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Geoscience Services for Geothermal Energy & Rare Earth Exploration in the Green Transition

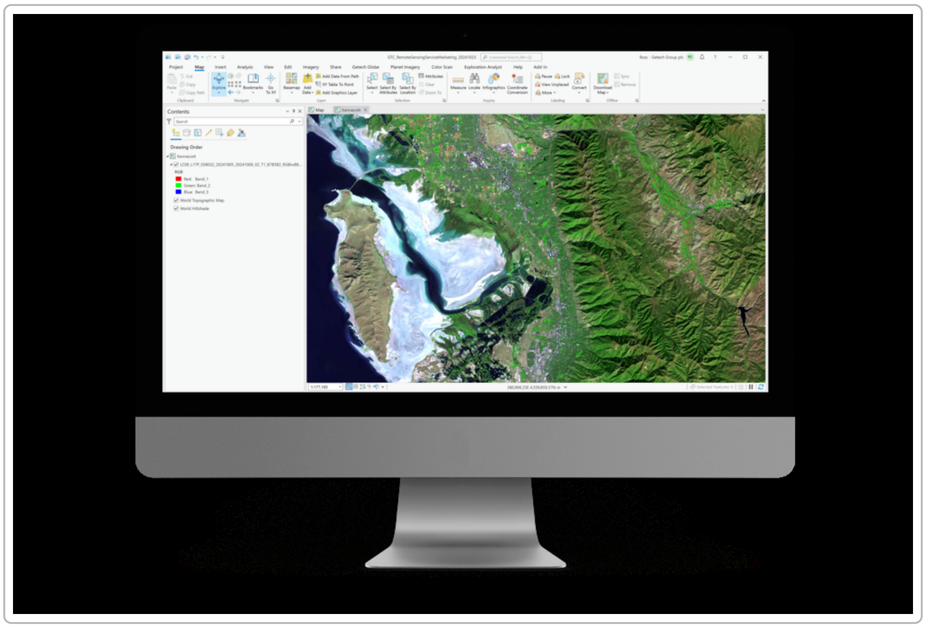
Introduction:
Geothermal energy and rare earth elements (REEs) are both critical to the green transition – geothermal provides a constant low-carbon energy source, and REEs are essential for electric vehicles, wind turbines, and other clean technologies. However, exploring the subsurface for geothermal reservoirs or REE deposits is challenging. Drilling can account for up to 75% of a geothermal project's cost, and a lack of good subsurface data is the single biggest project risk [1]. Similarly, locating economically viable REE concentrations is difficult because these minerals are often buried or dispersed in complex geology [2]. Our knowledge of the Earth's subsurface is still relatively poor compared to our understanding of the surface or oceans [3]. Data are often fragmented in proprietary silos, which historically led to missed opportunities in the subsurface domain [4]. Today, a new wave of **geoscience services** is emerging to tackle these challenges. These services leverage *remote sensing*, *GIS*, *AI-driven geospatial analysis*, and integration of *public and commercial subsurface datasets* to rapidly identify promising targets and de-risk detailed exploration. This report surveys the most effective and market-relevant geoscience service offerings for geothermal energy and REE exploration, focusing on: - **"Quick scan" surveys** that provide rapid, regional screening of potential sites. - **Detailed exploration services** that follow up on high-potential targets with in-depth analysis. - Use of advanced tools like satellite imagery, machine learning, Google Earth Engine, and big data integration. - **Global service models** that offer scalable solutions (e.g. screening entire regions for "quick wins"). - Business models and pricing (from one-off project consulting to subscription-based data platforms). - Leading competitors and examples of companies providing these services.

Throughout, we incorporate insights from industry analyses and case studies – including a Reuters whitepaper on *"Geoscience: The race to understand the subsurface"*, a Cleantech Group article on geothermal innovation, and information from GeoTechnic Solutions (GTS) and other firms – to illustrate how modern geoscience is accelerating the green transition.

Rapid "Quick-Scan" Surveys with Remote Sensing & GIS

At the front end of exploration, quick-scan surveys aim to **quickly identify "low-hanging fruit"** – the most promising areas – with minimal time and cost. These surveys exploit remote sensing data and GIS to screen large regions for geologic indicators of geothermal resources or mineralization.

Satellite & AI-Powered Scanning: Advanced Earth observation now allows geoscientists to scan vast areas for subtle clues of subsurface potential. High-resolution satellite imagery, aerial data, and even **hyperspectral** sensors can reveal surface patterns associated with geothermal activity or REE deposits. For example, new spaceborne imaging spectrometers (like Germany's EnMAP satellite) have demonstrated the ability to directly detect spectral signatures of certain rare-earth minerals in exposed rocks [5] – a feat not possible with older multispectral satellites. In geothermal exploration, thermal infrared imagery and multispectral maps can pinpoint surface hot spots, hydrothermal alteration zones, or volcanic features that suggest underlying heat sources. AI algorithms can then comb these multi-layered images to flag anomalies. As one industry expert notes, **AI can now process terabytes of geospatial data in hours – including hyperspectral, magnetic, radiometric, and other layers – to detect subtle anomaly patterns invisible to humans** [6] . This dramatically speeds up the initial reconnaissance phase. Marek Wilgucki, CEO of TerraEye, an AI satellite analytics firm, explains that *"AI lets us read geology at district scale (tens of thousands of square kilometers) and turn messy, incomplete data into clear 'where-to-look-first' maps."* [7] [8] These AI-generated target maps highlight priority zones for ground follow-up, effectively focusing exploration on the most prospective ground from the outset.



Example: Satellite remote-sensing imagery being analyzed in a GIS platform. High-resolution multispectral and radar images, combined with AI, help rapidly screen large territories for geothermal or mineral prospectivity.

Global GIS-Based Resource Screening: Several service providers offer **interactive GIS tools and platforms** to perform rapid resource screening from the desktop. **GeoTechnic Solutions (GTS)**, for instance, provides an online *"Green Energy Scan"* – a beta web app where users can outline an area on a map and receive a free preliminary report on its wind, solar, and geothermal energy potential [9] . GTS specializes in creating state-of-the-art maps with advanced GIS software (QGIS™, ArcGIS Online™) and AI to reveal an area's renewable energy prospects [10] . This kind of **free initial scan** is a quick win: it leverages global datasets to identify whether a particular land parcel is likely suitable for geothermal development (as well as other renewables), at no cost to the client. On the backend, GTS's mapping services combine numerous publicly available and commercial data sources – from satellite imagery to geological databases – to generate these assessment maps. They draw on data libraries including **Google Earth Engine**, NASA's Earth Observing System, ESA's Copernicus satellite data, and even specialized datasets like Microsoft's Planetary Computer and InSAR ground deformation data [11] [12] . By fusing these layers, GTS can highlight zones with favorable attributes (e.g. high heat flow, suitable geology, accessible land) in a visually compelling format for decision-makers. Such **data-driven storytelling** – using strong maps and visuals – helps stakeholders quickly grasp where opportunities lie [13] .

Likewise, larger geoscience companies offer rapid screening on a global scale. **Getech** (UK) has developed a platform called **Heat Seeker®** as part of its geoscience data suite. Heat Seeker is a **global geothermal**

knowledge-base built on decades of geological and geophysical data, allowing *"rapid screening of many locations by integrating above-ground and subsurface data"* [14]. In practice, Getech can take any region in the world and, using Heat Seeker, quickly evaluate its geothermal potential based on parameters like subsurface temperature gradients, depth to basement, known aquifers, and surface constraints. This *regional evaluation* stage delivers quick results – essentially a heat map of hotspot areas – which clients can use to decide where to focus more detailed studies. Notably, Getech's approach integrates both **surface data** (e.g. satellite-derived heat flow, climate data) and **subsurface data** (e.g. deep temperature measurements, well logs) in one GIS environment [14]. Governments have also recognized the value of broad geospatial screening: Geoscience Australia, for example, has made nationwide subsurface data publicly available, and the U.S. Geological Survey's Earth MRI program is mapping critical mineral potential across the country. These open datasets feed into private sector tools, enabling a more efficient "first pass" scan of where riches and risks lie underground [15] [16].

For **rare earth exploration**, quick scanning often involves identifying geological environments known to host REEs (such as carbonatite complexes, ionic clay deposits, or heavy mineral sands) and then zeroing in with remote sensing. REE-bearing minerals can sometimes be inferred by *proxy* signals detectable from space: for example, certain REE deposits are associated with thorium and potassium anomalies, which appear in radiometric (gamma-ray) surveys and satellite spectral bands. New hyperspectral satellites add the possibility of detecting REE minerals' unique absorption features in outcrops [5]. Startups and research groups have begun applying **machine learning on multi-sensor data** to flag prospective REE locales. In one case, NASA's Jet Propulsion Lab flew imaging spectrometers over western Nevada to map lithium and other critical minerals from the air [17]. The same principle can apply globally with satellites: an executive from an AI-focused explorer noted that *"exploration workflows that once took months can now be completed in hours"* by algorithms that sift through spectral, magnetic, electromagnetic, and geochemical layers for patterns linked to ore deposits [6]. The output of these quick scans is typically a shortlist of targets or anomaly zones that merit ground truthing.

Leveraging Existing Data & "Low-Hanging" Opportunities: A particularly effective quick-win strategy is to **reuse known data or infrastructure** in new ways. In geothermal, one low-hanging fruit is to revisit the thousands of existing oil & gas wells that were drilled in the past. Many oil wells encountered hot water or had warm bottom-hole temperatures but were simply plugged and abandoned when they did not find hydrocarbons. GTS explicitly targets this opportunity: they use the extensive **IHS oil & gas well database and national public well data** to identify old wells in depleted fields that could be converted into geothermal producers or used for lithium extraction from brines [18]. With ~200 years of drilling records, the subsurface data is enormous – GTS conducts data mining to pinpoint which abandoned wells intersect hot aquifers or lithium-rich waters, then assesses if re-entering those wells for geothermal energy is feasible [18]. This approach illustrates how *quick desktop analysis of public-domain subsurface data can uncover "green transition" projects* (geothermal heat or battery minerals) at sites that were previously written off by the oil industry. It's a win-win: shortening development timelines by using existing wells, while also recycling old assets for clean energy.

Another quick-win tactic is combining sectors – for instance, **integrating geothermal operations with mineral extraction**. The U.S. Department of Energy has encouraged R&D in geothermal plants that also *co-produce* valuable minerals from their brines. As far back as 2014, DOE offered $3 million to support geothermal systems capable of economically extracting rare earth elements from geothermal brine [19]. This kind of project would use **geochemical analysis and process engineering** (rather than remote sensing) to add a revenue stream of REEs (or lithium, etc.) to geothermal projects, improving viability. For exploration services, it means evaluating not just heat in the subsurface, but also fluid chemistry data to see if dissolved metals are present. We see a convergence of geoscience disciplines: geothermal consultants now may examine water geochemistry datasets, and mining experts consider geothermal wells as sampling tools – all enabled by cross-referencing public databases in a GIS.

Case Example – Quick Global Screening: In 2020, CGG's Geothermal Science team completed a *global geothermal resource study* for a major energy company, evaluating geothermal potential worldwide [20] [21]. The project was essentially a massive quick-scan: CGG compiled over **700,000 subsurface temperature data points** from public and client sources, quality-controlled and integrated them, and then mapped out the areas of greatest geothermal promise on every continent [22] [23]. The study identified not only well-known volcanic geothermal regions, but also highlighted *sedimentary basin settings* with significant potential (which are more widespread geographically) [24]. This illustrates how global data integration – a hallmark of modern geoscience services – can reveal "hidden" opportunities in the green transition. The client, likely an oil supermajor, used these insights to guide its strategy for geothermal investments, showing the growing demand for quick-turnaround, data-driven advisory services in this field.

Detailed Exploration & Subsurface Analytics

After high-potential targets are identified by quick scanning, the next step is **detailed exploration** to confirm the resource and plan for development. Geoscience service companies offer a suite of advanced techniques for this stage, often involving on-site data collection combined with sophisticated modeling. The focus shifts from "where might something be?" to "what exactly is there and how do we extract it safely and economically?"

Geothermal: Feasibility Studies and Subsurface Modeling

For geothermal projects, detailed exploration means building a 3D picture of the geothermal reservoir and assessing its capacity, temperature, permeability, and risks. Leading service providers combine **geology, geophysics, and reservoir engineering** in their feasibility studies:

- **Geophysical Surveys:** To probe deep beneath the surface, methods like **magnetotellurics (MT), gravity, and seismic surveys** are employed. MT, for example, measures naturally occurring electromagnetic fields to map resistivity variations underground – useful for locating hot brines or porous channels. GTS has partnered with Tipper Deep Detection International to offer proprietary MT technology that leverages ultra-low frequency signals to image deep geothermal targets [25]. These surveys can reveal the shape of high-conductivity geothermal reservoirs or the faults that feed them, even several kilometers down. Similarly, gravity data can hint at subsurface density anomalies (potentially magma or high-porosity zones), and reflection seismic can delineate structural traps and stratigraphy relevant to geothermal fluids. By integrating these datasets, geoscientists reduce uncertainty about the reservoir's extent and characteristics.

- **3D Geological Modeling:** Modern software like Seequent's **Leapfrog 3D** is widely used to construct subsurface models for geothermal fields. In fact, major geothermal developers like Ormat Technologies use Leapfrog to integrate geological, geophysical, and well data – one of the "major benefits" being that it brings together different data layers and allows geoscientists to collaborate in real time [26] [27]. The Reuters *"race to understand the subsurface"* report highlighted how such modeling software facilitated planning a delicate tunneling project in Barcelona (to avoid disturbing

La Sagrada Família) [28] [29], underscoring its power in geotechnical contexts as well. For geothermal, a 3D model helps estimate the volume of accessible hot water/steam and guides well targeting.

- **Thermal and Reservoir Analysis:** Providers like Getech offer specialized analytics to quantify the geothermal resource. Their studies include *"temperature evaluations"* where they use physics-based models and **machine learning** on inputs like heat flow measurements, borehole temperatures, and rock thermal properties to map the 3D temperature distribution beneath a site [30]. Knowing the depth at which, say, 150°C is reached is crucial, since drilling cost increases with depth. They also do *"structure assessments"* – mapping faults and fracture networks from geophysical data and assessing whether these are likely open conduits or sealed (by comparing fault orientations to the stress field) [31]. Open, intersecting fractures can be targets for enhanced geothermal systems (EGS) or natural hydrothermal flow, whereas sealed faults might impede circulation. Additionally, *"lithology determination"* is performed: by leveraging global geological maps and local well data, they estimate the porosity and permeability of the reservoir rocks [32]. All these factors (temperature, structure, rock properties, fluid recharge) feed into **reservoir simulation models** predicting how a geothermal reservoir will respond to production.

- **Risk Mitigation and De-Risking Tools:** Because geothermal projects carry exploration and drilling risk, services often include risk analysis. GTS utilizes the GeoRisk mitigation tool (developed under an EU project) as a **risk register for geothermal projects** [33]. This database lists all plausible risks (e.g. resource temperature lower than expected, drilling problems, seismicity, finance shortfall, etc.) and suggests **mitigation measures** for each [34]. By systematically addressing risks – and proposing de-risking steps – consultants help make geothermal projects bankable. As another example, the Cleantech Group noted that in the near term, having **offtake agreements** (e.g. a data center buying the heat/power) can de-risk new geothermal technology deployment [35]. Geoscience advisors sometimes assist clients in understanding such market and engineering risks in tandem with subsurface risks.

- **Feasibility Reporting:** The outcome of detailed exploration is typically a **feasibility or pre-feasibility study** report. This includes an evaluation of the resource size (e.g. MW of heat or power potential), conceptual design of the geothermal plant (number of wells, expected output per well), and economic analysis. For instance, Getech offers *pre-feasibility studies to prioritize sites* and full feasibility studies as separate service tiers [14]. These comprehensive studies often precede major investment decisions like drilling the first full-scale geothermal production well [36]. They convert raw data into actionable plans.

Service providers use various business models to deliver these detailed studies. **GeoTechnic Solutions** has a tiered consulting model: after an initial free consultation, clients can choose a *Basic*, *Optimal*, or *Premium* support package for a feasibility study. The Basic package includes a limited-scope study (10–100 hours of work) with key findings and one revision, priced roughly **€800–€5,000** (at €80–160/hour) [37] [38]. The Optimal package is a full feasibility study with bi-weekly updates and detailed reporting, starting around **€5,000 and up (typically €5k–€15k)** for 100+ hours [39] [40]. The Premium package offers end-to-end project support (24/7 access to experts, project management, regulatory support) to fast-track development, generally costing **€5,000 up to ~€25,000** for larger engagements [41] [42]. These prices include necessary data, software, and are often negotiable depending on scope [43]. This **hourly consulting model** with tiered deliverables is common among smaller firms and allows even a modest-budget client (say a local developer or municipality) to get a basic geothermal feasibility check, while bigger clients can opt for premium, hands-on support.

Meanwhile, larger firms like **Getech** and **CGG** often bundle their proprietary data and software into the service. Getech's business model blends **recurring software subscriptions and data sales** with **tailored services** [44]. For example, a client might license Getech's Globe or Heat Seeker platform (subscription) to internally analyze a region, and then hire Getech's experts to do a custom study on a specific site (service fee). Getech also sometimes pursues **strategic project partnerships** – taking an equity stake or royalty in a geothermal project – to capture upside from the development in addition to consulting fees [44]. This hybrid model indicates confidence in their targeting: they are willing to invest in projects where their geoscience analytics suggest strong potential.

Rare Earth Exploration: Target Delineation and Resource Evaluation

Detailed exploration for rare earth elements and other critical minerals proceeds along a parallel track, with some differences in methods:

After identifying a promising area via remote sensing or regional geochemistry, exploration companies will conduct **field investigations**: ground mapping, sampling of rocks/soils, and geophysical surveys targeted for mineral exploration. Common steps and services include:

- **Geochemical Sampling & Analysis:** Teams might collect soil samples, stream sediments, or drill core to measure REE concentrations directly. Geoscience labs and consultancies provide geochemical analysis services, and increasingly they use portable analyzers (XRF, spectral sensors) in the field to get immediate data. The *Inc.* magazine article highlighted companies like GeologicAI that use **hyperspectral sensors on drill core** to rapidly determine mineral and elemental composition on-site [45] [46]. This real-time analysis, fed into AI models, can guide where the next drill hole should go without waiting weeks for lab assays [46]. By iteratively updating the geological model with each new data point, they optimize drilling – *"drilling the optimum holes"* and avoiding unnecessary ones [47] [48]. This approach can **cut exploration drilling costs by as much as 80%**, according to startups in the field [49].

- **Integrated Geophysical Surveys:** For REEs, geophysical methods like **magnetics, radiometrics, gravity, and electromagnetics** are used depending on deposit type. Many REE deposits (e.g. carbonatites or pegmatites) have clear geophysical signatures – magnetic highs or lows, radiometric anomalies (from thorium, uranium), or conductivity contrasts. Service providers will often recommend airborne geophysical surveys over the target area. Modern surveys are high-resolution and data-rich; interpreting them with AI can help pinpoint drilling targets. Professor Emil Bayramov notes that AI algorithms digest a suite of geophysical data (magnetic, radiometric, resistivity, IP, etc.) together with geological information to detect subtle exploration targets [6]. An example is the *Mineral Systems* approach offered by Getech: They feed **thousands of data layers** into machine learning models to find proxies for the geological "ingredients" of various deposit types [50] [51]. For instance, to target a REE-enriched carbonatite, the model might look for coincident signals of ancient rifting (from regional geology), carbonate rock outcrops, thorium anomalies, and certain structural settings – a combination that a human might miss if analyzing maps one by one. Getech reports that its AI-enabled critical minerals analysis works globally across many deposit types [52]. It produces **"play fairway" maps** where areas meeting multiple genetic criteria for a deposit type are highlighted as exploration targets [53]. These play maps are delivered in standard GIS format to clients, often with layers like infrastructure or environmental constraints overlayed for further filtering [54]. The result is a ranked set of drill targets with a quantified degree of certainty.

- **Resource Estimation:** Once drilling has intersected REE-bearing material, geoscience service firms can assist with **resource modeling and estimation** – essentially translating drill data into an initial resource/reserve statement. This involves statistics and geostatistical modeling (block modeling, grade interpolation) to estimate how many tons at what grade of REE are present, and in what form (oxides, minerals). While this is more of a mining engineering service, many geoscience firms have mining geology divisions or partner with mining consultants. Notably, the push for *"responsible" and efficient exploration* means these steps are increasingly done in parallel with exploration, not sequentially at the very end. AI and cloud-computing enable a more continuous update of the resource model as new data arrives, which can accelerate the timeline to project development.

- **Sustainability & Supply Chain Analysis:** An emerging aspect, especially relevant for critical minerals like REEs, is evaluating the *sustainability and geopolitical factors*. Some service providers now include analyses of permitting, community impact, and sovereign risk as part of target evaluation [55]. For example, a target area might be downgraded if it lies in a protected forest or if jurisdiction risk is high. By factoring such criteria early (made possible by GIS layers like the World Database of Protected Areas or governance indices [56]), companies focus their detailed exploration on targets that are not just geologically sound but also viable to develop. This is crucial in the REE space given that >60% of global REE production is currently in China [57] – new projects often aim to diversify supply in regions with stricter environmental and social standards. Geoscience consultants thus may advise on how a potential REE project fits into the broader supply chain strategy.

Leading-edge Competitors & Approaches: The drive to find critical minerals has spawned several high-profile companies blending geoscience with tech:

- **KoBold Metals (USA)** – Backed by Bill Gates' Breakthrough Energy and other billionaires, KoBold applies AI and massive datasets to discover battery metals and possibly REEs. KoBold's vision is often described as creating a "Google Maps of the Earth's crust" using machine learning [58]. The company has raised over $500 million and even plans to develop mines itself [49]. KoBold's model is to *partner with or acquire interests in exploration projects*, contributing their proprietary data-crunching platform to locate hidden orebodies. This **equity partnership model** departs from traditional fee-for-service consulting – KoBold shares in the upside of a discovery. Their success underscores how valuable AI-guided exploration has become in the market (recently attracting investment from majors like BHP and Stanford University's endowment) [59] [60].

- **SensOre and Earth AI (Australia)** – These startups use algorithms to predict locations of mineral deposits and have claimed significant reductions in the cost per discovery. For instance, Earth AI (which raised a Series B in 2025) develops its own targets and finances drilling, aiming to earn royalties or ownership if a discovery is made [49]. They advertise up to 80% cost reduction in exploration via AI optimizations.

- **TerraEye (Poland)** – A specialized player focusing on **AI for satellite data** in mineral exploration. As mentioned, TerraEye's technology integrates multi-sensor satellite imagery (optical, radar, thermal) with geoscience datasets to generate target maps along with reasoning and uncertainty metrics [61].

Their service essentially provides mining companies an AI-vetted shortlist of targets in a region, with a report on why each area was selected. Anglo American and other large companies have used TerraEye, showing that even majors outsource some of the initial target generation to AI-driven specialists [7] [62].

- **Minalyze (Sweden/Australia)** – Innovator of the **"Minalyzer CS"** core scanning system. This is a hardware/software service where drill cores are fed through an automated scanner that uses X-ray fluorescence, imaging, and lasers to capture a continuous log of rock density, structure, and chemistry (over 50 elements) in one pass [63]. The data is then integrated into geological models rapidly. Such technology is being adopted by giants like Rio Tinto and BHP, indicating market relevance for speeding up the resource delineation phase.

- **Traditional Geoscience Firms (CGG, Getech, SRK, etc.):** Companies like **CGG** have expanded from oil & gas services into geothermal and mining. CGG's new **GeoVerse**™ platform offers multi-client data packages tailored to energy transition needs (e.g. geothermal atlases, critical minerals datasets) [64]. They often sell these as subscriptions or licenses to multiple clients. CGG also provides consulting – their 130-project geothermal team can be contracted for bespoke studies [65]. **SRK Consulting**, **Behre Dolbear**, **Sander Geophysics**, and **Geosoft/Seequent** (now part of Bentley Systems) are other established groups bridging classical geology with modern data techniques for mining and geothermal.

Below is a summary of some representative service providers, their focus areas, and business models:

Company / Service	Focus & Key Technologies	Applications (Sector)	Business Model & Pricing
GeoTechnic Solutions (NL)	AI & GIS mapping; uses QGIS, Google Earth Engine, public data for quick **renewable energy scans** [12] [11]. Offers online map app for free screening [9].	Wind, Solar, **Geothermal** site screening (global). Also leveraging oil well data for geothermal & lithium [18].	Consulting packages (Basic ~€0.8k–€5k; Optimal ~€5k–€15k; Premium up to ~€25k) [38] [42]. Free initial polygon scan to attract clients.
Getech (UK)	Large geoscience data suites (**Globe** platform); **Heat Seeker** global geothermal tool integrating subsurface & satellite data [14]; AI/ML for mineral systems analysis [66] [67]. Also provides GIS, remote sensing, and geophysical services [68] [69].	**Geothermal, Critical Minerals, Natural Hydrogen**; also O&G legacy. Global and regional studies (e.g. temperature-depth maps, mineral potential maps).	Mixed model: **Software subscriptions** (to data platforms & apps) [44], **data sales** (gravity/ magnetics packages, reports), and **tailored consulting services**. Also pursues project equity in some cases [44]. Pricing varies – enterprise subscriptions and project-based fees.

Company / Service	Focus & Key Technologies	Applications (Sector)	Business Model & Pricing
CGG (France)	Full-spectrum geoscience with new Energy Transition division. **GeoVerse** multi-client data (e.g. global geothermal studies, CO2 storage atlases) [64]. Multi-disciplinary team for custom projects (130+ geothermal projects exp.) [65]. Strong in geophysical data analytics and databanks.	**Geothermal, CCUS, Mining**. Delivered global geothermal potential study to a supermajor [20] [22]; researching offshore geothermal potential [70]. Also critical minerals assessments leveraging petroleum basin data.	**Multi-client studies** sold to multiple customers; **proprietary studies** on contract for single clients. Likely high-value contracts (six to seven figures) with integrated data provided. No public pricing; often long-term partnerships with industry and gov.
KoBold Metals (USA)	Cutting-edge **AI and big-data** exploration. Combines geoscientists ("Human Intelligence") with machine learning to model probability of deposits. Building a "digital twin" of Earth's crust for critical minerals [71]. Invests in data gathering (geophysics, geochem) in target areas.	**Critical Minerals** (initially cobalt, nickel, copper; expanding to lithium, rare earths). Projects in North America, Africa, Australia. Using AI to locate deep or buried deposits that were overlooked [72] [73].	**Equity/partnership model**: raises venture capital (>$500M) [49] and funds exploration in return for ownership stakes in discoveries. Not a service-for-hire, but rather a high-tech exploration company that partners with majors (e.g., BHP) [59].
TerraEye (Poland)	**AI-powered satellite analytics** for mining. Fuses multi-sensor satellite data (optical, SAR, thermal) with geological knowledge to produce target maps + uncertainty analysis [61]. Outputs "where-to-drill" recommendations.	**Mineral Exploration** (serves mining companies like Anglo American). Particularly suited for **early-stage REE and metal exploration** in remote or large areas.	**Service contract** basis: Clients hire TerraEye to analyze a region. Delivers digital map products and reports. Pricing likely per project or area analyzed. Emphasizes democratizing access to high-end targeting via AI [74].
GeologicAI (Canada)	Integrates **downhole sensors & AI**. Uses hyperspectral core scanners to instantly log geology and chemistry of drill cores [75]. AI compares results to known deposits to predict if a new hole is promising [76]. Essentially real-time adaptive drilling.	**Mining Exploration** (all minerals, incl. REEs). Useful in defining and extending orebodies quickly. Reduces need for lengthy lab assays and manual logging.	Provides **hardware + software service** to drill sites. Likely a combination of equipment leasing and data interpretation service fees. Recently raised $44M with industry backing [59], indicating growing demand.

Table: Examples of geoscience service providers and their offerings in geothermal energy and critical minerals exploration.

Business Models and Market Trends

The geoscience services market for green transition commodities is evolving rapidly, shaped by the need for both agility and depth of expertise:

- **Subscription Platforms vs. Consulting Projects:** Some companies monetize through **SaaS or data subscriptions** (e.g. paying for continual access to a geoscience database, or cloud-based analytical tools), providing clients the means to do their own analyses. Getech's Globe and CGG's GeoVerse modules are examples – a mining or energy company might subscribe annually to access global geological layers, climate data, remote sensing feeds, etc., to inform their strategy [44]. This provides a recurring revenue stream. In parallel, **consulting services** remain in demand for custom, project-specific work like feasibility studies or target generation in unfamiliar regions. Firms often blend these: for instance, a client may license a data platform but also pay the vendor's experts to interpret the data or to train their staff. Notably, Getech highlights *"high-margin data sales"* and *"tailored services and training"* alongside subscriptions in its business model [44]. This diversification helps smooth out the cyclical nature of exploration by ensuring multiple income streams.

- **Pricing Structures:** We've seen tiered fixed-price packages in smaller firms (e.g. GTS offering Basic/Optimal/Premium studies ranging from a few thousand to tens of thousands of euros) [38] [42]. Larger engagements (like a country-scale resource assessment) can run into hundreds of thousands. Some governments and development banks sponsor such studies for public good, often contracting big service firms via tenders. In those cases, pricing might be milestone-based or cost-plus. There is also a trend of **success-based pricing** or **joint venture models** – where the service provider's reward increases if a discovery is made or a project reaches development. This aligns incentives and is seen in the KoBold-style approach, but even consultancies sometimes negotiate discovery bonuses or equity kickers.

- **Government Initiatives and Public-Private Collaboration:** Since the energy transition has a public interest component, many geoscience service projects involve government data or funding. National geological surveys (e.g. USGS, Geoscience Australia, Geological Survey of Canada) openly provide enormous datasets that private services repackage. Additionally, programs like the DOE's geothermal-REE extraction grants show public support to bootstrap innovative services [19]. In Europe, the Geological Survey agencies are working on a joint data infrastructure (e.g. the Geological Service for Europe initiative) to support the Green Deal [77]. This open-data movement benefits service companies by lowering their data acquisition costs and allowing them to focus on value-added analysis. It also means that **speed and analytical prowess** become key differentiators – since basic data is available to all, the winners are those who interpret it fastest and most accurately.

- **Competition and Convergence:** Interestingly, the skill sets for geothermal and mineral exploration services are converging. Both require synthesizing geology, geophysics, geochemistry, and remote sensing. A geoscientist who once might have worked only in oil exploration might now apply those skills to, say, locate a sedimentary basin suitable for geothermal heat or to find brines with lithium. The Reuters whitepaper observes that a *"host of diverse industries are now seeking answers underground"* – from mining and water management to renewable energy – creating rapid developments in geoscience [78] [79]. This has led to **cross-pollination of technology**: oil industry software being used for hydrogen storage and geothermal, mining prospectivity algorithms being applied to natural hydrogen exploration, etc. It's also contributing to a talent crunch – smart young professionals often gravitate to cutting-edge fields like AI and robotics, so geoscience firms are embracing those technologies to stay attractive and boost productivity [80] [81]. Automation (like remote drilling or robotic surveys) is gradually entering the field service side as well [82].

- **Future Outlook:** By 2030, we can expect **more geoscience services to be delivered via cloud platforms** with on-demand analytics. For example, a client might log into a portal, outline an area of interest, and receive an AI-generated geological report within hours. Early versions of this exist (e.g. GTS's Quick Scan web app, or BHP's in-house exploration portals). Another trend is integrating **real-time monitoring**: for geothermal, that could be real-time micro-seismic monitoring or InSAR satellite tracking of ground deformation once a project is operating, which service firms can provide as a subscription to ensure the project's ongoing stability. We also see geoscience firms collaborating with **AI startups and space agencies** to incorporate the latest tech. As one mining tech CEO put it, *"portfolio management of mining companies will become completely optimized [by AI]"*, with exploration targets and even mining schedules determined by algorithms for maximum efficiency [83] [84]. This speaks to a future where geoscience service providers don't just find resources, but also help optimize how those resources are developed over their life cycle (tying into carbon footprint reduction, etc.).

Conclusion:
The green transition's success hinges in part on our ability to **understand and harness the subsurface** – to tap geothermal heat deep below our feet, and to unearth critical minerals with minimal environmental impact. Geoscience service companies are racing to provide the needed insights, using every tool from satellites to supercomputers. Quick, global screening surveys driven by remote sensing and AI are enabling governments and companies to spot opportunities (and avoid dry holes) much faster than before. At the same time, detailed exploration services – de-risking plans, 3D modeling, and innovative drilling analytics – are improving success rates and driving down costs.

Crucially, these services do not operate in a vacuum; they integrate with business models and policy drivers. Whether it's a small startup offering a €1,000 quick-look study, or a large firm selling a subscription to a world geological database, the market is rewarding those who can deliver actionable intelligence swiftly and credibly. The **geothermal sector** is benefitting from the transfer of oil & gas exploration expertise, now augmented with AI and public data, to identify viable projects even in non-volcanic regions [24]. In **REE and critical mineral exploration**, AI-driven approaches are already uncovering new prospects in regions previously dismissed, helping to diversify supply away from a few dominant countries [57] [74]. As one commentator noted, *"Mining is a complex equation with sparse data… AI can help fill in the gaps and cut costs"* [85] [86] – a statement equally true for geothermal exploration.

In summary, the most effective geoscience services today are those that **leverage advanced technology to integrate data at multiple scales** – from satellite images down to borehole logs – and translate it into clear, decision-ready insights. They target quick wins (like repurposing abandoned wells or scanning known districts with fresh eyes) while also laying the groundwork for sustainable, long-term resource development. As the energy transition accelerates, these geoscience services are becoming indispensable: they reduce the uncertainty inherent in subsurface ventures, making investors and governments more willing to back geothermal projects and new mining ventures for critical minerals. By prioritizing smart surveying and detailed analysis, we can better unlock the Earth's clean energy potential and critical materials **while saving time, money, and environmental cost** – truly a case of science driving sustainable progress. [87] [88]

Sources: The information in this report was drawn from a combination of industry publications, company resources, and expert commentary, including the Reuters Events whitepaper *"Geoscience: The race to understand the subsurface"*, GeoTechnic Solutions' service descriptions and pricing, Cleantech Group's analysis of geothermal innovation, and various technical references on remote sensing and AI in exploration. Key points have been cited throughout for verification and further reading.

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1 35 82 87 Executive Summary: Geothermal Drilling
https://tech2.cleantech.com/geothermal-drilling

2 6 7 8 45 46 47 48 49 57 59 60 61 62 63 73 74 75 76 83 84 85 86 88 In the Rare Earth Metals Gold Rush, AI Is the New Pickaxe
https://www.inc.com/chris-stokel-walker/in-the-rare-earth-metals-gold-rush-ai-is-the-new-pickaxe/91230641

3 4 15 16 26 27 28 29 78 79 80 81 Reuters whitepaper final.pdf
file://file_00000000c108720e8ff5f2262a428f33

5 Detecting rare earth elements using EnMAP hyperspectral satellite data: a case study from Mountain Pass, California | Scientific Reports
https://www.nature.com/articles/s41598-024-71395-2?error=cookies_not_supported&code=b7c326b2-ebf3-48a1-b2c9-e03485531456

9 10 AI and GIS Supported Renewable Energy Solutions
https://www.geotechnic.solutions/

11 12 13 56 AI and GIS Supported Renewable Energy Solutions - GIS and Satelite Data Services
https://www.geotechnic.solutions/services/gis-and-satelite-data-services

14 30 31 32 36 Geothermal Services | Getech | Unlocking the Earth’s Energy Potential
https://getech.com/getech-services-support/geothermal-services/

17 NASA Flights Map Critical Minerals From Skies Above Western US
https://www.jpl.nasa.gov/news/nasa-flights-map-critical-minerals-from-skies-above-western-us/

18 25 33 34 AI and GIS Supported Renewable Energy Solutions - Geothermal Feasibility Studies
https://www.geotechnic.solutions/services/geothermal-feasibility-studies

19 Geothermal Technologies Office Archives - Page 2 of 2 | CleanTechnica
https://cleantechnica.com/tag/geothermal-technologies-office/page/2/

20 21 22 23 24 65 CGG delivers global geothermal resource study to support client’s energy transition strategy
https://www.worldoil.com/news/2020/10/20/cgg-delivers-global-geothermal-resource-study-to-support-client-s-energy-transition-strategy

37 38 39 40 41 42 43 AI and GIS Supported Renewable Energy Solutions - Pricing
https://www.geotechnic.solutions/services/pricing

44 Business Model | Getech | Unlocking the Earth’s Energy Potential
https://getech.com/getech-investors/business-model/

50 51 52 53 54 55 66 67 Minerals Exploration Services | Getech | Unlocking the Earth’s Energy Potential
https://getech.com/getech-services-support/minerals-exploration-services/

58 71 Gates, Bezos-backed KoBold Metals raises $537 million in race for ...
https://www.mining.com/gates-bazos-backed-kobold-metals-raises-537-million-in-race-for-critical-minerals/

64 CGG Licenses Geothermal Multi-Client Studies Supporting Energy ...
https://www.viridiengroup.com/company/newsroom/news/cgg-licenses-geothermal-multi-client-studies-supporting-energy-transition-us

68 69 Remote Sensing Services - Getech
https://getech.com/getech-services-support/remote-sensing-services/

70 CGG paper explores the potential of offshore geothermal
https://www.thinkgeoenergy.com/cgg-paper-explores-the-potential-of-offshore-geothermal/

72 How KoBold Metals Uses AI to Find Rare Earth Minerals
https://www.deeplearning.ai/the-batch/how-kobold-metals-uses-ai-to-find-rare-earth-minerals/

77 Open access to digital geoscience data and knowledge supports ...
https://www.sciencedirect.com/science/article/pii/S1569843224001894?via%3Dihub