UTILIZATION OF REMOTELY SENSED DATA TO GEOTHERMAL, OIL AND GAS DEVELOPMENT*

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ABSTRACT

Some of LEMIGAS experiences in the utilization of remotely sensed data will be briefly discussed, these are: Jambi Sub Basin and North East Java Basin for preliminary and advanced oil and gas exploration respectively, Dieng Field for geothermal exploration, and Balikpapan offshore for sea water quality assessment. It is hoped, through this information, better understanding of the operational aspects and appreciation of the subject can be achieved.

I. INTRODUCTION

In recent years, interest of Indonesian scientists, engineers, and decision makers in remote sensing have grown rapidly. Application using remotely sensed data are increasingly diversed especially because the technology has great promise to the communities as a technique which yields both reconnaissance and detailed information. One of this communities is the geothermal, oil and gas industry.

In this fuel energy development, the most promising application of remote sensing is an exploration and environment assessment. Its major contribution is guiding the explorationists to focus more extensive conventional geologic and geophysical tools on area with the highest probability of success. On the other hand, constructing of historical perspective through multi temporal data is the main expectation of the environmentalists.

II. EXPLORATION

Since 1990, a number of remote sensing studies has been carried out by LEMIGAS, either as their internal research or a joint research (Figure 1 and Table 1). The main aim of these studies is to appraise the satellite remotely sensed data for oil exploration on various conditions in Indonesia. On the basis of that experiences contribution of remote sensing can be broadly categorized into two groups as follows :

- Remotely sensed data is considered as rapid and inexpensive tool to assess less explored areas. Information gained is regional geological map (particularly structure), tectonic modeling, and probability of hydrocarbon occurrence. This information is a guidance to other methods to further define and test the given features.
- To highly explored areas, this data is best used in combination with other data, thereby a fresh look of geological model and exploration concept can be constructed. Information required will be a detailed geological map, and prospects and lead to evaluations.

As an illustration, three of the above studies : Jambi Sub Basin, North-east (NE) Java Basin, and Dieng Field will be presented.

A. *Jambi Sub Basin*

The North-east–South-west (NE–SW) trending Jambi Sub Basin forms part of the well-known South Sumatra Basin and is situated between two prolific oil production areas, Central Sumatra Basin (the biggest oil

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Tabel 1
LEMIGAS remote sensing studies

Locations	Imageries	Objectives
Nias Island	Landsat MSS	Regional tectonic mapping
Bird Head Irian Jaya	Landsat MSS, SPOT, & airborne radar	Regional geological mapping
North Sumatra	Landsat MSS & TM Radar JERS-1	Regional and detail geological mapping
Central Sumatra	Landsat MSS & TM	Regional and detail geological mapping; Prospect evaluation
South Sumatra	Landsat TM, SPOT & Radar JERS-1	Regional and detail geological mapping, Geobotany analysis, Tectonic modeling & Prospect evaluation
Seram Island	Landsat TM	Regional tectonic mapping
NE Java	Landsat MSS, TM & SPOT	Regional and detail geological mapping, spectral analysis, Sequence stratigraphy analysis, GIS, & Prospect evaluation
Eastern Kalimantan	Landsat MSS & TM Radar JERS-1	Regional and detail geological mapping, tectonic modeling, GIS, & Prospect evaluation

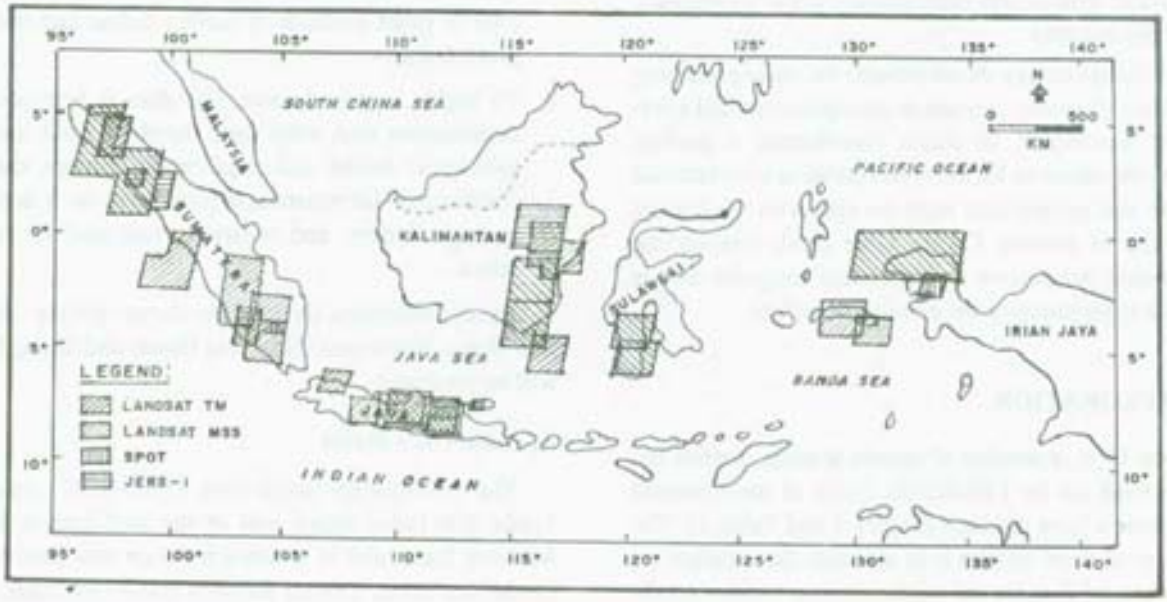

Figure 1
Image coverage map of LEMIGAS studies

Figure 2
Location map of Jambi Sub Basin

Figure 3
Image coverage map of Jambi Study

production in Indonesia) to the North-west (NW) and Palembang Sub Basins to the South-east (SE) (Figure 2). The study is a joint research between LEMIGAS and Japex Geoscience Institute, Inc (JGI). Imageries used were Landsat TM and Radar JERS-1 (Figure 3). Result of the study was the geological map and the tectonic evolution.

Three tectonic events are apparently occured to this area, these are (Figure 4) : Extension episode, quiescent phase followed by normal faulting, and compression phase - developed reverse faults as reactivating of normal faults (structural inversion). This study confirms the existence of NW-SE trending lineaments, which is considered as surface expression of basement lineation proposed by Moulds (1989) who has studied the Bengkalis Graben (Central Sumatra). Implication of this phenomenon is speculation that the Central Sumatra Basin and Jambi Sub Basin form a single continuous depocenter (Figure 5).

Result of this study is now encouraging several LEMIGAS study groups, i.e. Paleontology, stratigraphy, structures and geochemistry to intensively explore this area.

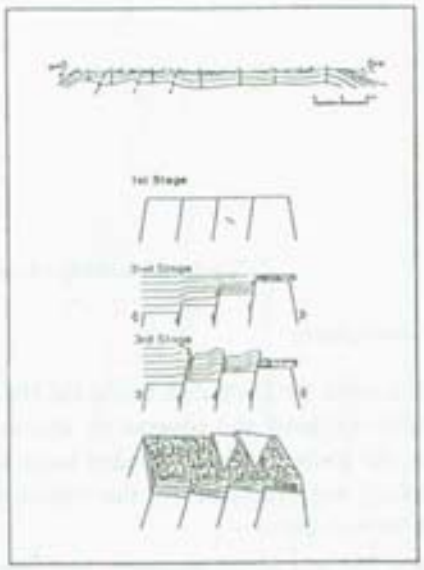

Figure 4
Tectonic evoluation of Jambi Sub Basin

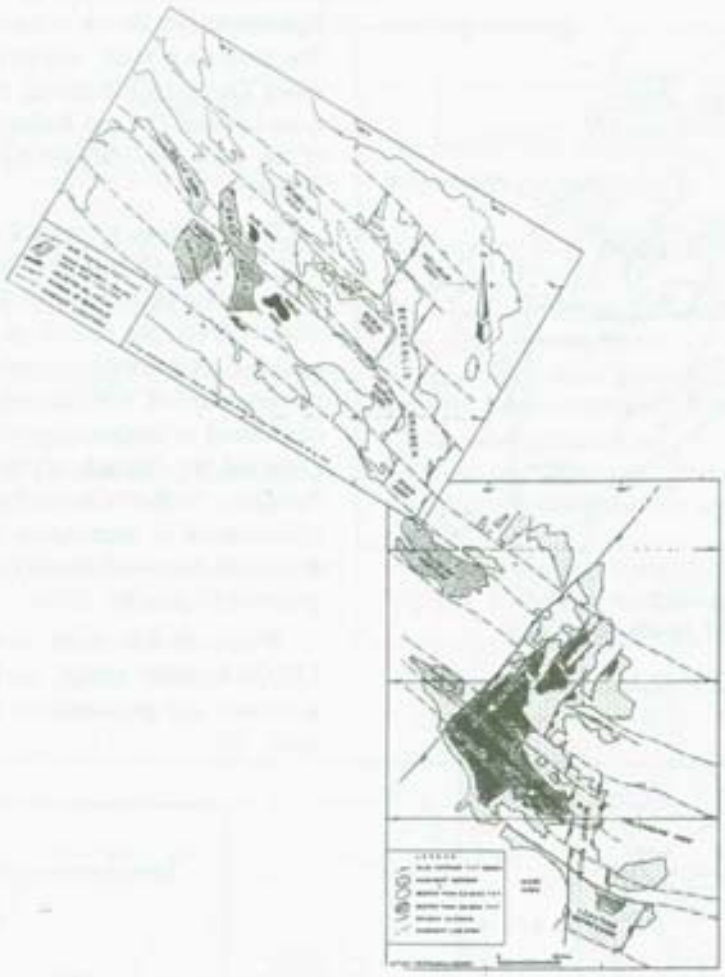

Figure 5
Tectonic setting of Jambi Sub Basin (modified from Moulds, 1989)

B. *NE Java Basin*

By contrast to the Jambi Sub Basin, the NE Java Basin is highly explored and covered by less vegetation. Therefore the study will be a detailed study to extract both lithology and structures. For that reason, the study approach were as follows :

- Landsat TM and SPOT imageries (coverage map is shown in Figure 6) are enhanced independently and simultaneously to produce 1 : 50.000 and 1 : 25.000 scales hard copies and spectrally informative.
- Processed imageries were then analyzed based on either conventional photo geologic techniques or sequence stratigraphic analyses.
- Utilized GIS to manage and analyze result of interpretation, was field work data, and subsurface data (wells and seismic section).

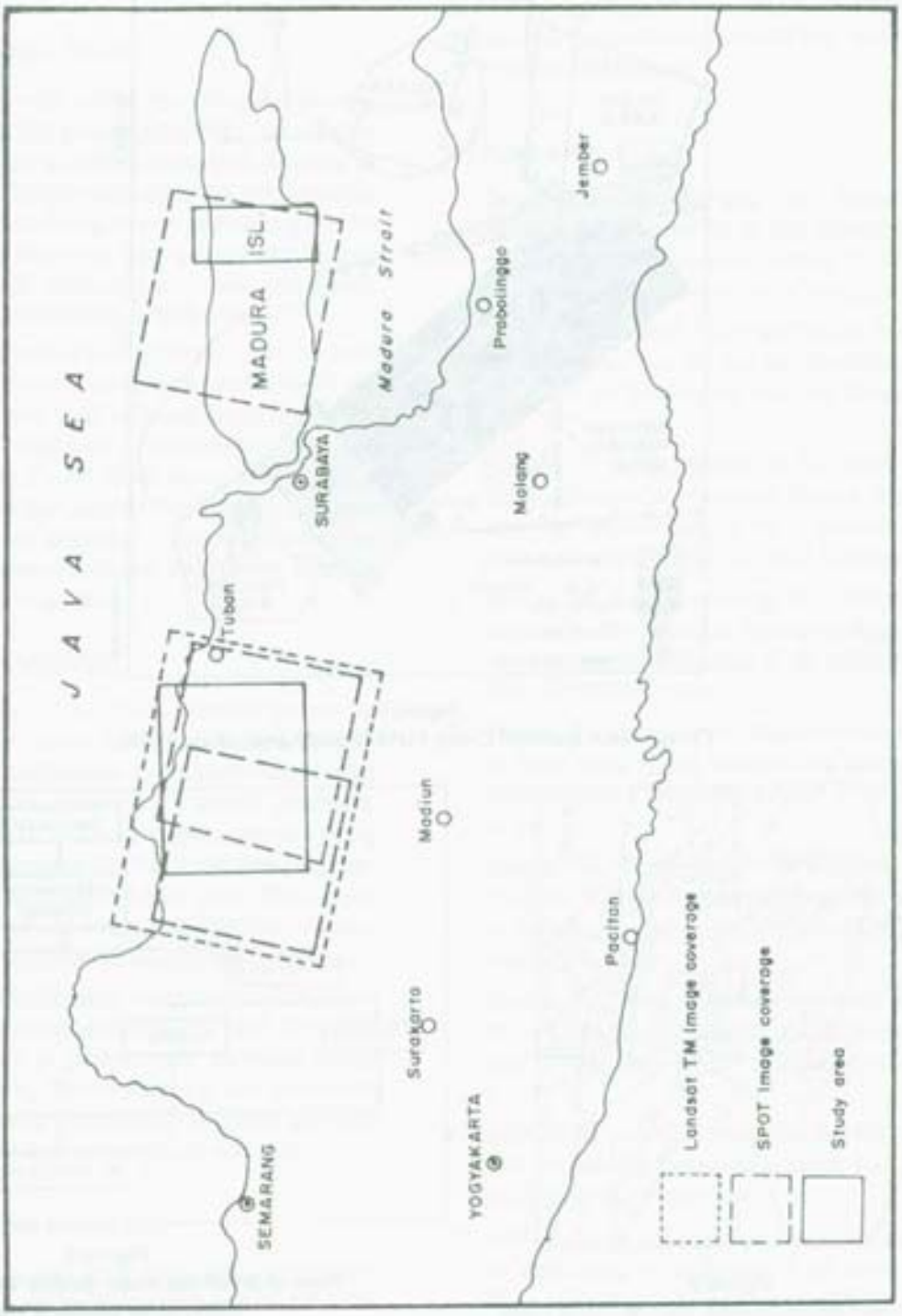

Figure 6
Image coverage map of NE Java Study

Figure 7
Prospective areas of Dieng Field (Soedibardi, et al., 1991)

Figure 8
Lineament Interpretation map of Dieng Field

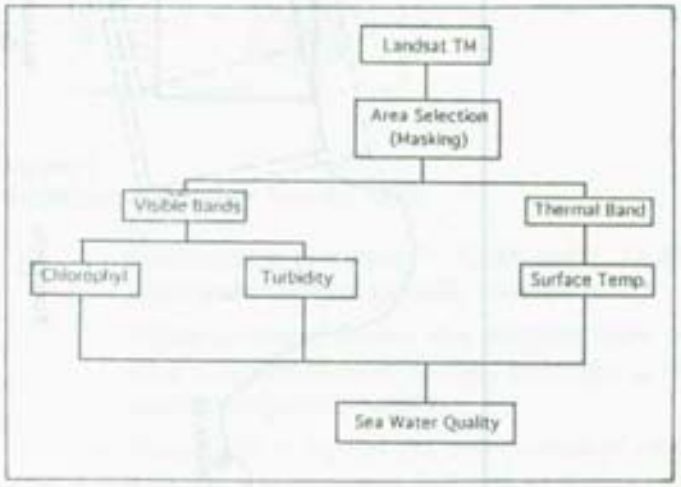

Figure 9
Flow chart of sea water quality assessment of Balikpapan offshore study

Result of the study is the proposed area and target of oil accumulation.

C. *Dieng Geothermal Fields*

Indonesia is situated within the volcanic belts and blessed with abundant geothermal energy. We are now making all our efforts to explore geothermal fields as an alternative energy. Remote sensing technology can contribute to the geothermal exploration in detecting surface thermal anomalies, lineament analysis (that are conduits for geothermal fluids, mapping the volcanic framework and delineating hydrothermally altered area.

The Dieng geothermal field (Central Java) has been subjected to many exploration activities including 10 exploration wells. Latest study indicates four prospect areas, i.e. Sileri, Siglagah, Sikidang-Merdada and Pakuwajaya (Figure 7). All of the above prospect areas can be identified in the Landsat TM imageries as circular and linear features, moreover, other features are also identified to adjacent area (Figure 8). Thereby prospect consideration can be extended.

III. ENVIRONMENTS

The oil industry is one of the potential sources of pollution. This can occur during exploration, production, refining and distribution. The main environmental concern is the use of production of wasted chemicals, hot water and oil spill. To some degree, remote sensing can contribute to this issue for both monitoring and historical analyses. The following case study (Balikpapan Offshore) is one of the current LEMIGAS environmental studies in which remote sensing has taken part.

The purpose of Balikpapan study is to analyze physical (surface temperature and turbidity) and biological (chlorophyll) aspects as parameters of sea water quality assessment (Figure 9). This technique is now considered as cost effective tool in constructing historical sea water quality that might change due to the oil operation.

IV. CONCLUDING REMARKS

Remotely sensed data are a viable and cost effective tool for exploration and environmental assessment when properly analyzed, weighted and integrated into existing data (if there is any). The oil industry is called to adopt this technology particularly to assist new discoveries and enviromental assessment.

REFERENCES

1. **Boedihardi, M. Suranto** and **Sudarman, S.**, 1991, "Evaluation of the Dieng Geothermal Fields : Review of Development Strategy", *Proc. Indon. Petroleum Assoc., 20nd Ann. Conv.*, p347-361.
2. **Carter, J. S.**, 1984, "Satellite Remote Sensing - An Effective Tool For Oil and Gas Exploration", *Proc. Int. Conf. on Shallow Oil and Gas Resources*, 77 - 82.
3. **Carter, J. S.** and **Koger, O. G.**, 1988, "Successful Application of Remotely Sensed Data for Oil and Gas Exploration", *Proc. Thematic Conf. on Remote Sensing for Exploration Geology*, 19-25.
4. **Husen, M.** and **Situmorang, B.**, 1992, Integration of Landsat TM Data and Surface Geology: Implication for Tectonic Modeling of the Jambi Sub Basin, *Proc. IIPRS-92*, 14 pp.
5. **Husen, M.**, et al., 1993, "Improved Discrimination of Rock Units Using Landsat TM imagery of The Rembang Zone Central-East Java", *Proc. IIPRS-93*, 20 pp.
6. **Husen, M., Hermansyah** and **Riyanto, H.**, 1993, "Satellite Remote Sensing for Exploration Geology in Indonesia", *National Conf. on ERS1, Landsat and SPOT*, 29 pp.
7. **Husen, M.**, 1994, "Operational Status and Future of Satellite Remote Sensing for Exploration Geology", *Proc. 2nd Seminar LEMIGAS - JICA*, p.11-21.
8. **LEMIGAS – JGI**, 1992, "Geological Interpretation for Satellite Imageries in South Sumatra, Indonesia", *unpublished report.*
9. **LEMIGAS – JICA**, 1994, "Image Processing and its application to Geological Analysis in Rembang Zone, East Java, Indonesia", *unpublished report.*

10. **Morgan, K. M.**, 1988, "Basic Concepts in the Use of Remotely Sensed Data for Resources Exploration", *Proc. Thematic Conf. On Remote Sensing for Exploration Geology*, p. 1-10.

11. **Moulds, P. J.**, 1989, "Development of Bengkalis Depression, Central Sumatra and its Subsequent deformation - A Model for other Sumatran Grabens ?", *Proc. Indon. Petroleum Assoc. Conv.*, p. 217-245.

12. **Pyron, A. J.**, 1988, "Lowering the Cost of Exploration for Independent : How Remotely Sensed Aids in the Search for Oil and Gas", *Proc. Thematic Conf. on Remote Sensing for Exploration Geology*, p 27-36.

13. **Yamaguchi, Y., Hase, H.** and **Ogawa, K.**, 1992, "Remote Sensing for Geothermal Applications", *Episodes*, Vol. 15, No.1, p 62-67. □