7th Intercontinental Geoinformation Days

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An application of remote sensing and GIS in geothermal alteration and potential in Ziga/Aksaray (Türkiye)

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Keywords
Remote sensing
Geographic Information System
Geothermal
Alteration

Abstract

Where energy production is essential today, geothermal energy, one of the renewable energy sources, is of great importance. Ziga geothermal field, chosen as the study area, has an essential geothermal potential. Ziga Geothermal Area benefits from numerous sources, wells, thermal tourism, residential heating, greenhouse cultivation, and balneological practices. Hydrothermal alteration zones are one of the critical indicators for the exploration of geothermal fields. It contributes significantly to the exploration studies by narrowing the target areas in the feasibility studies of geothermal exploration studies. With remote sensing (UA) techniques in detecting hydrothermal alteration minerals spread over large areas, it is ensured that large areas can be evaluated holistically, and effective results can be obtained by saving time and economy. In the study, it was evaluated in a GIS environment by using ASTER satellite data to determine the hydrothermal alteration zones. The differences in the determined parameters of all alteration types in the study area were mapped with ASTER data. As a result of the data obtained by remote sensing and GIS methods, guiding data for the discovery of new potential areas in the rocks of Ziga and its surroundings are explained in detail in the study.

1. Introduction

Countries' energy needs are constantly increasing depending on their development and growth rate. Today, energy consumption is equated with the level of development. About 90% of the energy consumption in the world is met by coal, oil, and natural gas, which are called fossil fuels. Alternative energy sources are being researched due to the high carbon dioxide emissions of fossil energy sources and the fact that they are not renewable. Geothermal energy, one of the alternative sources, is significant because of its low carbon dioxide rate and renewable nature. Geothermal energy is preferred because it is uninterrupted compared to renewable energy sources such as the sun and wind (Arslan et al. 2000).

Geothermal energy can be defined as hot water and steam formed by the heat in various depths of the earth's crust, whose temperature is above the regional and atmospheric temperatures and contains molten minerals, salts, and gases. Since the waters that make up the geothermal fluid are generally of meteoric origin, geothermal resources are renewed as long as the atmospheric conditions continue (Kara, 2010). Parameters required for the formation of a geothermal system; The heat source deep in the earth's crust is the fluid that carries the heat (nutrition), the reservoir rock that contains the fluid, and the cover rock that prevents the loss of heat. Magma activities that reach shallow depths in the crust and/or the earth's surface from fractured and weak zones due to tectonism constitute the heat source of the geothermal system. Meteoric waters, which filter through cracks and cracks from the earth, accumulate in the reservoir rock, which is porous and permeable, after warming in the depths. Some of these waters rise along the fault lines and reach the earth's surface and form geothermal resources.

The criteria taken into account in geothermal resource exploration; are hot springs, steam outlets, geysers, and hydrothermal alteration zones. The most important of these is hydrothermal alteration, and potential geothermal areas have been determined by investigating hydrothermal alteration zones in many countries. Hydrothermal alteration is the chemical and mineralogical changes that occur in the rocks in the relatively shallow parts of the earth's crust by being affected by the heat-loaded fluids circulating in them. In this study, alteration types, distributions, and

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Cite this study

Bilgilioğlu H (2023). An application of remote sensing and GIS in geothermal alteration and potential in Ziga/Aksaray (Turkey) 5th Intercontinental Geoinformation Days (IGD), 25-28, Peshawar, Pakistan

interrelationships in the study area were examined (Burçak, 2006; 2009).

The kaolinization of feldspars is an example of this. In addition, the changes that occur in the rock with the elements added or withdrawn by the hydrothermal fluid (for example, silicification) can be considered in this context (Öngür, 1980). There are two types of hydrothermal alteration, active and inactive hydrothermal alteration. Active hydrothermal alteration is a continuous hydrothermal alteration and is used in the investigation of economically significant fluidized beds such as geothermal energy. On the other hand, inactive hydrothermal alteration is hydrothermal alteration; the activity gradually decreases over time and is used to investigate stable deposits of economic importance. This concept, which is examined in two parts as active and inactive hydrothermal alteration, depends on the rock composition, the composition of the geothermal fluid, and the physicochemical conditions (pressure and temperature) during the phase changes that develop. It is time-consuming and costly to prepare the alteration maps used to determine potential hydrothermal areas with classical field studies. Therefore, especially in recent years, remote sensing has been used frequently in the determination of alterations, and its success has been demonstrated by many researchers (Kratt et al., 2010; Calvin et al., 2015; Rodriguez-Gomez et al., 2021; Ramadhan et al., 2021; Canbaz et al., 2021; Şener and Şener, 2021; Uzun and Turgay, 2022).

This study aimed to determine the potential hydrothermal areas in and around Ziga thermal in Aksaray province by remote sensing. Advanced argillic, kaolinization, propylitization, sericitization and quartz alteration, and land surface temperature maps were produced and combined in this context. Finally, the geothermal suitability map was created.

2. Method

The Central Anatolian region tectonically forms an area where significant deformations are observed, bounded by the North Anatolian Fault and the East Anatolian Fault (Ketin, 1969). All these deformations are directly related to the volcanic activities in Central Anatolia. The volcanic activities that continued from the Miocene to the Quaternary created critical geothermal fields in the Central Anatolian region. One of these fields is the Aksaray Ziga field, located approximately 50 km southwest of Nevşehir.

The oldest unit, which cannot be observed in the study area but is stratigraphic, is the Bozçaldağ metamorphic schists and the Paleozoic age unit formed by the ultrabasic. Götük ignimbrite and Karakaya volcanic overlie this unit unconformably. Pink and yellow basalt, spilite obsidian, pumice, and Selime tuffs rich in andesite overlie these units. Kızılkaya ignimbrites with welded tuff are overlying the Selime tuff. It crops out in a wide area around the Ziga hot and mineral springs in the study area. Quaternary units overlie all these units (Afşin ve Yıldız, 1997; Duru, 2006).

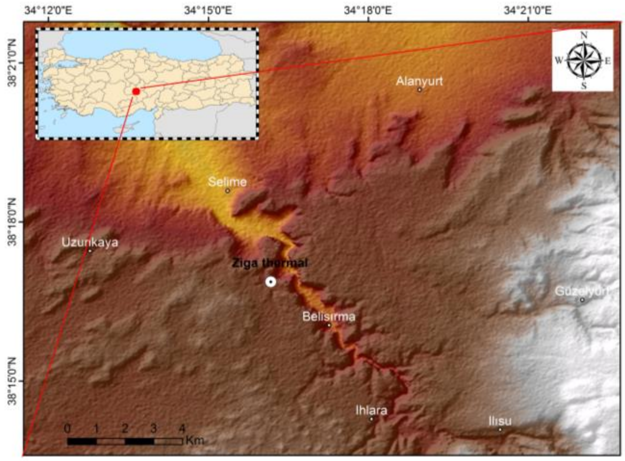

Figure 1. Study area

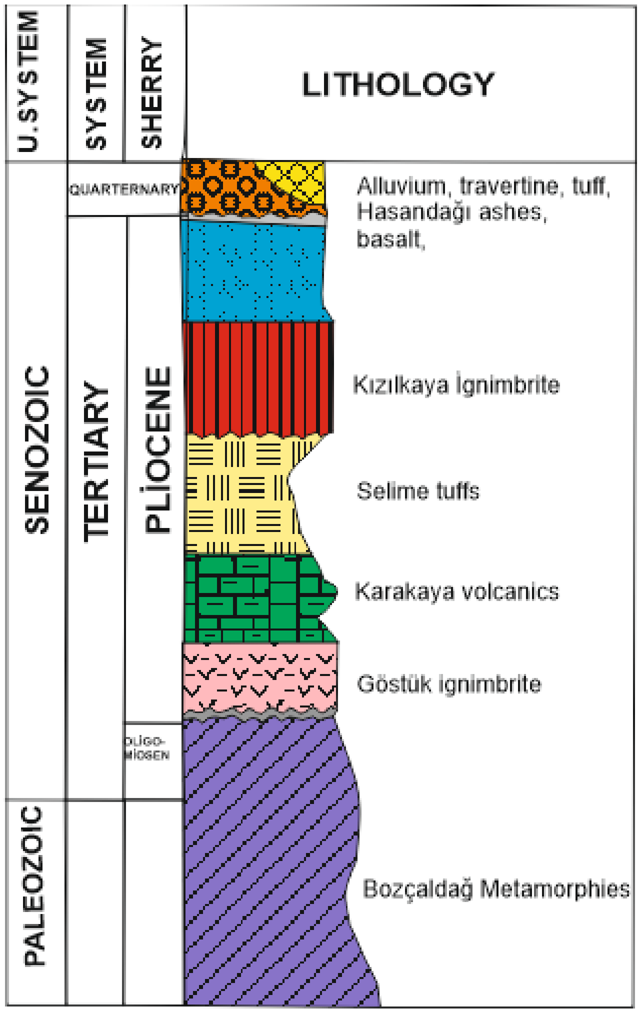

Figure 2. Stratigraphic section of the study area (Şimşek, 1993)

3. Results

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) L1T dataset was used for creating alteration maps such as; advanced argillic, kaolinization, propylitization, sericitization, and quartz. The band ratios used in the determination of the relevant alterations as a result of the literature research are as follows;

- (B4+B6)/B5 band ratio for advanced argillic alteration (Fakhari et al., 2019; Uzun and Turgay, 2022),
- (B4/B5)(B8/B6) band ratio for Kaolenization (Ninomiya, 2003),
- (B6+B9)/(B7+B8) band ratio for Propylitization (Shahi and Kamkar-Rouhani, 2014),
- (B5+B7)/B6 band ratio for Sericitization (Fatima et al., 2017),
- $(B11^2)/(B10*B12)$ band ratio for Quartz (Ninomiya, 2003).

After overlaying alteration and land surface maps using the ArcGIS raster calculation tool, the geothermal suitability map was created.

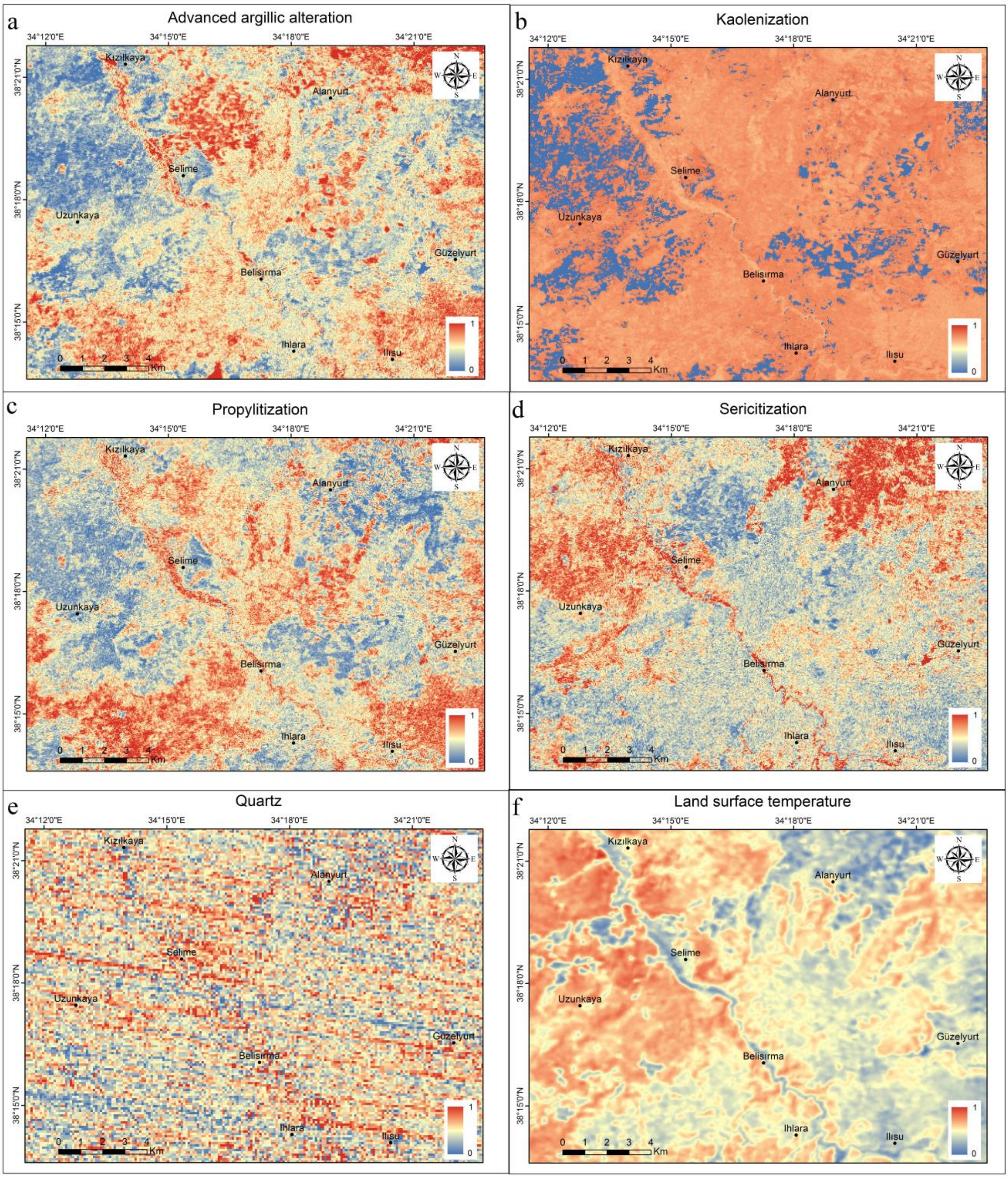

Figure 3. a: advanced argillic b: kaolinization c: propylitization d: sericitization e: quartz f: land surface temperature

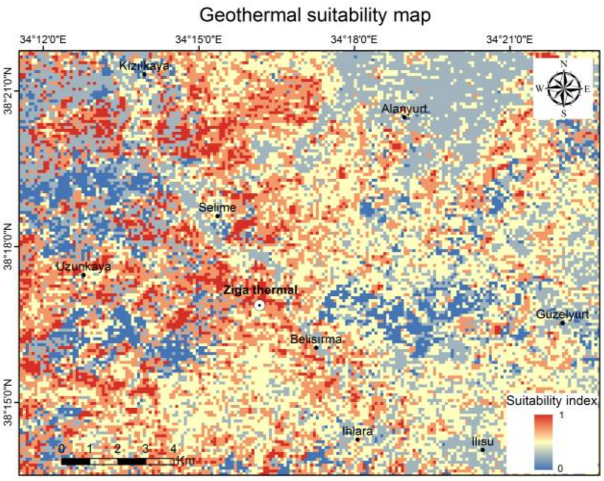

Figure 4. Geothermal suitability map

4. Conclusion

Alteration maps such as; advanced argillic, kaolinization, propylitization, sericitization, and quartz were produced by band combination with aster images. In addition, the land surface temperature was obtained with the help of thermal sensors. The obtained six different maps were combined by overlay analysis, and a geothermal suitability map was produced. According to the resulting map produced, "Ziga gothermal field", which are currently used as a thermal hotel and where hot water tourism is made, emerged in a suitable area, which shows the methodology's accuracy. This study is preliminary, and it is thought that candidate regions are determined this way. Laboratory studies are to be carried out with more detailed land and samples to be taken in suitable areas.

References

Afşin, M. & Yıldız, M. (1997). Ziga kaplıcası ve çevresinin jeolojik ve hidrojeolojik incelenmesi, N.Ü. Aksaray Mühendislik Fakültesi Jeoloji Mühendisliği Bölümü,10 s, (yayımlanmamış).

Arslan, S., Darıcı, M., & Karahan, Ç. (2000). Jeotermal Enerji Hizmet İçi Eğitim Seminer Notları, MTA Genel Müdürlüğü, Ankara.

Burçak, M. (2006). Aksaray jeotermal sahaları (Acıgöl-Ziga-Şahinkalesi) jeotermal ısı kaynaklarının araÇtırılması ve jeotermal sistemlerin kavramsal modellemesi, Yüksek Lisans Tezi,N.Ü. Fen Bilimleri Enstitüsü, Aksaray, 58-78.

Burçak, M. (2009). Aksaray jeotermal sahalarında (Acıgöl-Ziga-Şahinkalesi) su kimyası ve izotopik çalışmalar, MTA Dergisi, No: 138, Ankara, 45-68.

Calvin, W. M., Littlefield, E. F., & Kratt, C. (2015). Remote sensing of geothermal-related minerals for resource exploration in Nevada. Geothermics, 53, 517-526.

Canbaz, O., Gürsoy, Ö., Karaman, M., Çalışkan, A. B., & Gökce, A. (2021). Hydrothermal alteration mapping using EO-1 Hyperion hyperspectral data in Kösedağ, Central-Eastern Anatolia (Sivas-Turkey). Arabian Journal of Geosciences, 14(21), 1-23.

Duru, G. (2006). Ziga-Yaprakhisar (Aksaray) sıcak ve mineralli kaynak alanlarındaki traverten çökeliminde etkili olan faktörlerin su kimyası ve izotopik yöntemlerle belirlenmesi, Yüksek Lisans Tezi, N.Ü. Fen Bilimleri Enstitüsü Jeoloji Müh. ABD, 59-107, (yayımlanmamış).

Fakhari, S., Jafarirad, A., Afzal, P. & Lotfi, M. (2019), Delineation of hydrothermal alteration zonez for porphyry systems utilizing ASTER data in Jebal-Barez area, SE Iran, Iranian Journal of Earth Sciences, Vol.11, No.1, 2019, 80-92.

Kara, İ. (2010). Nevşehir / Acıgöl - Derinkuyu - Gülşehir sıcak ve mineralli sularının hidrojeokimyasal özellikler, MTA Dergisi, Ankara

Ketin, İ. (1969). Tectonic units of Anatolia. MTA Dergisi, 66, 24-33.

Kratt, C., Calvin, W. M., & Coolbaugh, M. F. (2010). Mineral mapping in the Pyramid Lake basin: Hydrothermal alteration, chemical precipitates and geothermal energy potential. Remote Sensing of Environment, 114(10), 2297-2304.

Ninomiya, Y. A. (2003). Stabilized Vegetation Index and Several Mineralogic Indices Defined for ASTER VNIR and SWIR Data. In Proceedings of the IEEE International Geoscience and Remote Sensing Symposium, Toulouse, France, 21–25 July 2003, 3, 1552–1554.

Ramadhan, R. F., Salsabila, G., Mogi, G. D., Ulhaq, H. D., & Saputra, R. A. (2021). Remote Sensing for Hydrothermal Alteration Zone Identification Using Landsat 8 OLI/TIRS Satellite Imagery on The Geothermal Prospect Area of Mountain Sirung, East Nusa Tenggara. Remote Sensing.

Rodriguez-Gomez, C., Kereszturi, G., Reeves, R., Rae, A., Pullanagari, R., Jeyakumar, P., & Procter, J. (2021). Lithological mapping of Waiotapu Geothermal Field (New Zealand) using hyperspectral and thermal remote sensing and ground exploration techniques. Geothermics, 96, 102195.

Şener, E., & Şener, Ş. (2021). Exploration of geothermal potential using integrated fuzzy logic and analytic hierarchy process (AHP) in Ağrı, Eastern Turkey. Turkish Journal of Earth Sciences, 30(9), 1134-1150.

Shahi, H. & Kamkar-Rouhami, A. (2014), A gis based weights of evidence model for mineral potential mapping of hydrothermal gold deposits in Torbat-e-Heydarieh area. Journal of Mining and Environment 5(2), 2014, 79-89.

Şimşek, Ş. (1993). Ihlara (Kapadokya) özel koruma bölgesinin ve bölgede yer alan termal kaynakların hidrojeolojik ve hidrojeokimyasal araştırması ve korumaya ilişkin öneriler, Özel Çevre Koruma Kurumu Teknik Raporu, No: 6, Ankara, 116 s.

Uzun, Ö. F., & Turgay, O. (2022). Investigation of the Hamamayağı/Ladik (Samsun, Turkey) geothermal field and it's surroundings by optical Remote Sensing with GIS methods. Turkish Journal of Geosciences, 3(2), 75-83.

Yıldırım, T. & Koçan, N. (2008). Nevşehir Acıgöl Kalderası Kalecitepe ve Acıgöl Maarlarının Jeoturizm Kapsamında Değerlendirilmesi . Ege Üniversitesi Ziraat Fakültesi Dergisi , 45 (2) , 135-143 . Retrieved fromhttps://dergipark.org.tr/tr/pub/zfdergi/issue/5091/69556