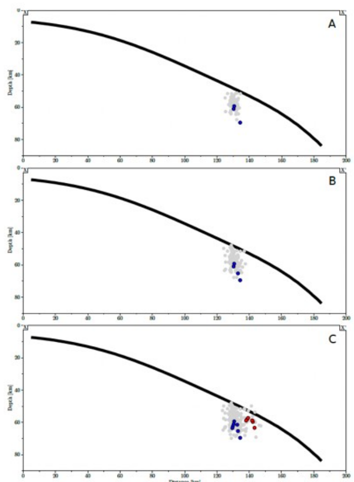

Figure 6 Temporal evolution of the seismic sequence (grey dots) in 1 day (A), 5 days (B) and 28 days (C). The spread of seismicity over time can be observed. The blue dots represent the earthquakes with normal focal mechanisms located in the main region of activity, while the red dots represent reverse focal mechanisms located near the upper region of the slab.

The location of the hypocenter at 69 km and the location of the centroid at around 60 km (Figure 5), suggest that the rupture could have propagated from the LSL to the USL in the region of the estimated plane. The earthquake rupture plane between the LSL and the USL has been described for some large-magnitude earthquakes of intermediate depth

25 Comments

Add a comment

I suggest the following change: seismic intensities of VI on the Modified Mercalli Intensities scale (MMI) were reached.

XPC 16 Sep

Add an inset global map for reference. Not all the readers are familiar with the region.

XPC 16 Sep

Fonts in figures are too small, enlarge them.

Page 3 2

xyoli 16 Sep

I don't think there is a need of the number below the beachballs since they are not referenced anywhere else in the manuscript.

XPC 28 Jun

inverse

Page 5 2

XPC 16 Sep

Might want to change the aspect ratio to make them look as circles.

XY **xyoli** 16 Sep

Also, it is impossible to distinguish the symbols for compression and tension, make them bigger.
It is also impossible to see the T and the P.
I suggest you to use the same color code as in Figure 7 for inverse and normal mechanisms.

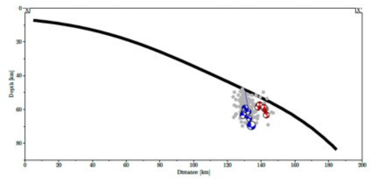

Figure 7 Representation of the relocated seismicity (grey dots) and the estimated focal mechanisms for the largest aftershocks, the focal mechanism of the Mw 6.2 earthquake is at the nucleation point. The fault plane is marked with the dotted blue line (of approximately 22 km), which projects towards the entire region of seismic activity. Earthquakes with reverse focal mechanisms are located between the rupture plane and the top of the slab.

(Twardzik and Ji, 2015) for which it was identified through the associated aftershocks: the 2014 Mw 7.9 earthquake in Rat Islands, Alaska (Twardzik and Ji, 2015), the 2005 Mw 7.7 earthquake in Tarapaca, Chile (Peyrat et al., 2006; Delouis and Legrand, 2007), the 1993 Mw 7.6 Kushiro-Oki earthquake in Japan (Ide and Takeo, 1996) and the 2017 Mw 8.2 earthquake in Tehuantepec, Mexico, where two parallel faults were identified within the slab (SSN, 2017). The dip angle of the plane of these earthquakes varies considerably.

On the other hand, in the Chilean subduction zone, earthquakes of moderate magnitude have been reported for which it has also been possible to describe the rupture plane through the registered aftershocks, Marot et al. (2012) describes the rupture plane of a Mw 5.7 earthquake that occurred in January 2003 in Central Chile, while Cabrera et al. (2021), identifies a fault plane of a Mw 6.3 earthquake, which occurred in October 2017 in the northern region of that country.

As mentioned, it is evident that most of the seismicity was generated in the region of the suggested plane, especially in the first days of activity. However, later, more dispersed seismicity is observed with depths closer to the top of the slab, probably in the USL (Figures 6 y 7). This scenario, where the seismicity generated by an extension earthquake triggers seismicity with compression focal mechanisms, was also observed for the Mw 8.2 earthquake in Tehuantepec, Mexico (Ortega et al., 2019) and in the Mw 5.7 earthquake in Central Chile (Marot et al., 2012). Chu and Beroza (2022) propose that intermediate-depth aftershocks are enabled by stress transfer and pore fluid redistribution in the proximity of the mainshock, which is enabled by dehydration. In our case due the closeness betwen the fault plane of mainshock and the USL, it is possible que such effects reach that region, triggerin seismic actctivity with another rupture mechanism.

Several intermediate depth earthquakes with normal focal mechanisms have been documented in MGESZ, similar to the Mw 6.2 earthquake analyzed in this work (Figure 2), however, this is the first time that the fault plane has been identified through of the associated aftershocks and the triggering of seismicity outside the mainshock rupture surface with another type of focal mechanism.

3.3 Conclusions and discussion of results

Despite the fact that the sequence of earthquakes described was triggered by the Mw 6.2 earthquake, the zone had manifested constant seismic activity (relative to the rest of the region) prior to 16 February 2022 and continued during the following months. Background seismicity can be observed in Figure 8, mostly with magnitudes less than four. Some earthquakes with magnitudes greater than 5 stand out, whose focal mechanisms were also of extension. In mid-2021, a seismic sequence was generated, although there was no earthquake of outstanding magnitude.

This background activity has not been observed for other intermediate-depth extension earthquakes in MGESZ between 2013 and 2019, where both the number of aftershocks and the days of their production have been lower (Figure 9). Although the improvement of the RSN has been notable only in recent years, the magnitude of completeness of the INSIVUMEH catalog has been between 3.5 to 3.9 since 1984 (Benito et al., 2012), hence the detectability of earthquakes above these magnitudes can be considered effective. Figure 9 shows the number of aftershocks with magnitudes above 3.5. While for historical earthquakes the days of aftershock production have been between 5 and 7 days, with a maximum amount of around 40 earthquakes, for the 16 February 2022 earthquake, after a month of activity, more than sixty events were registered. In the months of May and June, there were other outstanding earthquakes with normal focal mechanisms. The difference in the behavior of these seismic sources is possibly due to different dehydration processes of the slab (Kiser et al., 2011; Chu and Beroza, 2022) but the data is not conclusive, so this explanation is outside the scope of this work.

Although the estimated area with the sequence of relocated aftershocks is equivalent to an area of $\sim$350 km^2, the empirical relationships of Wells and Coppersmith (1994) suggest that the rupture area for a Mw 6.2 earthquake would reach 170 km^2, about half of the area covered by the sequence. On the other hand, the estimate of 22 km of fault length penetrating the slab is consistent with the minimum value of 20 km reported by Ranero et al. (2003a)

25 Comments

Add a comment

XY **xyoli** 16 Sep

Also, it is impossible to distinguish the symbols for compression and tension, make them bigger.
It is also impossible to see the T and the P.
I suggest you to use the same color code as in Figure 7 for inverse and normal mechanisms.

XPC 16 Sep

Make them bigger. It is impossible to see them.

Page 6 1

xyoli 16 Sep

Include also the map view of the relocated epicenters.

Page 7 5

xyoli 16 Sep

Could you make the beachballs larger? It's hard to distinguish them, even applying zoom in the digital version.

xyoli 16 Sep

You could add the number of the beachballs in Figure 4 for better reference.

XPC 28 Jun

You might want to include the reference by Suárez et al. (2021):

Suárez, G, M A Santoyo, V Hjorleifsdottir, A Iglesias, C Villafuerte, V M Cruz-Atienza (2019). Large scale lithospheric detachment of the

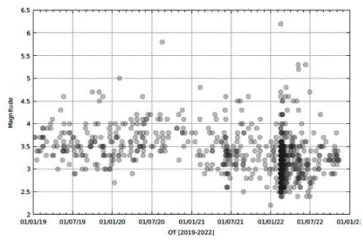

Figure 8 Temporal distribution of seismic activity in the region of activity of the 16 February 2022 earthquake (Figure 3), with the horizontal axis showing the origin time (OT) of the earthquakes that occurred between 2019 and 2022 and the magnitude on the vertical axis. Seismic activity has been constant, including some earthquakes with M>5 and a seismic sequence in 2021. It is possible to note the improvement of the RSN in the detectability of smaller magnitude earthquakes.

through seismic reflection data for bending-related faulting in the incoming plate at the Middle America trench. So, it is possible that the main event triggered the seismicity in a pre-existing fault, generated in the outer rise (Ranero et al., 2005; Kiser et al., 2011; Marot et al., 2012), also triggering out-of-plane seismicity.

Said seismicity outside the fault plane includes the compression earthquakes of the Figures 6 C and 7, possibly in the USL. Assuming that the nucleation of the mainshock occurred in the LSL we can estimate an average separation between LSL and USL of 12.2 ± 5.0 km (taking into account the estimated errors for the calculation of preliminary hypocenter depths and assigning an error of 10 % for the values taken from Slab 2), consistent with previous estimates, especially with Florez and Prieto (2019), confirming the trend of several double subduction zones with normal focal mechanisms in LSL and inverse ones in USL (Craig et al., 2022; Chu and Beroza, 2022).

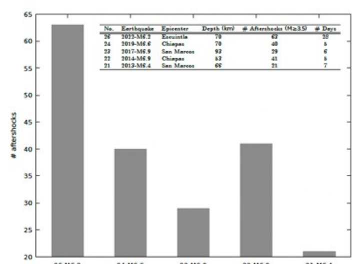

Figure 9 Number of aftershocks with M≥3.5 for earthquakes of extension at intermediate depths from 2013 to 2022 in MGESZ. Inserted table describes the number of earthquake (as numbered in Figure 2), the year and magnitude of the earthquake, the place of the epicenter, depth, number of aftershocks and the number of days in which they were generated, according to the INSIVUMEH catalog. See discussion in text.

Acknowledgements

The support of the Swiss Agency for Development and Cooperation (SDC), the Swiss Seismological Service (SED) at ETH Zurich and the Volcano Disaster Assistance Program (VDAP) of the US Geological Survey (USGS), have been important for the expansion of the RSN and the improvement of the information generated by the INSIVUMEH. Thanks to Gabriela Xol and Jorge Cárcamo for reviewing some of the data used.

× **25 Comments**

Add a comment

by Suárez et al. (2021):

Suárez, G, M A Santoyo, V Hjorleifsdottir, A Iglesias, C Villafuerte, V M Cruz-Atienza (2019). Large scale lithospheric detachment of the downgoing Cocos plate: The 8 September 2017 earthquake (Mw 8.2), Journal Earth and Planetary Science Letters, 509, 9-14.

XPC 28 Jun

that

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Page 8 4

robin 16 Sep

This was removed from the manuscript.

xyoli 16 Sep

Text in the inset table is impossible to read.

xyoli 16 Sep

You mentioned in the text that this earthquakes are in the same region as the earthquake studied here. I suggest to include their epicenters in Figure 1. Aside from the mentioning on hydration as possible explanation, can you see any other that their location can tell you?

robin 16 Sep

It was considered to compare the productivity of aftershocks of these earthquakes because INSIVUMEH has

Data and code availability

The HypoDD program (https://www.ldeo.columbia.edu/ felixw/hypoDD.html) was used within the SeisAn Software (http://seisan.info/). The preliminary and relocated catalogs, information about seismic stations, as well as the configuration and input files for the relocation can be found at: (review pending).

For the inversion of W Phase, stations of the following seismic networks were also used: Caribbean Network (CU; doi: 10.7914/SN/CU), GEOFON (GE; doi: 10.14470/TR560404), Global Seismograph Network - IRIS/IDA (II; doi: 10.7914/SN/II) Nicaraguan Seismic Network (NU; doi: 10.7914/SN/NU). For the generation of maps we used QGIS V. 2.14.11 ESSEN (https://qgis.org/en/site/forusers/download.html) and GMT V. 6.4.0 (Wessel et al., 2019).

Competing interests

The authors have no competing interests.

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× **25 Comments**

Add a comment

Journal Earth and Planetary Science Letters, 509, 9-14.

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Page 8 4

robin 16 Sep

This was removed from the manuscript.

xyoli 16 Sep

Text in the inset table is impossible to read.

xyoli 16 Sep

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triggering

Page 8 4

robin 16 Sep

This was removed from the manuscript.

xyoli 16 Sep

Text in the inset table is impossible to read.

xyoli 16 Sep

You mentioned in the text that this earthquakes are in the same region as the earthquake studied here. I suggest to include their epicenters in Figure 1. Aside from the mentioning on hydration as possible explanation, can you see any other that their location can tell you?

robin 16 Sep

It was considered to compare the productivity of aftershocks of these earthquakes because INSIVUMEH has given a better follow-up to these seismic sequences. However, the National Seismological Network had not yet been strengthened, so the catalogs of these sequences are not comparable with the catalog of the sequence analyzed in this work.

We have reconsidered this position and we have identified difficulties in drawing other conclusions about the behavior of these other seismicity regions, so we decided to omit this analysis in the manuscript.

Page 9 1

XPC 28 Jun

Add the data you used from SDC, SSN, etc.

Review of:

The rupture plane of the February 2022 Mw 6.2 3

Guatemala, intermediate depth earthquake

By Yani-Quiyuch, Asturias and Castro

Line-by-line comments to authors.

Abstract

It says: was generated

It should say: occurred

Done. We changed the redaction.

Introduction

Line 11: It says: was generated

It should say: occurred

Done

Line 12/Figure 1: Show where departmentas of Escuintla and Suchitepéquez are

Done (Figure 1 unified)

Figure 1: Show background seismicity; place station locations in an inset

Done (Figure 1 unified)

Epicentral location of the main shock should be given somewhere. In fact, location by various agencies (e.g., INSIVUMEH, PDE, Centroid, etc.) would be helpful

Done (Figure 1 unified). The epicenter of the main earthquake was highlighted. The different locations of the centroid were not considered, since the epicentral locations were used for both the main earthquake and the background seismicity.

Line 14 What is INSIVUMEH, anyway?

Done

What is the objective of this work? It should be clearly stated in the Introduction.

We include the following text:
"In this paper, we utilize waveforms from a strengthened seismic network to conduct a detailed analysis of the earthquake that occurred on 16 February 2022, along with its subsequent sequence of aftershocks. By relocating the hypocenters, we successfully identified the rupture plane, which aligns with the moment tensor of the main earthquake and the normal focal mechanisms of certain aftershocks. Additionally, we discovered other earthquakes in the sequence, situated further away from the rupture plane, in the upper part of the slab, some of which exhibited an inverse focal mechanism. The analysis and interpretation procedure are described below."

Line 32: Change heading to "The subducted Cocos Plate"

Done

Line 34: What do you mean by "the most seismicity per year"

This was changed "This subduction zone gives rise to a significant number of earthquakes, which are monitored and recorded by the RSN"

Lines 35-36: "the slab dip angle gradually changes from 20 to 60 degrees" This statement is contradictory with the figure caption for Figure 2 "the geometry of the slab (Hayes et al., 2018) is relatively uniform” and also contrdictory with the area of study shown in Figure 2. In fact, 20º of dip takes place further to the northwest of Figure 2, at about longitude -97º

- We changed the word “geometry” to “shape”. The meaning is to describe that the shape of the slab does not undergo important changes in MGESZ..
- The caption of Figure 1 (now unified) was clarified: “The iso-depth lines at the top of the slab (Hayes, et al., 2018) indicate its relatively uniform shape”.

Line 36: It is “Mid America Trench” (not Mesoamerican Trench)

Done

Figure 2 caption: The convergence velocity of the Cocos plate decreases slightly from Mexico to El Salvador (too little to mention; within error limits – see line 38)

We remove the description of an decrease. The text in Figure 1 (unified) caption was changed to: “Red arrows indicate the convergence velocities of the Cocos plate relative to the Central America forearc sliver, according to Ellis et al. (2019)”

Line 40: “Historically several destructive earthquakes have been generated in this subduction zone” (show on map and/or table)

Figure 1 shows the destructive earthquakes documented in the ISC-GEM catalog.

Lines 43-49: Map with focal mechanisms/CMT’s needed.

Done. Figure 1 was updated with CMTs information.

Line 50: Intermediate-depth earthquakes are usually triggered by slab-pull

The initial works analyzed the intraslab stress field through focal mechanisms of intermediate-depth earthquakes and suggest that intraslab deformation is dominated by the influence of axial plate stresses (i.e., slab pull, ridge push, tractions on the edges of slabs, and lower mantle resistance) (see Craig, et al., 2022).

However, the mechanism for any earthquake below approximately 70 km depth is still a subject of debate due to the need to overcome the high confining pressure that would otherwise prohibit the sudden release of strain as earthquakes (see Brudzinski, et al., 2007).

The existence of double subduction zones represents an important means of gaining insights into earthquakes at intermediate depths of 70 to 300 km, as a hypothesis for such seismogenesis must explain the presence of the two layers and the separation between them (see Brudzinski, et al., 2007).

It is inferred that the upper seismicity layer (USL) occurs within the subducting oceanic crust and/or the upper mantle due to dehydration reactions. Meanwhile, the lower seismicity layer (LSL) occurs in the lithospheric mantle, and its mechanism is still a topic of debate. Hypotheses for this process include the dehydration-embrittlement of antigorite, reactivation of preexisting shear zones, and quasi-adiabatic shear-heating instabilities. Furthermore, laboratory experiments suggest that faulting at intermediate depths can occur under dry conditions or due to dehydration-induced stress transfer under partially hydrated mantle conditions (see Cabrera, et al., 2020).

Line 66: Change title to Seismicity associated to the Mw 6.2 earthquake

Done

Line 67: Map with epicenters of relocated shocks needed. A map (like Figure 3 – original locations) can placed side by side with relocated epicenters.

Done

Line 75: It says Table 1 shows some results; it should say Table 1 shows results

Done. The wording was changed for a better understanding.

Table 1: Make clear what the headings mean. Is the depth epicentral or centroid?

Done: Centroid depth

Lines 78-81: Rewrite entire paragraph. Very confusing.

We rewrote said paragraph: “Additionally, 12 focal mechanisms were estimated for the largest magnitude aftershocks using the P-wave first-arrival polarity method. The focal mechanisms obtained showed dominant normal and inverse components (Figure 4). The SeisAn software (Havskov and Ottemoller, 1999) was utilized, employing the FOCMEC (Snoke, 2003) and FPFIT (Reasenberg and Oppenheimer, 1985) algorithms for this analysis.”

Figure 4: Compression, dilation, P, and T symbols are barely visible. Enlarge.

Done

Figure 4, caption: It says: 1,2,3,5,8,10 and 13 have It should say: Events 1,2,3,5,8,10 and 13 have; same for events 4,6,7,9,11 and 12

Done. It was clarified.

Line 82: I prefer the title of the section
Epicentral relocation

Done: we use the title “Hypocentral relocation”

Line 83: It says: To obtain a catalog of relocated seismic events It should say: In order to obtain a catalog of relocated seismic events

Done

Line 93: What are the links in the region?

This expressions are specific to the relocation process that are not adequately explained in the text. The wording was changed for better understanding.

Line 95: What are strongly linked events?

This expressions are specific to the relocation process that are not adequately explained in the text. The wording was changed for better understanding.

Line 96: Reference for the local velocity model.

Done

Figure 5: Show same (original and relocated) on map.

Done

Figure 5 caption: make it clear that the model of the slab is the TOP of the slab (as stated in lines 98-99).

Done

Line 103: Temporal evolution of what?

Done: Temporal evolution of seismicity

Lines 104-110: Rewrite paragraph; it is confusing.

We rewrote said paragraph:
"Based on the catalog of relocated earthquakes, the initial days showed concentrated seismic activity in a limited region with a subvertical orientation. As the seismic activity

progressed, additional earthquakes were recorded both within this same area and further away, near the top of the slab, as depicted in Figure 5.

The estimated moment tensor analysis indicates that NP2 in Table1 represents the primary rupture plane, where the majority of seismicity is distributed, as illustrated in Figure 6. Additionally, focal mechanisms with the highest normal component were found in the vicinity of this fault plane (blue beach balls in Figure 6), while focal mechanisms with the highest inverse components were observed in the upper region of the seismic activity (red beach balls in Figure 6).

Figure 6: Add map

Done

Figure 7: Add map; the fault plane is not visible. Focal mechanisms are too small.

Done: map was updated

Line 113: You are not considering thickness of slab. Or are the USL and LSL the physical limits of the slab?

As mentioned, earthquakes in the lower seismicity layer (LSL) occur in the lithospheric mantle, possibly near the lower limit of the subducted oceanic crust. However, there is currently no detailed model to trace this limit.

Lines 111-136 should be left for Discussion section.

Done

Line 137: It should be: Discussion and conclusions.

Done

Line 140: Background seismicity should also be shown on map, not just a progressive graph (Figure 8)

Done

Line 141: Extensional focal mechanisms are NOT shown on Figure 8

Since these earthquakes are not part of the earthquakes analyzed in this sequence, we decided to remove that description since these focal mechanisms are not included in the work.

Lines 143-144: Are you certain?

It was considered to compare the productivity of aftershocks of these earthquakes because INSIVUMEH has given a better follow-up to these seismic sequences. However, the National Seismological Network had not yet been strengthened, so the catalogs of these sequences are not comparable with the catalog of the sequence analyzed in this work.

We have reconsidered this position and we have identified difficulties in drawing other conclusions about the behavior of these other seismicity regions, so we decided to omit this analysis in the manuscript.

Figure 9: Not clear at all. What is horizontal axis? Table should not be inserted. Show as a separate table. By the way, the table does not "describe" number of earthquakes, ot only shows it.

Please, refer to the previous explanation (related to lines 143-144)

Review of
The rupture plane of the February 2022 Mw 6.2 Guatemala, intermediate depth earthquake
Authors: R. Yani-Quiyuch, L. Asturias, and D. Castro

Dear R. Yani-Quiyuch and co-authors:

Your manuscript "**The rupture plane of the February 2022 Mw 6.2 Guatemala, intermediate depth earthquake"** presents the analysis of the mainshock-aftershock sequence for the Mw 6.2 subduction earthquake in the segment of the Middle America Trench offshore Guatemala. This is the first time such an analysis is performed for an intra-slab, intermediate depth earthquake in this region. The relocalization of all the events in the sequence and the estimation of focal mechanisms for the mainshock and several aftershocks, allowed to establish the rupture plane, which was a subvertical plane cutting through the lower seismicity zone of the subduction slab, in which extensional events were produced. This activity also triggered aftershocks with compressional events in the upper seismicity zone, near the top of the slab. The size of the estimated rupture area, its location in with respect to the double seismicity zone and similarities with other subduction zones around the world allowed the authors to hypothesize this seismic activity occurred at a pre-existing fault, reactivated by dehydration embrittlement processes on the down going slab. Since extensional, intermediate depth, intra-slab earthquakes occur often in the region, they represent an important hazard which needs to be characterized and understood. This work is an important step towards that goal.

The manuscript is very well written and is a pleasure to read through. I found Figures 5, 6, and 7 particularly striking. If not for a few details, the paper could be ready for publication as is. However, I noted a few places where the discussion could be refined and a few figures could be improved slightly. Also, some final copy-editing to remove a few typos and grammatical errors would improve the clarity of the manuscript.

Find my comments below.

Apart from these minor comments, please accept my congratulations on a very interesting paper.

Best wishes,

Beatriz Cosenza-Muralles

× 37 comentarios

Agregar un comentario

robin 3 jul.

The objective in this section was only to mention that it was sensitive in a large part of the country, so the text was simplified.

It is not possible to indicate a distance, since the reported seismic intensities are instrumental and since we do not have a very dense seismic network in Guatemala, we cannot approximate at what distance significant ground accelerations were recorded.

robin 3 jul.

done

robin 5 sep.

done

robin 8 jul.

SSN: done

Seismic Netwok of El Salvador does not have a DOI

robin 5 sep.

The Sesimic network of Honduras has not been registered.

robin 8 jul.

It has been adequately cited in the text, Seismica requires this type of link in the Data and code availability section.

robin 8 jul.

done

robin 8 jul.

At the end of the phrase, the cite Ellis et al., (2019) is included

Comments:

1. Abstract: since different countries subdivide their territories differently, consider giving more context when giving geographical references, for example: "with epicenter southwest of the department of Escuintla, at the coast."

2. Figure 2 caption: "the focal mechanisms of historical intermediate-depth (>50 km) downdip extension earthquakes". It is my understanding that "historical" usually refers to earthquakes before instrumental records, and the earthquakes on the figure are from the gCMT and ANSS catalogs. Consider removing the word. Also, the word "downdip" seems unnecessary, removing it might help shorten the sentence and add more clarity.

3. Lines 13-14: It might be more accurate to say "the generated seismic waves were felt in a large part of the country". Also, instead of mentioning the reports from several departments of the country, it could be more illustrative to say it was reported within X km from the epicenter.

4. Line 14: Introduce here the full name and acronym of INSIVUMEH, which has not been mentioned earlier in the main text.

5. Figure 1 caption: I suggest using the full citation of the Red Sismológica Nacional and including it in the references:

   Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia (INSIVUMEH). (1976). ***Red Sismologica Nacional*** [Data set]. International Federation of Digital Seismograph Networks. https://doi.org/10.7914/SN/GI

6. I suggest the same as in comment 6 for the Servicio Sismológico Nacional (SSN) of Mexico and other seismological networks (lines 26, 176-178), and the HypoDD, SeisAn and QGIS softwares (lines 173, 174, and 179).

7. Line 36: In the maps, you use Middle America Trench and, in the text, you use Mesoamerican Trench. I recommend to be consistent with the terminology.

8. Line 38: include a citation for the statement on this line.

9. Lines 67-68: Consider mentioning the duration of the aftershock sequence in its description.

10. Line 96: which is the local 1D velocity model you use? Is there a citation for it?

11. From section 3.2 and Figure 6, the early aftershock activity concentrates on what has been interpreted as the rupture plane of the mainshock, which describes a subvertical fault cutting the interior of the slab. Later on, a second cluster of activity appears near the top of the slab, in the upper seismicity region. Was this a total migration of the activity from one initial plane to another? Does the activity at the first plane cease giving way to the activity at the second

37 comentarios

Agregar un comentario

Página 2 13

robin 15 sep.

along the Pacific coast

added in: Abstract, Resumen, Non-technical summary

robin 15 sep.

Figure two was unified with figure one. This uses the entire ISC-GEM catalog so this confusion no longer appears.

robin 3 jul.

The objective in this section was only to mention that it was sensitive in a large part of the country, so the text was simplified.

It is not possible to indicate a distance, since the reported seismic intensities are instrumental and since we do not have a very dense seismic network in Guatemala, we cannot approximate at what distance significant ground accelerations were recorded.

robin 3 jul.

done

robin 5 sep.

done

robin 8 jul.

SSN: done

Seismic Netwok of El Salvador does not have a DOI

robin 5 sep.

The Sesimic network of Honduras has not been registered.

robin 8 jul.

It has been adequately cited in the text, Seismica requires this type of link in the Data and code availability section.

plane? (Perhaps an extra figure not showing the cumulative aftershocks, but just the events happening within separate time intervals, with an added snapshot at a suitable time between 5 and 28 days could help clarify this). In your opinion, the activity at the late stages of the sequence is clustered and organized enough to define a clear second rupture plane or there are not enough events to anything other than seismicity more disperse than in the early stages?

12. Line 109: Did you mean *reverse* components?

13. Line 133: Consider adding citations for the statement on this line and a reference to Figure 2.

14. Line 137: “Discussion of results and conclusions” might be more appropriate.

15. Lines 139-140: When describing the background seismicity for the area (shown in Figure 8), it is not clearly stated how this area is delimited: from line 139 I infer this is not the seismicity of the whole Guatemala subduction segment, as delimited in Figure 2. Is it just for the area delimited by the profile in Figure 3, or is it a different area? In Figure 9, the mention of the MGESZ makes it clear that the information shown there is from the whole segment.

16. Line 142: Was the seismic sequence of mid-2021 a swarm? Is the location of the events of that sequence related in any way to the plane characterized in this manuscript?

17. Line 148: See my comment 2 about the term “historical earthquakes”.

18. Line 157: The correct citation is Ranero et al. (2003), without the “a” after the year. This also needs to be corrected in the reference list.

19. Lines 158-160: Is the fault plane orientation, when rotated to the position it would have been when it originated in the outer rise, consistent with the orientation of current faults in the outer rise? This could strengthen your argument in favor of the pre-existing fault.

Suggestions for the figures:

1. In printed versions of the manuscript, some of the text in the figures, particularly maps, may be hard to read. This is also true for the symbols representing the polarities in the focal mechanisms shown in Figure 4. Of course, this is absolutely not an issue when reading the manuscript in digital form, where one can easily zoom in. Nevertheless, consider enlarging the labels that have the smallest fonts.

2. Figure 1:

   - Consider making the focal mechanism larger and labeling the departments of Escuintla and Suchitepéquez, mentioned in the main text. Also, consider mentioning in the main

Agregar un comentario

Página 3 13

robin 5 sep.

We updated the series of graphs to clarifity this

robin 8 jul.

Question 3- Answer: The seismicity proposed for the upper part of the slab is scarce and despersed compared with de seismicity en the main plane, so it does not allow us to identify another possible fault plane.

robin 8 jul.

It was changed by "inverse" in entire document

robin 15 sep.

Done.
Please note that this text has been moved to the Discussion and Conclusions section.

robin 15 sep.

done.

robin 15 sep.

Please note that this paragraph has been moved further down in this section.

We change the word "the" for "this" in the phrase: "the zone had manifested constant seismic activity" (this zone had exhibited constant seismic activity).

Furthermore, we clarify that the rest of the region refers to " telative to the rest of the MGESZ region"

Finally, we expand the description of the background seismicity area: "Background seismicity in the area of the seismic sequence analyzed in this study can be seen... "

robin 15 sep.

text that the Guatemalan subduction zone (or the MGESZ) is a segment of the Middle America Trench, since it appears labeled on the map.

3. Figure 2
    - I noticed the earthquake focal mechanisms are labeled with numbers, what do they mean? If the numbers are not meaningful to the manuscript, consider removing them.
    - Consider adding labels to the slab contours (maybe every 20 km?).
    - Is there a lower limit for the depth of the earthquakes shown in the figure? If there is, it would be worth it to mention in the caption.
    - In the caption, consider referring to the red arrows in the plot to indicate these are the convergence velocities of the Cocos plate.
4. Consider combining the features of Figure 1 and 2 into one single figure.
5. Figures 3 and 5 caption: Consider writing "The black line shows the model of the line along the profile" instead of "The model of the slab in region is shown".
6. Figures 3, 5, 6, and 7: From what I see in the bottom panel, the horizontal axis is showing the distance from the trench, not the distance from the starting point of the profile (the thick black line representing the model of the slab from point X does not begin at 0 km). If this is the case, it might be better to label the axis "distance from the trench (km)". If this is not the case, consider extending the slab model all the way to 0 km.
7. Figure 5 shows beautifully how the aftershocks cluster and align after relocation. I would have really liked to see the clustering effect in map view too, in a two-panel figure like Figure 3, but showing the earthquakes on the map as equally sized dots instead of circles with sizes related to the magnitude. If space is a concern, the new map doesn't need to cover the whole country, and it can show just the area of interest.
8. I think Figures 6 and 7 would be much clearer if the horizontal axis started at ~80 km and the vertical axis ended at 30 or 20 km. This would allow the enlargement of the area in the figure containing the events for a better appreciation of what the authors are trying to show.
9. Figure 8 does not have a color scale yet the events appear to be color coded with a grey scale. What is the meaning of the color? Please revise this. Also, it would be helpful to mention in the caption when the network was enlarged to make more evident the improvement in detectability of low magnitude events.

robin 15 sep.

In Figure 1 (now consolidated), subduction earthquakes at different depths are depicted. According to the catalog used (ISC-GEM), the deepest recorded normal earthquake is at around 140 km depth. This is consistent with the depth estimated by Florez and Prieto (2019), who suggest that the double seismicity zone for the region converges at around 140 - 150 km. However, with the available data, it is not possible to confirm a depth limit for the occurrence of normal earthquakes.

robin 15 sep.

done

robin 5 sep.

done

robin 15 sep.

This is clarified by referring to the profile along X-X'

robin 16 jul.

done.

robin 16 jul.

done

robin 16 jul.

done

robin 16 sep.

We add in the description of Figure 7:

Earthquakes are depicted with transparent gray circles, where darker shades indicate a higher concentration of seismic events.

It is possible to observe an improvement in the RSN's ability to detect smaller magnitude earthquakes starting from 2021.