PEMANTAUAN SEISMIK *AMBIENT NOISE* DAN AMPLITUDO SPEKTRAL SEISMIK UNTUK IDENTIFIKASI PENINGKATAN AKTIVITAS GUNUNG IJEN

SKRIPSI

Diajukan sebagai syarat untuk memperoleh gelar Sarjana Sains

Program Studi Fisika Kelompok Bidang Kajian Fisika Kebumian

Oleh:

Fauzan Nur Elsafitri

NIM 2100100

PROGRAM STUDI FISIKA

FAKULTAS PENDIDIKAN MATEMATIKA DAN ILMU PENGETAHUAN ALAM

UNIVERSITAS PENDIDIKAN INDONESIA

2025

PEMANTAUAN SEISMIK *AMBIENT NOISE* DAN AMPLITUDO SPEKTRAL SEISMIK UNTUK IDENTIFIKASI PENINGKATAN AKTIVITAS GUNUNG IJEN

Oleh:

Fauzan Nur Elsafitri

Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar Sarjana Sains pada Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam

LEMBAR PENGESAHAN

FAUZAN NUR ELSAFITRI

PEMANTAUAN SEISMIK *AMBIENT NOISE* DAN AMPLITUDO SPEKTRAL SEISMIK UNTUK IDENTIFIKASI PENINGKATAN AKTIVITAS VULKANIK GUNUNG IJEN

Disetujui dan disahkan oleh:

Pembimbing I

Dr. Mimin Iryanti, S.Si., M.Si.

NIP. 197712082001122001

Pembimbing II,

Ir. Kristianto, M.Si.

NIP. 196612191996031001

Mengetahui,

Ketua Program Studi Fisika

Prof. Dr. Endi Suhendi, M.Si.

NIP. 197905012003121001

Pemantauan Seismik *Ambient Noise* Dan Amplitudo Spektral Seismik Untuk Identifikasi Peningkatan Aktivitas Gunung Ijen

ABSTRAK

Gunung Ijen merupakan salah satu gunung api aktif di Indonesia yang memerlukan pemantauan berkelanjutan untuk mitigasi bencana. Penelitian ini bertujuan mengidentifikasi peningkatan aktivitas vulkanik Gunung Ijen melalui analisis variasi kecepatan seismik relatif (δv/v) dan pengukuran amplitudo spektral seismik (SSAM) menggunakan data dari stasiun tunggal IJEN. Metode yang digunakan meliputi autokorelasi seismik ambient noise untuk memperoleh nilai δv/v, serta analisis SSAM untuk memetakan distribusi energi seismik. Hasil penelitian menunjukkan bahwa peningkatan aktivitas vulkanik ditandai oleh penurunan nilai δv/v sebesar -0,6% hingga -0,8%, yang bertepatan dengan periode krisis Januari 2020, Desember 2022–Januari 2023, dan Juli–Agustus 2024. Penurunan ini signifikan secara statistik berdasarkan uji *Modified Z-score* ($p < 0,05$) dan berkorelasi dengan peningkatan jumlah gempa vulkanik, tremor, serta erupsi. Analisis SSAM menunjukkan peningkatan energi seismik pada frekuensi rendah (0–5 Hz) selama periode aktivitas meningkat, yang selaras dengan kenaikan gempa Tremor dan Hembusan. Perbandingan visual δv/v dan SSAM tidak menunjukkan kesesuaian yang konsisten pada seluruh periode krisis; hal ini mengindikasikan variasi mekanisme sumber, di mana periode tertentu didominasi proses hidrotermal dangkal dan periode lainnya dipengaruhi oleh proses magmatik dalam. Integrasi kedua metode ini memberikan pemahaman yang lebih komprehensif untuk memantau dinamika internal Gunung Ijen dan berpotensi memperkuat sistem peringatan dini erupsi.

Kata Kunci: Gunung Ijen, Seismik *Ambient Noise,* SSAM, δv/v, Aktivitas Vulkanik

Ambient Noise Seismic Monitoring and Spectral Seismic Amplitude for Identification of Increased Volcanic Activity of Ijen Volcano

ABSTRACT

Ijen Volcano is one of the active volcanoes in Indonesia that requires continuous monitoring for disaster mitigation. This study aims to identify the increase in volcanic activity of Ijen Volcano through the analysis of relative seismic velocity variations (δv/v) and Seismic Spectral Amplitude Measurement (SSAM) using data from the single IJEN station. The methods applied include seismic ambient noise autocorrelation to obtain δv/v values and SSAM analysis to map the distribution of seismic energy. The results show that an increase in volcanic activity is marked by a decrease in δv/v values of -0.6% to -0.8%, coinciding with crisis periods in January 2020, December 2022–January 2023, and July–August 2024. This decrease is statistically significant based on the Modified Z-score test ($p < 0.05$) and correlates with an increase in the number of volcanic earthquakes, tremors, and eruptions. SSAM analysis indicates an increase in seismic energy at low frequencies (0–5 Hz) during periods of heightened activity, which corresponds with an increase in Tremor and Emission earthquakes. Visual comparison of δv/v and SSAM does not show consistent agreement across all crisis periods; this suggests variations in source mechanisms, with certain periods dominated by shallow hydrothermal processes and others influenced by deeper magmatic processes. The integration of these two methods provides a more comprehensive understanding of the internal dynamics of Mount Ijen and has the potential to strengthen the early warning system for eruptions.

Keywords: Ijen Volcano, Ambient Seismic Noise, SSAM, δv/v, Volcanic Activity.

DAFTAR ISI

DAFTAR GAMBAR

DAFTAR TABEL

DAFTAR PUSTAKA

Ackerley, N. (2014). Encyclopedia of Earthquake Engineering. In *Encyclopedia of Earthquake Engineering* (Nomor September 2014). https://doi.org/10.1007/978-3-642-36197-5

Aggarwal, C. C. (2017). An Introduction to Outlier Analysis. In *Outlier Analysis* (hal. 1–34). Springer International Publishing. https://doi.org/10.1007/978-3-319-47578-3_1

Agustiani, R., Santosa, B. J., Suparman, Y., & Syahbana, D. K. (2023). *Seismic Analysis of Ambient Noise Volcanic Earthquake on Mount Agung Analisis Seismik Ambient Noise Gempa Vulkanik Pada Gunung Agung*. *1*(4), 2985–3877. https://jurnal.institutsunandoe.ac.id/index.php/ESE

Anjelina, F., & Pohan, A. F. (2024). Indeks Kerentanan Seismik Menggunakan Data Mikrotremor Untuk Daerah Perbukitan Dan Pemukiman Di Bukit Nobita Kota Padang. In *Jurnal Fisika Unand*. https://doi.org/10.25077/jfu.13.4.511-517.2024

Ayu, H. D., & Jufriadi, A. (2014). Mekanisme Erupsi Dan Model Kantong Magma Gunungapi Ijen. *Jurnal Neutrino*, 74–83. https://doi.org/10.18860/neu.v0i0.2585

Basuki, B., Romadhona, S., Sari, V. K., & Erdiansyah, I. (2021). Karakteristik Iklim dan Tanah Vulkanis Di Sisi Barat Gunung Api Ijen Jawa Timur Sebagai Dasar Penentu Pengelolaan Varietas Tanaman Padi (Oriza Sativa L.). In *Jurnal Penelitian Pertanian Terapan*. https://doi.org/10.25181/jppt.v21i2.2050

Basuki, B., Sari, V. K., Farisi, O. A., & Mandala, M. (2023). Teknologi Penataan Pola Tanam Padi Sawah Berdasarkan Karakteristik Iklim Di Lahan Sub Optimal Das Sampian Lereng Gunung Ijen. In *Jurnal Agrotek Tropika*. https://doi.org/10.23960/jat.v11i1.5943

Benmansour, N., Derbal, R., Djafour, M., Ivorra, S., & Matallah, M. (2021). Impact of Local Site Conditions on Simulation of Non-Stationary Spatial Variable Seismic Motions. *Periodica Polytechnica Civil Engineering*. https://doi.org/10.3311/ppci.16208

Bennington, N. L., Haney, M. M., Thurber, C. H., & Zeng, X. (2018). Inferring Magma Dynamics at Veniaminof Volcano via Application of Ambient Noise. In *Geophysical Research Letters*. https://doi.org/10.1029/2018gl079909

Bormann, P., Klinge, K., & Wendt, S. (2009). Data Analysis and Seismogram Interpretation. *New manual of seismological observatory practice*, *Potsdam : Deutsches GeoForschungsZentrum GFZ*, 1-102. https://doi.org/https://doi.org/10.2312/GFZ.NMSOP_r1_ch11

Brenguier, F., Campillo, M., Hadziioannou, C., Shapiro, N. M., Nadeau, R. M., & Larose, E. (2008). Postseismic relaxation along the San Andreas fault at Parkfield from continuous seismological observations. *Science*, *321*(5895), 1478–1481. https://doi.org/10.1126/science.1160943

Brenguier, F., Clarke, D., Aoki, Y., Shapiro, N. M., Campillo, M., & Ferrazzini, V. (2011). Monitoring volcanoes using seismic noise correlations. *Comptes Rendus - Geoscience*, *343*(8–9), 633–638. https://doi.org/10.1016/j.crte.2010.12.010

Brenguier, F., Shapiro, N. M., Campillo, M., Ferrazzini, V., Duputel, Z., Coutant, O., & Nercessian, A. (2008). Towards forecasting volcanic eruptions using seismic noise. *Nature Geoscience*, *1*(2), 126–130. https://doi.org/10.1038/ngeo104

Brenguier, F., Shapiro, N. M., Campillo, M., Nercessian, A., & Ferrazzini, V. (2007). 3-D surface wave tomography of the Piton de la Fournaise volcano using seismic noise correlations. *Geophysical Research Letters*, *34*(2). https://doi.org/10.1029/2006GL028586

Browne, P. R. L., & Lawless, J. V. (2001). Characteristics of hydrothermal eruptions, with examples from New Zealand and elsewhere. *Earth Science Reviews*, *52*(4), 299–331. https://doi.org/10.1016/S0012-8252(00)00030-1

Caudron, C., Lecocq, T., Syahbana, D. K., McCausland, W., Watlet, A., Camelbeeck, T., Bernard, A., & Surono, S. (2015). Stress and Mass Changes at a "Wet" Volcano: Example During the 2011–2012 Volcanic Unrest at Kawah Ijen Volcano (Indonesia). In *Journal of Geophysical Research Solid Earth*. https://doi.org/10.1002/2014jb011590

Caudron, C., Syahbana, D. K., Lecocq, T., Van Hinsberg, V., McCausland, W., Triantafyllou, A., Camelbeeck, T., Bernard, A., & Surono. (2015). Kawah Ijen volcanic activity: a review. *Bulletin of Volcanology*, *77*(3). https://doi.org/10.1007/s00445-014-0885-8

Caudron, C., Taisne, B., Neuberg, J., Jolly, A. D., Christenson, B., Lecocq, T., Suparjan, Syahbana, D., & Suantika, G. (2018). Anatomy of phreatic eruptions. *Earth, Planets and Space*, *70*(1). https://doi.org/10.1186/s40623-018-0938-x

Chandola, V., Banerjee, A., & Kumar, V. (2009). Anomaly detection: A survey. *ACM Comput. Surv.*, *41*(3). https://doi.org/10.1145/1541880.1541882

Chouet, B. A. (1996a). Long-period volcano seismicity: its source and use in eruption forecasting. *Nature*, *380*(6572), 309–316. https://doi.org/10.1038/380309a0

Chouet, B. A. (1996b). New Methods and Future Trends in Seismological Volcano Monitoring. *Monitoring and Mitigation of Volcano Hazards*, 23–97. https://doi.org/10.1007/978-3-642-80087-0_2

Ciaramella, A., Lauro, E. De, Falanga, M., & Petrosino, S. (2011). *Automatic detection of long - period events at Campi Flegrei Caldera (Italy)*. *38*(September), 1–5. https://doi.org/10.1029/2011GL049065

Clarke, D., Zaccarelli, L., Shapiro, N. M., & Brenguier, F. (2011). *Assessment of resolution and accuracy of the Moving Window Cross Spectral technique for monitoring crustal temporal variations using ambient seismic noise*. 867–882.

https://doi.org/10.1111/j.1365-246X.2011.05074.x

Coppola, D., Laiolo, M., Cigolini, C., Massimetti, F., Delle Donne, D., Ripepe, M., Arias, H., Barsotti, S., Parra, C. B., Centeno, R. G., Cevuard, S., Chigna, G., Chun, C., Garaebiti, E., Gonzales, D., Griswold, J., Juarez, J., Lara, L. E., López, C. M., … William, R. (2020). Thermal Remote Sensing for Global Volcano Monitoring: Experiences From the MIROVA System. *Frontiers in Earth Science*, *7*(January), 1–21. https://doi.org/10.3389/feart.2019.00362

Cornelius, R. R., & Voight, B. (1999). *Real-time Seismic Amplitude Measurement (RSAM) and Seismic Spectral Amplitude Measurement (SSAM) Analyses with the Materials Failure Forecast Method (FFM), June 1991 Explosive Eruption at Mount Pinatubo*. USGS.

Dewanti, T., Nurchayati, N., & As'ari, H. (2020). Identifikasi Tumbuhan Paku (Pteridophyta) Di Kawasan Ijen Banyuwangi. In *Jurnal Biosense*. https://doi.org/10.36526/biosense.v3i1.949

Duputel, Z., Ferrazzini, V., Brenguier, F., Shapiro, N., Campillo, M., & Nercessian, A. (2009). Real time monitoring of relative velocity changes using ambient seismic noise at the Piton de la Fournaise volcano (La Réunion) from January 2006 to June 2007. *Journal of Volcanology and Geothermal Research*, *184*(1–2), 164–173. https://doi.org/10.1016/j.jvolgeores.2008.11.024

Edwards, W. N., Eaton, D. W., & Brown, P. (2008). Seismic Observations of Meteors: Coupling Theory and Observations. *Reviews of Geophysics*. https://doi.org/10.1029/2007rg000253

Elnashai, A. S., & Sarno, L. Di. (2008). *Fundamentals of Earthquake Engineering* (Second Edi).

ESDM. (2011). Pedoman Mitigasi Bencana Gunungapi, Gerakan Tanah, Gempabumi, Dan Tsunami. *Jdih Esdm*, 2–8. https://jdih.esdm.go.id/index.php/web/result/741/detail

Fee, D., & Matoza, R. S. (2013). An overview of volcano infrasound: From hawaiian to plinian, local to global. *Journal of Volcanology and Geothermal Research*, *249*, 123–139. https://doi.org/10.1016/j.jvolgeores.2012.09.002

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics*. SAGE Publications. https://books.google.co.id/books?id=AlNdBAAAQBAJ

Galone, L., Panzera, F., Colica, E., Fucks, E., Carol, E., Cellone, F., Rivero, L., Agius, M., & D'Amico, S. (2024). A Seismic Monitoring Tool for Tidal-Forced Aquifer Level Changes in the Río De La Plata Coastal Plain, Argentina. *Sustainability*. https://doi.org/10.3390/su16041432

GeoNet. (n.d.). *RSAM & SSAM*. https://www.geonet.org.nz/about/volcano/rsamssam

Gestrich, J. E., Fee, D., Tsai, V. C., Haney, M. M., & Eaton, A. R. Van. (2020). A Physical Model for Volcanic Eruption Tremor. In *Journal of Geophysical Research Solid Earth*. https://doi.org/10.1029/2019jb018980

Giudicepietro, F., López, C., Macedonio, G., Alparone, S., Bianco, F., Calvari, S., Cesare, W., Delle Donne, D., Di Lieto, B., Esposito, A., Orazi, M., Peluso, R., Privitera, E., Romano, P., Scarpato, G., & Tramelli, A. (2020). Geophysical precursors of the July-August 2019 paroxysmal eruptive phase and their implications for Stromboli volcano (Italy) monitoring. *Scientific Reports*, *10*, 10296. https://doi.org/10.1038/s41598-020-67220-1

Gutenberg, B. (1951). Observation and theory of microseisms. *American Meteorological Society*, *In Malone*, *T. F.*, *editor*, *Compendium of Meteorology*, 1303–1311.

Hauke, J., & Kossowski, T. (2011). Comparison of values of pearson's and spearman's correlation coefficients on the same sets of data. *Quaestiones Geographicae*, *30*(2), 87–93. https://doi.org/10.2478/v10117-011-0021-1

Hendrasto, M. (2006). *Pemantauan Seismitas Gunung Ijen*.

Holland, A. S. P., Watson, I. M., Phillips, J. C., Caricchi, L., & Dalton, M. P. (2011). Degassing processes during lava dome growth: Insights from Santiaguito lava dome, Guatemala. *Journal of Volcanology and Geothermal Research*, *202*(1), 153–166. https://doi.org/https://doi.org/10.1016/j.jvolgeores.2011.02.004

Iglewicz, B., & Hoaglin, D. C. (1993). How to Detect and Handle Outliers. In *Technometrics* (Vol. 36, Nomor 3). https://doi.org/10.2307/1269377

Jiwani-Brown, E., Planès, T., Pacheco, J. F., Mora, M. M., & Lupi, M. (2022). Magmatic and Tectonic Domains of Central Costa Rica and the Irazú-Turrialba Volcanic Complex Revealed by Ambient Noise Tomography. In *Journal of Geophysical Research Solid Earth*. https://doi.org/10.1029/2022jb024575

Jufriadi, A., Maryanto, M., Susilo, A., Purwanto, B. H., & Hendrasto, M. (2013). Analisis Sinyal Seismik Untuk Mengetahui Proses Internal Gunung Ijen Jawa Timur. In *Jurnal Neutrino Jurnal Fisika Dan Aplikasinya*. https://doi.org/10.18860/neu.v0i0.2443

Julian, B. R. (1994). Volcanic tremor: nonlinear excitation by fluid flow. *Journal of Geophysical Research*, *99*(B6). https://doi.org/10.1029/93jb03129

Kadarsetia, E. (2006). Karakteristik kimiawi air danau kawah Gunung Api Kelud, Jawa Timur pasca letusan tahun 1990. *Indonesian Journal on Geoscience*, *1*(4), 185–192. https://doi.org/10.17014/ijog.vol1no4.20062

Kiswiranti, D. (2019). *SEISMOLOGI (Dasar-dasar Seismologi dan Apilikasinya)*. 1–150.

Koch, K. (2002). Seismic Event Identification of Earthquakes and Explosions in Germany Using Spectral Lg Ratios. In *Pure and Applied Geophysics*. https://doi.org/10.1007/s00024-002-8658-2

Konstantinou, K. I., Perwita, C. A., Maryanto, S., Budianto, A., Hendrasto, M., & Surono. (2013). Maximal Lyapunov exponent variations of volcanic tremor recorded during explosive and effusive activity at Mt Semeru volcano,

Indonesia. *Nonlinear Processes in Geophysics*, *20*(6), 1137–1145. https://doi.org/10.5194/npg-20-1137-2013

Kwietniak, A., Maćkowski, T., & Cichostępski, K. (2021). Seismic Signature of Transition Zone (Wolf Ramp) in Shale Deposits With Application of Frequency Analysis. In *Geofluids*. https://doi.org/10.1155/2021/6614081

Lahr, J. C., Chouet, B. A., Stephens, C. D., Power, J. A., & Page, R. A. (1994). Earthquake classification, location, and error analysis in a volcanic environment: implications for the magmatic system of the 1989-1990 eruptions at redoubt volcano, Alaska. *Journal of Volcanology and Geothermal Research*, *62*(1–4), 137–151. https://doi.org/10.1016/0377-0273(94)90031-0

Lecocq, T., Caudron, C., & Brenguier, F. (2014). Msnoise, a python package for monitoring seismic velocity changes using ambient seismic noise. *Seismological Research Letters*, *85*(3), 715–726. https://doi.org/10.1785/0220130073

Matoza, R., Jolly, A., Fee, D., Johnson, R., Chouet, B., Dawson, P., Kilgour, G., Christenson, B., Garaebiti, E., Iezzi, A., Austin, A., Kennedy, B., Fitzgerald, R., & Key, N. (2017). Seismo-acoustic wavefield of strombolian explosions at Yasur volcano, Vanuatu, using a broadband seismo-acoustic network, infrasound arrays, and infrasonic sensors on tethered balloons. *The Journal of the Acoustical Society of America*, *141*, 3566. https://doi.org/10.1121/1.4987573

McNamara, D. E., & Boaz, R. I. (2019). Visualization of the seismic ambient noise spectrum. *Seismic Ambient Noise*, 1–29. https://doi.org/10.1017/9781108264808.003

McNutt, S. R. (1996). Seismic Monitoring and Eruption Forecasting of Volcanoes: A Review of the State-of-the-Art and Case Histories. In *Monitoring and Mitigation of Volcano Hazards* (hal. 99–146). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-80087-0_3

McNutt, S. R. (2005). Volcanic seismology. *Annual Review of Earth and Planetary Sciences*, *33*, 461–491. https://doi.org/10.1146/annurev.earth.33.092203.122459

McNutt, S. R., & Roman, D. C. (2015). Chapter 59 - Volcanic Seismicity. In H. Sigurdsson (Ed.), *The Encyclopedia of Volcanoes (Second Edition)* (Second Edi, hal. 1011–1034). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-385938-9.00059-6

Montgomery, D. C. (2012). *Statistical Quality Control, 7th Edition*. Wiley. https://books.google.co.id/books?id=RgQcAAAAQBAJ

Mordret, A., Jolly, A. D., Duputel, Z., & Fournier, N. (2010). Monitoring of phreatic eruptions using Interferometry on Retrieved Cross-Correlation Function from Ambient Seismic Noise: Results from Mt. Ruapehu, New Zealand. *Journal of Volcanology and Geothermal Research*, *191*(1–2), 46–59. https://doi.org/10.1016/j.jvolgeores.2010.01.010

Muchtar, A., Manurung, Z. K. M., Rustadi, R., Suparman, Y., & Jumarang, M. I. (2022). Identifikasi Zona Reservoir Panas Bumi Gunung Ijen Jawa Timur Berdasarkan Pemodelan 2 Dimensi Anomali Geomagnetik. In *Positron*. https://doi.org/10.26418/positron.v12i1.49130

Mulyanti, H., Harjono, H., & Rendra, M. I. (2020). Penurunan Intensitas Hujan Ekstrem di Bengawan Solo Hilir dan Hubungannya dengan ENSO. *Jurnal Ilmu Lingkungan*, *18*(1), 73–81. https://doi.org/10.14710/jil.18.1.73-81

Musson, R. (2012). Intensity and Intensity Scales. *New manual of seismological observatory practice 2*, *June*, 1–41. https://doi.org/10.2312/GFZ.NMSOP-2

Neuberg, J. (2000). External modulation of volcanic activity. *Geophysical Journal International*, *142*(1), 232–240. https://doi.org/10.1046/j.1365-246X.2000.00161.x

Nishida, K., Mizutani, Y., Ichihara, M., & Aoki, Y. (2020). Time-Lapse Monitoring of Seismic Velocity Associated With 2011 Shinmoe-Dake Eruption Using Seismic Interferometry: An Extended Kalman Filter Approach. In *Journal of Geophysical Research Solid Earth*. https://doi.org/10.1029/2020jb020180

Nuryanto, D. E. (2011). Analisis Pseudo-Vektor Pada Aktivitas Konvektif Benua Maritim Indonesia. *Jurnal Meteorologi dan Geofisika*, *12*(2), 117–127. https://doi.org/10.31172/jmg.v12i2.92

Obermann, A., Planès, T., Larose, E., & Campillo, M. (2013). Imaging preeruptive and coeruptive structural and mechanical changes of a volcano with ambient seismic noise. *Journal of Geophysical Research: Solid Earth*, *118*(12), 6285–6294. https://doi.org/10.1002/2013JB010399

Olivier, G., Brenguier, F., Carey, R., Okubo, P., & Donaldson, C. (2019). Decrease in Seismic Velocity Observed Prior to the 2018 Eruption of Kīlauea Volcano With Ambient Seismic Noise Interferometry. *Geophysical Research Letters*, *46*(7), 3734–3744. https://doi.org/10.1029/2018GL081609

Patanè, D., Barberi, G., Cocina, O., De Gori, P., & Chiarabba, C. (2006). Time-resolved seismic tomography detects magma intrusions at mount etna. *Science*, *313*(5788), 821–823. https://doi.org/10.1126/science.1127724

Pearson, K. (1895). Note on Regression and Inheritance in the Case of Two Parents. *Proceedings of the Royal Society of London*, *58(-1)*, 240–242. https://doi.org/https://doi.org/10.1098/rspl.1895.0041

Poupinet, G., Ellsworth, W. L., & Frechet, J. (1984). *Monitoring Velocity Variations in the Crust Using Earthquake Doublets: An Application to the Calaveras Fault, California*. *89*(4), 5719–5731. https://doi.org/doi:10.1029/JB089iB07p05719

PVMBG. (2023). *Badan Geologi Tingkatan Status Gunung Api Ijen Menjadi WASPADA*. https://www.esdm.go.id/id/media-center/arsip-berita/badan-geologi-tingkatkan-status-gunung-api-ijen-menjadi-waspada

Rezeki, D. S. S., Putra, Y. S., Perdhana, R., Arman, Y., & Muhardi, M. (2023).

Penerapan Metode Amplitude Variance Frequency Pada Data Seismik Daerah Reservoir Dengan Studi Kasus Lapangan Teapot Usa. In *Jurnal Geosaintek*. https://doi.org/10.12962/j25023659.v9i1.14005

Rodríguez, A., Bergen, M. J. van, & Eggenkamp, H. (2018). Experimental Evaporation of Hyperacid Brines: Effects on Chemical Composition and Chlorine Isotope Fractionation. In *Geochimica Et Cosmochimica Acta*. https://doi.org/10.1016/j.gca.2017.10.032

Rogers, J. A., & Stephens, C. D. (1995). SSAM: real-time seismic spectral amplitude measurement on a PC and its application to volcano monitoring. *Bulletin - Seismological Society of America*, *85*(2), 632–639.

Sabra, K. G., Gerstoft, P., Roux, P., Kuperman, W. A., & Fehler, M. C. (2005). Extracting time-domain Green's function estimates from ambient seismic noise. *Geophysical Research Letters*, *32*(3), 1–5. https://doi.org/10.1029/2004GL021862

Sager, K., Boehm, C., Ermert, L., Krischer, L., & Fichtner, A. (2020). Global-Scale Full-Waveform Ambient Noise Inversion. *Journal of Geophysical Research Solid Earth*. https://doi.org/10.1029/2019jb018644

Santoso, G. D. T. (2024). *Peningkatan Tingkat Aktivitas G. Ijen dari Level I (Normal) Menjadi Level II (Waspada)*. https://vsi.esdm.go.id/press-release/peningkatan-tingkat-aktivitas-g-ijen-dari-level-i-normal-menjadi-level-ii-waspada

Scher, S., Williams-Jones, A. E., & Williams-Jones, G. (2013). Fumarolic Activity, Acid-Sulfate Alteration, and High Sulfidation Epithermal Precious Metal Mineralization in the Crater of Kawah Ijen Volcano, Java, Indonesia. In *Economic Geology*. https://doi.org/10.2113/econgeo.108.5.1099

Schmid, A., Grasso, J. R., Clarke, D., Ferrazzini, V., Bachlery, P., & Staudacher, T. (2012). Eruption forerunners from multiparameter monitoring and application for eruptions time predictability (Piton de la Fournaise). *Journal of Geophysical Research: Solid Earth*, *117*(11). https://doi.org/10.1029/2012JB009167

Sens-Schönfelder, C., & Wegler, U. (2006). Passive image interferemetry and seasonal variations of seismic velocities at Merapi Volcano, Indonesia. *Geophysical Research Letters*, *33*(21), 1–5. https://doi.org/10.1029/2006GL027797

Shapiro, N. M., & Campillo, M. (2004). Emergence of broadband Rayleigh waves from correlations of the ambient seismic noise. *Geophysical Research Letters*, *31*(7), 8–11. https://doi.org/10.1029/2004GL019491

Siswowidjoyo, S., Sudarsono, U., & Wirakusumah, A. D. (1997). The threat of hazards in the Semeru volcano region inEast Java, Indonesia. *Journal of Asian Earth Sciences*, *15*(2), 185–194. https://doi.org/https://doi.org/10.1016/S0743-9547(97)00007-X

Snieder, R., Grêt, A., Douma, H., & Scales, J. (2002). Coda wave interferometry

for estimating nonlinear behavior in seismic velocity. *Science*, *295*(5563), 2253–2255. https://doi.org/10.1126/science.1070015

Song, Z., Zeng, X., Chi, B., Bao, F., & Osotuyi, A. G. (2022). Using the Three-Station Interferometry Method to Improve Urban DAS Ambient Noise Tomography. *Frontiers in Earth Science*. https://doi.org/10.3389/feart.2022.952410

Song, Z., Zeng, X., Xie, J., Bao, F., & Zhang, G. (2021). Sensing Shallow Structure and Traffic Noise With Fiber-Optic Internet Cables in an Urban Area. *Surveys in Geophysics*. https://doi.org/10.1007/s10712-021-09678-w

Spica, Z., Caudron, C., Perton, M., Lecocq, T., Camelbeeck, T., Legrand, D., Piña-Flores, J., Iglesias, A., & Syahbana, D. K. (2015). Velocity models and site effects at Kawah Ijen volcano and Ijen caldera (Indonesia) determined from ambient noise cross-correlations and directional energy density spectral ratios. *Journal of Volcanology and Geothermal Research*, *302*, 173–189. https://doi.org/10.1016/j.jvolgeores.2015.06.016

Stehly, L., Campillo, M., & Shapiro, N. M. (2006). A study of the seismic noise from its long-range correlation properties. *Journal of Geophysical Research: Solid Earth*, *111*(10). https://doi.org/10.1029/2005JB004237

Sugiyono. (2013). *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D*.

Sugiyono. (2023). Metode Penelitian Kuantitatif, Kualitatif dan R&D. In *Alfabeta: Vol. 2(5)* (Nomor 1).

Suparman, Y., Geologi, B., Syahbana, D. K., Resources, M., & Pagacancang, A. (2019). *Pemantauan Seismik Ambient Noise dan Realtime Seismic Amplitude Measurement Untuk Identifikasi Peningkatan Aktivitas Gunung Api*. *January*.

Tauzin, B., Debayle, E., Quantin, C., & Coltice, N. (2013). Seismoacoustic Coupling Induced by the Breakup of the 15 February 2013 Chelyabinsk Meteor. *Geophysical Research Letters*. https://doi.org/10.1002/grl.50683

Terada, A., Hashimoto, T., Kagiyama, T., & Sasaki, H. (2008). Precise Remote-Monitoring Technique of Water Volume and Temperature of a Crater Lake in Aso Volcano, Japan: Implications for a Sensitive Window of a Volcanic Hydrothermal System. *Earth Planets and Space*, *60*(6), 705–710. https://doi.org/10.1186/bf03353134

Tero, H., & Nakajima, J. (2024). Amplitude-Dependent Energy Dissipation Inferred From Spectral Analyses of Intraslab Earthquakes. In *Journal of Geophysical Research Solid Earth*. https://doi.org/10.1029/2023jb028492

Tero, H., & Nakajima, J. (2025). Seismological Observations on Amplitude-Dependent Energy Dissipation in the Crust and Uppermost Mantle. In *Geophysical Research Letters*. https://doi.org/10.1029/2024gl112427

Vila, J., Ortiz, R., Tárraga, M., Macià, R., García, A., Kumar, D., & Correig, A. M. (2008). Near-Real Time Analysis of Seismic Data of Active Volcanoes: Software Implementations of Time Sequence Data Analysis. In *Natural*

Hazards and Earth System Science. https://doi.org/10.5194/nhess-8-789-2008

Voight, B. (1988). A method for prediction of volcanic eruptions. *Nature*, *322*(6160), 125–130. https://doi.org/10.1038/332125a0

Yates, A. S., Savage, M. K., Jolly, A. D., Caudron, C., & Hamling, I. J. (2019). Volcanic, Coseismic, and Seasonal Changes Detected at White Island (Whakaari) Volcano, New Zealand, Using Seismic Ambient Noise. *Geophysical Research Letters*, *46*(1), 99–108. https://doi.org/10.1029/2018GL080580

Zhao, S., Meng, X., Gu, D., Guo, C., Wang, X., & Zhang, J. (2022). Study on Propagation Characteristics of Scholte Wave in Shallow Sea at Non-Horizontal Underwater Interface. *Journal of Vibroengineering*. https://doi.org/10.21595/jve.2022.22303

Zobin, V. M., Peral, J. J., Nava, F., & Bretón, M. (2015). Vulcanian explosions in the process of building-destruction of the lava dome of andesitic volcano: Insight from the seismic signals recorded at Volcán de Colima, México. *Physics of the Earth and Planetary Interiors*, *244*, 1–10. https://doi.org/10.1016/j.pepi.2015.05.001

Zulivandama, S. R., Hermansyah, G. M., & Wijaksono, E. (2018). Aplikasi Metode Sweetness Dan Spectral Decomposition Untuk Identifikasi Awal Potensi Hidrokarbon Di Perairan Utara Bali. In *Jurnal Geologi Kelautan*. https://doi.org/10.32693/jgk.v16i1.401