**PROCEEDINGS**
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# Management of Earthquake Mitigation as Effort to Increase National Oil and Gas Production

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**Abstract**

Geologically, Indonesia has a complex tectonic setting because it is located between various oceanic plates and continental plates that are actively moving all the time. With the combination of the Indo-Australian plate, the Eurasian plate and the Pacific plate, Indonesia has the potential to experience many earthquakes related to plate movement. Earthquakes that occur due to plate movement in the majority of Indonesia are shallow earthquakes, with a depth of less than 20 km which are very destructive. [1]

Indonesia's earthquake record data from the BMKG records that in 2008 – 2016 there were 5,000 – 6,000 earthquakes in Indonesia. In 2017 the incidence of earthquakes increased to 7,169 times, even in 2018 and 2019 to more than 11,400 times. In 2020 the incidence of earthquakes is still above the annual average of 8.258 times. Even in Jan – Mar 2021 alone there have been 2,108 earthquakes. Exceeds the normal average monthly earthquake event record in the range of 300 – 400 events.[2]

The data shows an increased risk of earthquakes as a warning alert to prioritize proper seismic mitigation management through the readiness of infrastructure and supporting facilities for predictive action (earthquake potential mapping) and corrective action (earthquake handling). In addition to managing seismicity mitigation, synergies from relevant institutions (BMKG, Ministry of Energy and Mineral Resources with Oil and Gas Companies and Oil and Gas Research Institutes) are urgently needed to optimize the potential for earthquakes to become an integrated source of information. As a record & early warning agency, BMKG should refer to an excellent example from the Japan Meteorological Agency (JMA) which monitors earthquakes, volcanoes, and weather in one integrated institution so that it focuses on coordination.

Earthquake is a risk that must be faced and needs to be mitigated properly because it can have a direct impact on upstream oil and gas operations. Studies of rocks excavated from fault zones have revealed crack marks, mineral-filled veins, and other signs that pressure fluctuates freely during and between earthquakes, concluding the theory that hydrocarbon fluid flows play an important role in triggering earthquakes and influencing when earthquakes occur. Including injection of artificial fluids associated with secondary/tertiary recovery operations that can cause earthquakes. Just as seismologists have linked oil and gas waste water wells to the dramatic increase in earthquakes in Oklahoma (USA) in 2009 because of injection of oil and gas wells by operators holding mining rights.[3]

SIG is the Earthquake Intensity Scale. This scale expresses the impact caused by an earthquake. The Earthquake Intensity Scale (SIG-BMKG) was initiated and compiled by accommodating information on the impact of an earthquake based on typical culture or buildings in Indonesia. This scale is structured more simply by having only five levels, namely I-V. GIS-BMKG is expected to be useful in delivering information related to earthquake mitigation and/or rapid response to destructive earthquakes. This scale can make it easier for the public to understand the level of impact caused by an earthquake better & more accurately.

| Skala SIG BMKG | Warna | Deskripsi Sederhana | Deskrispsi Rinci | Skala MMI | PGA (gal) |
|---|---|---|---|---|---|
| I | Putih | TIDAK DIRASAKAN (Not Felt) | Tidak dirasakan atau dirasakan hanya oleh beberapa orang tetapi terekam oleh alat. | I-II | < 2.9 |
| II | Hijau | DIRASAKAN (Felt) | Dirasakan oleh orang banyak tetapi tidak menimbulkan kerusakan. Benda-benda ringan yang digantung bergoyang dan jendela kaca bergetar. | III-V | 2.9-88 |
| III | Kuning | KERUSAKAN RINGAN (Slight Damage) | Bagian non struktur bangunan mengalami kerusakan ringan, seperti retak rambut pada dinding, atap bergeser ke bawah dan sebagian berjatuhan. | VI | 89-167 |
| IV | Jingga | KERUSAKAN SEDANG (Moderate Damage) | Banyak Retakan terjadi pada dinding bangunan sederhana, sebagian roboh, kaca pecah. Sebagian plester dinding lepas. Hampir sebagian besar atap bergeser ke bawah atau jatuh. Struktur bangunan mengalami kerusakan ringan sampai sedang. | VII-VIII | 168-564 |
| V | Merah | KERUSAKAN BERAT (Heavy Damage) | Sebagian besar dinding bangunan permanen roboh. Struktur bangunan mengalami kerusakan berat. Rel kereta api melengkung. | IX-XII | > 564 |

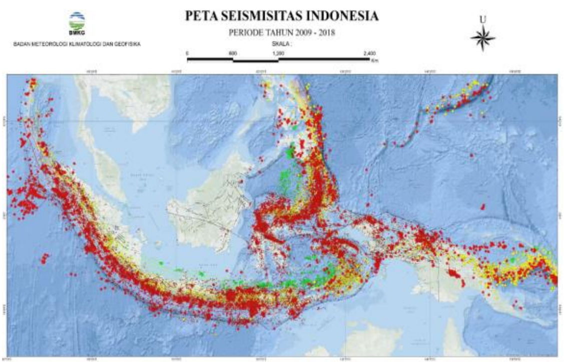


Figure 1: Peta Sebaran Gempa Nasional Data BMKG

Seismic waves generated from earthquakes can also have a positive impact as a stimulus to increase oil and gas production, due to an increase in porosity which allows hydrocarbon fluids to flow more easily. Research has been carried out by firing seismic waves at an oil and gas field through Vibro Seismic Impact Technology (VSIT) & High Resolution Electro Magnetic (HREM), both of which have been carried out massively in many oil and gas fields in the United States & Russia and which have been tested on a limited basis (pilot project) and national oil and gas fields in Indonesia (Sumatra & Kalimantan). [4]

**Introduction**

Indonesia has a complex geological tectonic setting because it is located between various oceanic plates and continental plates that are actively moving all the time. With the combination of the Indo-Australian plate, the Eurasian plate and the Pacific plate, Indonesia has the potential to experience many earthquakes related to plate movement. Earthquakes that occur due to plate movement in the majority of Indonesia are shallow earthquakes, with a depth of less than 20 km which are very destructive.[1]

Earthquakes generally occur without warning and occur rapidly within minutes and seconds. Earthquake events usually consist of 3 phases, namely the initial earthquake (fore shock), the main earthquake (main shock) and the aftershock (after shock). Earthquakes that occur at sea can cause ocean waves. Waves occur due to a change in the form of a fault with an upright (vertical) motion on the seabed due to an earthquake, a large wave is called a tsunami. Earthquakes occur naturally which cannot be avoided and are very difficult to predict or predict, so that when they occur they often cause a lot of loss and loss of life.[5]

Referring to Law Number 31 of 2009 concerning Meteorology, Climatology, and Geophysics and Government Regulation Number 11 of 2016 concerning Meteorology, Climatology and Geophysics Services, which is strengthened by Presidential Regulation Number 93 of 2019 concerning Strengthening and Development of Earthquake Information Systems and Warnings Early Tsunami, the government is obliged to provide meteorological, climatological, and geophysical services consisting of information and services. The information in question consists of public information and special information. One of the public information that must be provided regularly is tectonic earthquake information. Other public information is tsunami early warning.

Earthquake and tsunami early warning information systems are components that are regularly interconnected to form a totality that includes observation of disaster symptoms, analysis of observations, and dissemination of analysis results, in the form of information on tectonic and/or volcanic earthquakes originating from volcanoes in the sea. and tsunami early warning for community decision-making and action. Earthquake and tsunami early warning information systems have a strategic and important role in anticipating and mitigating so that efforts are needed for strengthening and sustainable development to improve the safety of life and property of the Indonesian people from earthquakes and tsunamis.

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**Data and Method**

Earthquake is a risk that must be faced and needs to be mitigated properly because it can have a direct impact on upstream oil and gas operations. Studies of rocks excavated from fault zones have revealed crack marks, mineral-filled veins, and other signs that pressure fluctuates freely during and between earthquakes, concluding the theory that hydrocarbon fluid flows play an important role in triggering earthquakes and influencing when earthquakes occur. Including injection of artificial fluids associated with secondary/tertiary recovery operations that can cause earthquakes. Just as seismologists have linked oil and gas waste water wells to the dramatic increase in earthquakes in Oklahoma (USA) in 2009 because of injection of oil and gas wells by operators holding mining rights.[3]

Seismic waves generated from earthquakes can also have a positive impact as a stimulus to increase oil and gas production, due to an increase in porosity which allows hydrocarbon fluids to flow more easily. Research has been carried out by firing seismic waves at an oil and gas field through Vibro Seismic Impact Technology (VSIT) & High Resolution Electro Magnetic (HREM), both of which have been carried out massively in many oil and gas fields in the United States & Russia and which have been tested on a limited basis (pilot project) and national oil and gas fields in Indonesia (Sumatra & Kalimantan). [4]

Currently, oil producing industry facing significant declining production in oil recovery operations by the existing method. Scientifically, natural pressure in the reservoir generated up to 15% recovery of the existing oil contained in the formation and secondary recovery commonly consequences up to 45% recovery factor. The remaining oil is difficult to produce due to its very low mobility. Frequently practical approaches for enhanced oil recovery (EOR) consist of steam, water and gas flooding, surfactants/polymer injection, hydraulic fracturing and layer burning. In the most successful cases, oil recovery can be enhanced by range of 50 – 70% of the total oil in place.

Separately of these EOR techniques has several restrictions, as well as some disagreeable side effects. Intended for illustration, some methods are expensive, requiring shutting down production or may generate damaging environmental consequences. The use of adaptable wave stimulation has been proposed, not as substitute or complimentary tool which, in certain occurrences, may kind conservative methods more effective.

Vibro Seismic Impact Technology (VSIT) applies the principle of vibration (seismic waves) to formations to improve properties of the containing reservoir rock and oil.

The waves are produced by resources of a surface seismic vibrator to stimulate the reservoir. This technology potentially a relative low-cost practice for attractive oil recovery in depleted fields or returning some shut-in wells to production. Comparatively, less supplementary infrastructures are compulsory, and no new wells necessity to be drilled. In Indonesia, VSIT pilot project are still inadequate yet and requires more implementation. Consist of Merbau Trend & Jene field (Sumatera) and Kalimantan.

Vibro Seismic Impact Technology (VSIT) is an alternative EOR technique using seismic waves, which are created by means of a surface seismic vibrator to stimulate the reservoir. The mechanisms responsible for improved recovery remain the subject of further research. However, the following mechanisms have been proposed to explain the change in fluid flow characteristics resulting from the seismic wave stimulation, that is, changes in wettability, coalescence and/or dispersion of oil drops, reduced viscosity and surface tension, and increased permeability.

**Result and Discussion**

The surface excitation method of reservoir stimulation requires significant further testing. The number of field test or applications conducted is, yet, insufficient. Attempts to use surface sources for oil production stimulation show both positive and negative results, depending on the formations or reservoir characteristics. A correlation between oil rates and earthquakes was observed in the 1970s. It resulted in the first attempts to use the energy of seismic waves to mobilize residual oil spread in the reservoir in the form of drops of different sizes, and to rehabilitate depleted oil fields with high water production.[5]

Vibro Seismic is a technology that can be applied to increase oil recovery and some papers say that this Vibro Seismic research has long been carried out in laboratory studies and applied to the field. Laboratory tests showed that oil displacement can be increased by application of low-frequency vibration. It was also confirmed by field tests of oil production due to Vibro Seismic stimulation impact increased by 30-40%.[8]

However, estimations show that such an increase in oil production does not occur with low-frequency vibration. Most probably some unknown phenomena exist which impact on the mechanism of seismic vibration-induced increases in oil production. The object of this study was the development of an analytical model of Vibro Seismic stimulation to explain the mechanism of residual oil mobilization. Such a model can provide the basis for effective use of vibration stimulation.

The model oil-saturated formation consists of blocks of different sizes. Each large block includes several blocks of smaller sizes. Block sizes depend on the geological processes taking place during their formation, while correlation between their sizes does not depend on properties of constituent materials.

Core measurements taken in the millimeter range and analysis of photographs of layer distribution in open hole taken in the metric range show that correlation between the large and small blocks occurs over a rather small range and varies between 2.91 and 3.43.

Simulation of Vibro Seismic impact on a formation shows that a process of low-frequency energy transfer from larger blocks to smaller ones, producing high-frequency vibration, takes place. These high-frequency vibrations provide conditions under which capillary forces, retaining oil drops in the porous media, are destroyed, improving conditions for oil mobilization. These results agree with experimental data of noise measurements recorded during pilot commercial tests of Vibro Seismic action at different oil fields in Russia. Thus the possibility of residual oil mobilization by applying low-frequency Vibro Seismic stimulation was confirmed both theoretically and in laboratory and field tests. The results received were an essential part of the creation of the technology for Vibro Seismic stimulation of waterflooded, depleted oil reservoirs.[6]

Ariadji (2005) explains the changes that occur in the physical properties of rocks and fluids when Vibro Seismic applied. In the experimental study used a variety of frequency variations to see indicators of change. From the results of the research, the optimum frequency results are 10 Hz and 15 Hz. With this optimum frequency, it can reduce the remaining saturation of oil, increase rock porosity, increase permeability, decrease oil viscosity and change capillary pressure.[7]

**Conclusions**

Indonesia, which is geographically located in a point prone to earthquakes with high intensity, needs to manage earthquake mitigation so that potential disasters can be avoided early on. In addition, the importance of earthquake mitigation management efforts can also have an impact on the good side of earthquakes on oil and gas activities.

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