

Trends in global and Indonesia geothermal research (1970-present)

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Background:

Geothermal is one way to energy independence. To achieve this, published subsurface data and information is the foundation. This paper presents the development of research in the geothermal field in the world and in Indonesia.

Methods:

Scope of the databases

We extracted papers from two academic databases: Scopus and Garuda. Both have different scopes. Scopus lists (a) articles published in journals worldwide, (b) the articles were written mainly in English, and (c) authored by global researchers (including Indonesian researchers), while Garuda lists (a) articles published in Indonesian journals, (b) the articles were written in Indonesian and English, (c) authored mainly by Indonesian researchers.

Keywords

In Scopus, we used two sets of “in title” keywords: (1) “geothermal” and (2) “geothermal AND Indonesia”. In the Garuda we used to extract papers from Indonesian researchers and/or written in Indonesian, using keywords “geothermal OR geothermal OR panas bumi” (Fig 1). From the search results, we extracted and downloaded the metadata for further visualizations using the Vosviewer software. The aim is to find out the pattern of connectedness between authors, institutions, countries, and research themes.

Analyses and discussions:

Distribution by year and notable milestones

Research on geothermal in Indonesia began to emerge in the decade of the 70s, which exponentially increased since 2005. From the visualization (Fig 2), we argue that geothermal research is closely related to government programs. Starting from the exploration of the Kamojang Field, geothermal research continues to grow in line with the exploration and operation of geothermal power plants in the Salak, Sibayak, and Wayang Windu which are the performance indicator for Pertamina as sole holder of exploration rights. In 2000 when Pertamina's monopoly was revoked, the issuance of UU 7 in 2003, and the geothermal development roadmap in 2006, geothermal research continued to increase sharply. More supporting milestone was the implementation of the World Geothermal Congress in Bali in 2010 and the claim of 2.6 MW of electricity production from Java geothermal fields in 2011.

Global research themes

We find research themes from upstream/exploration (green, blue, and yellow) to downstream/exploitation (Fig 3 above). The exploration section contains the theme of modeling geothermal systems with geological and geophysical methods (green). Yellow cluster contains themes: biology and biochemistry, the blue cluster contains themes: mineralogy, hydrochemistry, and trace elements, and red cluster with themes: exploitation, especially electricity production as an alternative energy.

Research themes in Indonesia

There are four theme clusters from upstream, middle, to downstream. Blue and green clusters are exploration clusters (Fig 3 below). The blue cluster contains research on geophysics, numerical modeling, temperature, and chemical analysis. The green cluster contains themes of geology, geophysics, mineralogy, drilling, and chemistry. The yellow cluster is the middle theme that bridges the exploration and exploitation clusters, consisting of drilling, reservoir, and fluid flow themes. The red cluster is an exploitation cluster containing the themes of power plant operation, energy generation, policy, optimization, and thermodynamics.

Collaborations

The data show strong collaboration between researchers from Indonesia and researchers from Asia, Europe (mostly Western Europe), the United States, and New Zealand (Fig 4). Collaboration with researchers from Africa and Eastern Europe is yet to be seen. This collaboration gap can be more intensively developed.

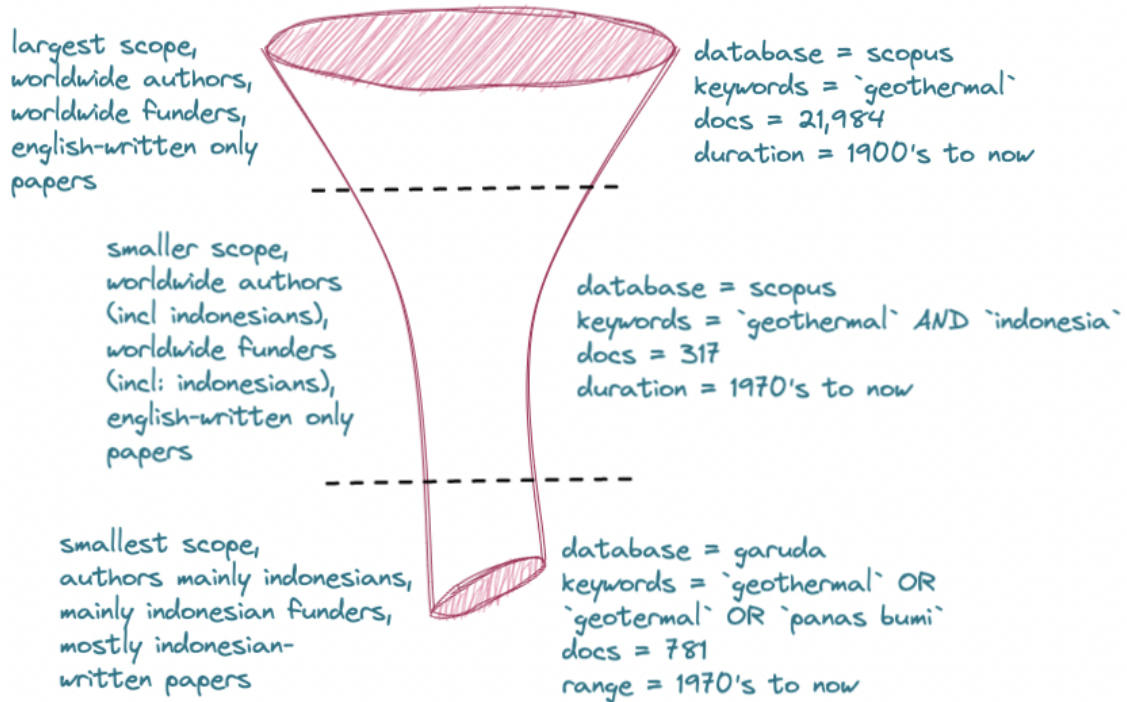
Proposed research direction

The author argues that geothermal exploration themes related to geology and geophysics have been widely studied, however, we expect research trends in the fields of geochemistry, isotopes, and biochemistry to continue. These themes will expand exploration missions to not only identify geothermal systems (conventional missions) but also to identify interactions between these systems and the environment, such as unconfined groundwater aquifers exploited by local communities and components of the aquatic environment. This will directly increase the collaboration between geosciences and basic sciences, life sciences, even health/medicine and social sciences.

Dataset: <https://doi.org/10.6084/m9.figshare.19418090.v1>

Author contributions: each author gave equal contributions to the manuscript

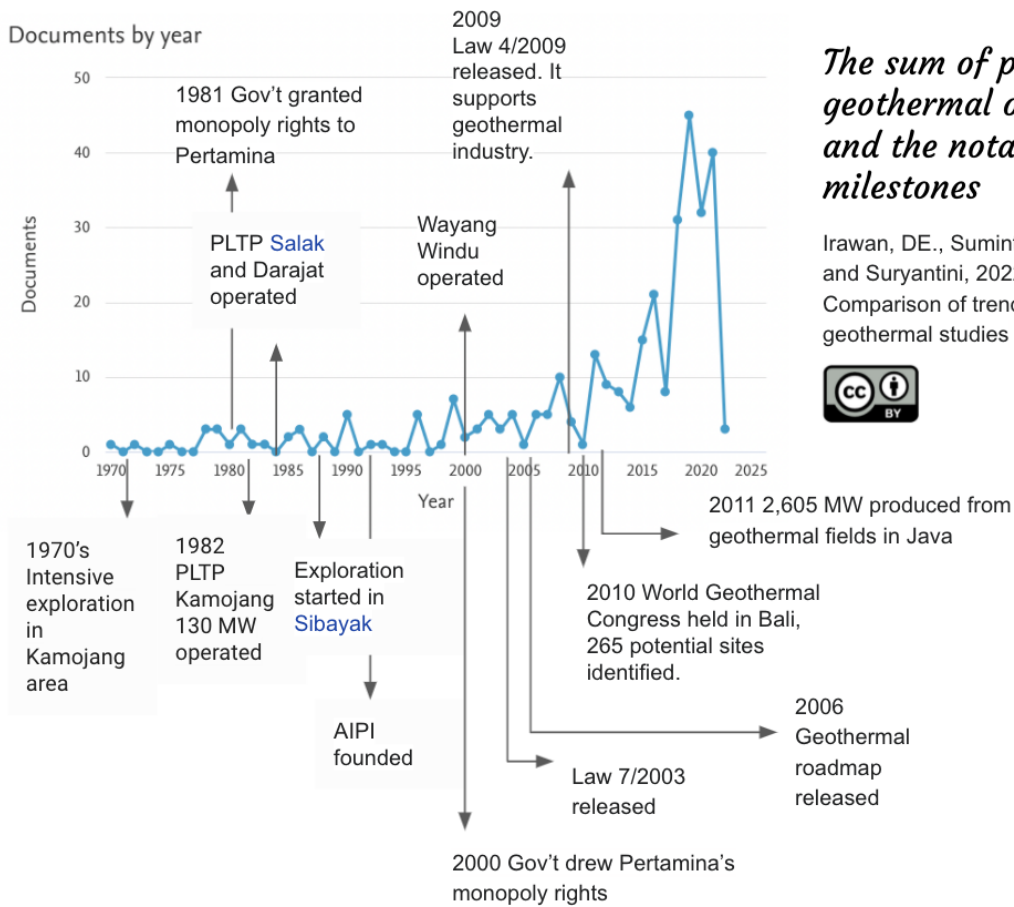
The funneling of academic papers in geothermal



data aggregation by @dasaptaerwin (Mar 5th, 2022)
part of an abstract for the IIGW2022
irawan, de., sumintadireja, p., and suryantini, n., 2022, trends in geothermal studies in comparison



Figure 1 The funneling of academic papers in geothermal

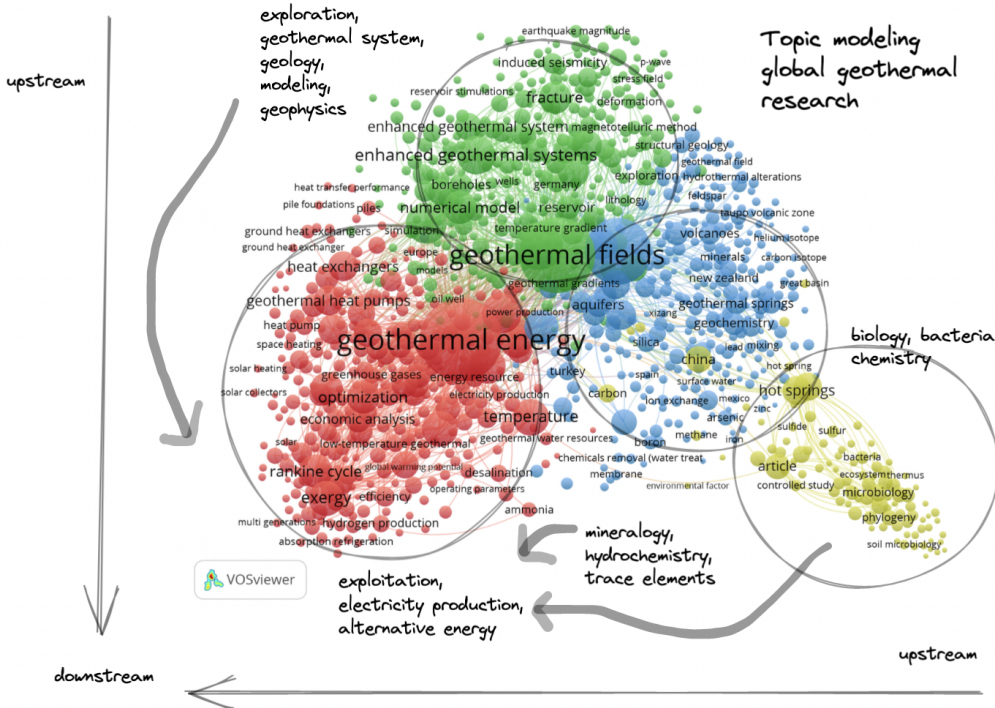


The sum of papers in geothermal of Indonesia and the notable milestones

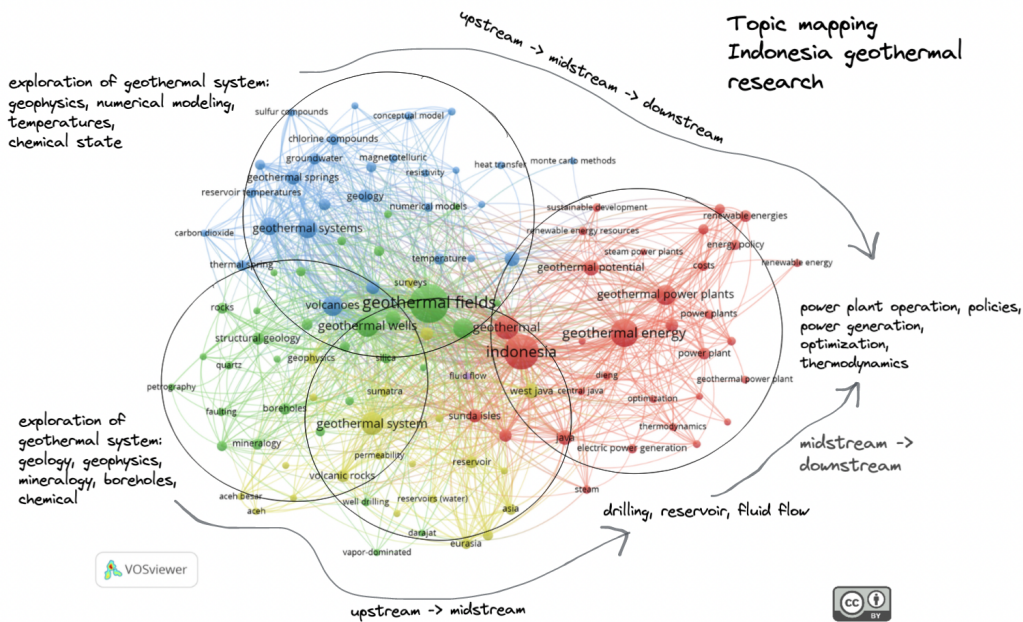
Irawan, DE., Sumintadireja, P., and Suryantini, 2022, Comparison of trends in geothermal studies



Figure 2 Documents by year and the notable milestones



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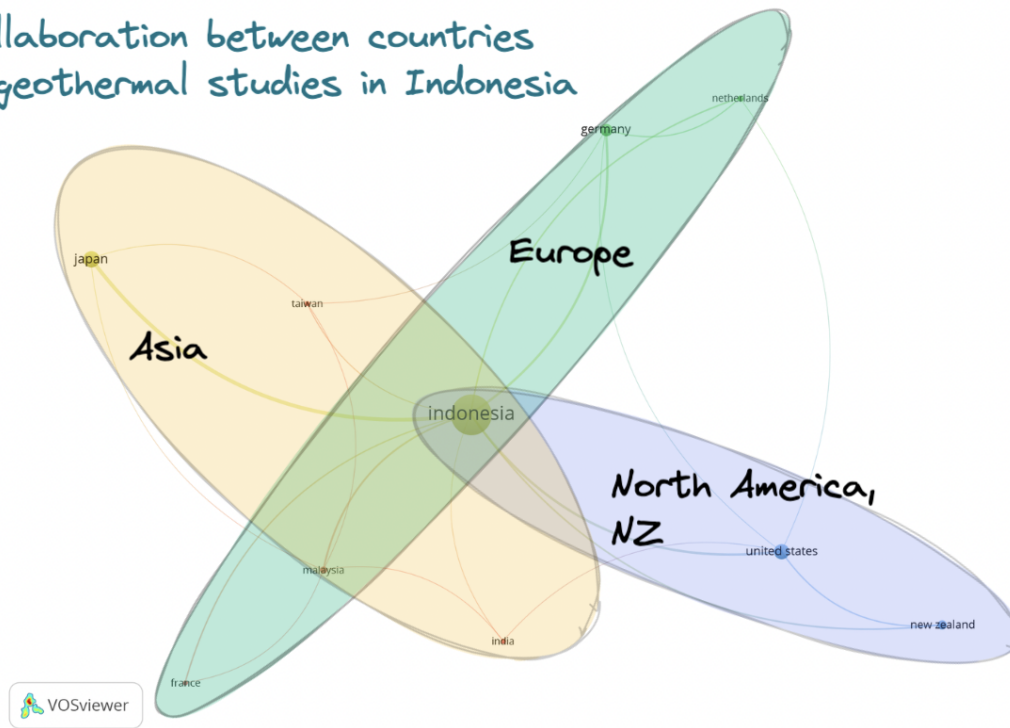


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Figure 3 Topic modeling using Vosviewer (International-above, Indonesia-below)

Collaboration between countries in geothermal studies in Indonesia



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Figure 4 Collaboration between countries in geothermal studies in Indonesia