History of geology in Liechtenstein

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Abstract. Liechtenstein is an ideal terrain for geosciences, but the scientific exploration began not earlier than the end of 19th century. Before there was only a utilitarian prospection. The beginning of scientific researches was initiated from abroad. Nowadays popularization is developing, thanks to generalist scientific societies, and public institutions. There is still no geological institute, but cooperation with the neighboring countries prove that science ignores national boundaries.

Keywords: Liechtenstein – Geography – Geology – History – Geosciences – Rhine valley

Introduction

In comparison to other countries Liechtenstein is not very well known, because with only 160 km^2 it is merely a dot on the alpine map (Fig. 1), though in a tectonically interesting location . There is no much scientific literature on the topic and our present schematic overview is the first publication about the history of geosciences in this country. Since over two centuries the Principallity of Liechtenstein is one of the most stable independant states from political, cultural and economic point of view, its landscape is not stable at all: there are permanent visible changes, due to geological processes and human intervention at nearly every point of the territory. The history reaches from the oldest stones ever found, until to the newest rocks which are presently in formation. Some examples of human investigations are additionnal historical landmarks. A list of institutional actors is certainly useful to anybody who wants to make a scientific study or compare with the neighbouring countries. Note that most literature about Liechtenstein is in German.

1- Geological history

1.1- Liechtenstein ideal terrain for Geosciences

Liechtenstein is an alpine country, that is celebrated as an ideal terrain by those geologists and geographers who studied it. Daniel Miescher, in his reference book *Geologie Liechtensteins*, speaks of an "*interesting geological variety*" (Miescher 2014). In a precedent article we explained, why this area is "a paradise for the geographer" (Deicha I. 2002).

The oldest stone cited by Miescher is an erratic block near the Pfälzer Hütte. It is 350 million years old (Fig. 2). The newest formation is visible along the road leading to the castle of Vaduz, where a pretty touristic fountain is now completely covered with thick tuffa deposits (Fig. 3). This compact rock appeared in less than 50 years. The tectonic structure can be summarized as Helvetic, Penninic and Austroalpine nappes, cut by two parallel valleys (Rhine and Samina) filled with sediments, and rubble from landslides (Fig. 4)

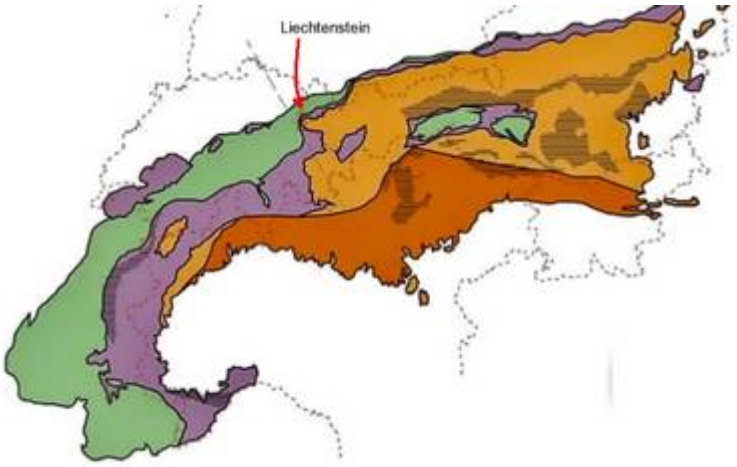

Fig. 1. Liechtenstein is in the middle of the Alps. Tectonic overview (Miescher, 2014, p. 9).

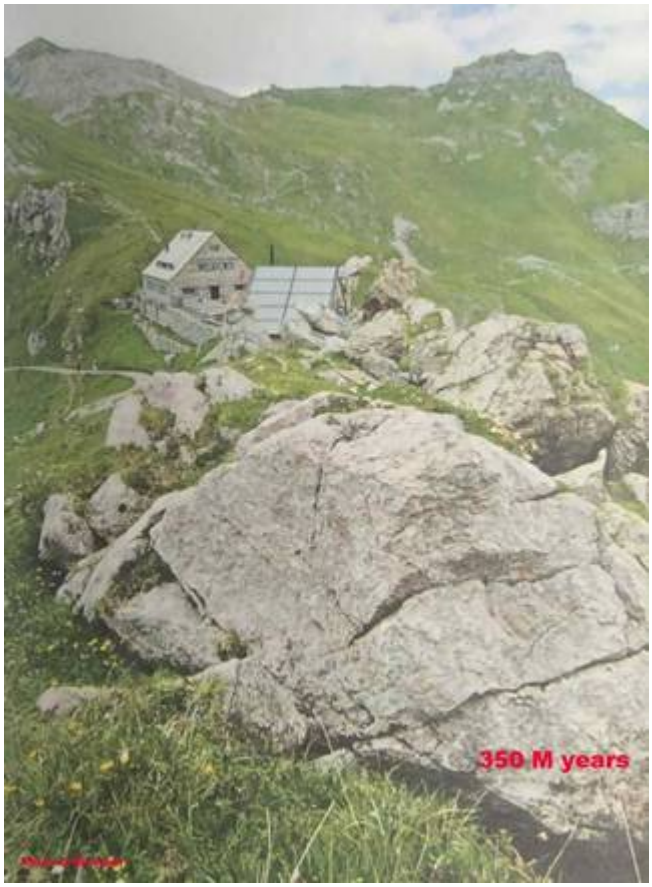

Fig. 2. The oldest rock of Liechtenstein, the Bettlerjoch-breccia 350 million years old (Miescher, 2014, p.76).

Fig. 3. The newest rocks formed by current tuffa-deposits are barely 50 years old. Petrifiyng fountain in Vaduz – Schlossstrasse (Photo by the autors).

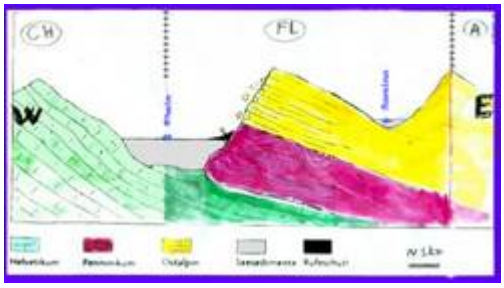

Fig. 4. Draft of an East-West tectonic section; FL= Liechtenstein, CH= Switzerland, A= Austria; (according to Miescher, 2014, p. 114).

1.2- Evolution in progress

The landscape evolution is visibly in continuous progress everywhere: For decades we have always liked to observe how the petrifiying fountain is still growing slowly. On the western slopes of the mountains erosion can be very important, so that the famous touristic trail *Fürstensteig* must be rebuild every year, and every field geologist has allways new rocky outcrops to explore (Fig. 5). The groundwater level is subject to seasonal changes. Nearly every day alluvions in the Rhine are changing dramatically, as well as the throwput of creeks.

Besides this continuous evolution let's remember that we are in a region submitted to brusk natural phenomena like landslides, floodings and earthquakes (Deichmann 2011). Mud flows (*Rüfen)* eventually reach the bottom of the valley and make some land unbuildable, the historic Rhine overflow of 1927 was a nationwide disaster, and the two last tremors recalled the importance of geologic phenomena to everybody, as well to poets (Helbert 1992) as to MPs (Albrich 2022)[1]. Many anthropic constructions try to limit the resulting dangers.

2- History of human investigations

2.1- Utilitarian investigations

Since the Middle Ages stone quarries are exploited at several places (Frommelt 1934). The *Schloss Vaduz*[2] and other medieval castles were build partially with limestone tuffa (Fig. 6). Other buildings are of "Balzner Marmor" extracted in the southern part of the country.

Two hundred years ago, people eventually mined and exported some other mineral resources (Broggi, 2022a, p.18). Historians remember that "in 1800 gypsum was Liechtenstein's most important industrial export product" (Vogt, 1990). Gypsum was extracted in quarries above Masescha and milled in Vaduz Mühleholz. Even iron ores were extracted in Valorsch until the 17th century. Smelted with charcoal they produced a small quantity of steel (Falk, 2011). Environmental specialists are now renaturating a zone in the north of the country, where peat was extracted until the 20th century (Broggi, 2022b, p.156).

In the beginning of the 20th century the construction of new roads, drainage channels and hydro-electric power-stations provided new geological knowledge. The national electricity provider *Liechtensteiner Kraftwerke* (LKW) began to work in 1927 (Lawenawerk, Saminawerk, Pumpspeicherkraftwerk). For the first time the Liechtenstein mountains were pierced from part to part, with the assistance of geologists. The dumps of the underground penstock, connecting the Steg reservoir in Samina valley to the power station in Vaduz, attracted researchers[3]. At this occasion microscopic liquid and gaseous inclusions were discovered in Triesen Flysch fissures in the fifties.

A road tunnel was digged in 1947. Half a century later soil drillings were performed to get groundwater or to investigate the possibilities of geothermy (Naef, 2011),

Internet sources say that "Liechtenstein has few natural resources, aside from alluvial gravel used by the concrete industry. Gravel extraction from the river interfered with groundwater flows and was banned after 1972."[4]. Indeed gravel extraction had even caused a bridge-collapse in the seventies. (Fig. 7).

[1] During our presentation at the INHIGEO meeting at les Eyzies, we reported about a sismic tremor occuring a few days ago, at the very moment when the Liechtenstein Parliament was debatting about... earthquake insurances!
Video https://www.youtube.com/watch?v=FvDdRI0iOGc

[2] Photograph illustrating the link. https://www.mindat.org/loc-263790.html referring to Sella *et al.* (1970).

[3] Citation from: https://www.mindat.org/loc-263789.html

[4] Wikipedia https://en.wikipedia.org/wiki/Geology_of_Liechtenstein

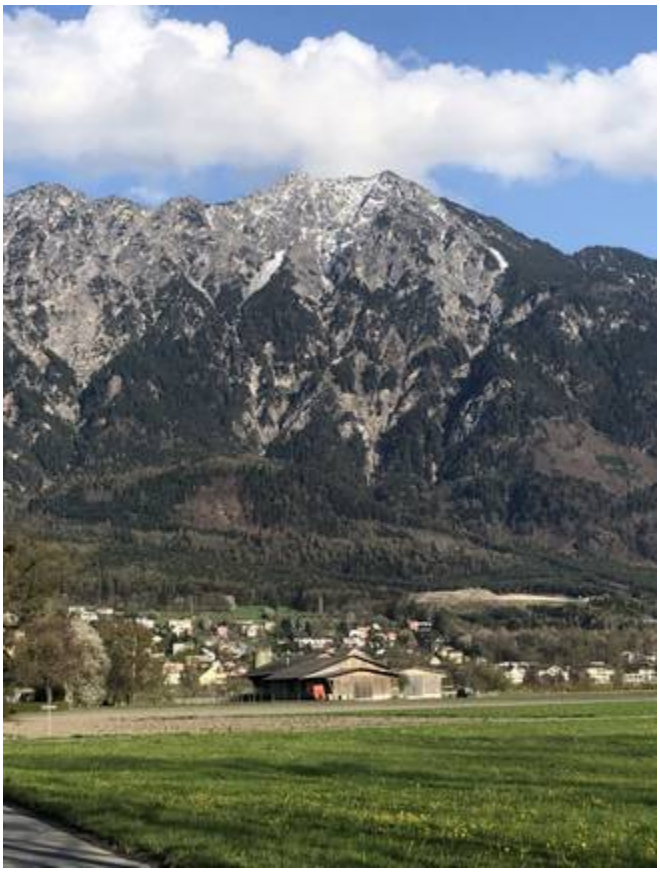

Fig. 5. The western slope of the Dreischwestern massif (2000 m). Foto taken by the authors from the bottom of the Rhine valley (450 m). The “Fürstensteig”, a narrow path leading to the snowy ridge must be rebuild every year. Clearly visible below are the canyons of temporary torrents (Rüfen). They transport plenty of erosion material after every intense rain on the summits.

Fig. 6. Schloss Vaduz was build with material quarried nearby.

Fig. 7. The collapse of the bridge between Schaan and Buchs in the seventies was caused by gravel extraction from the river Rhine (photo by the authors).

2.2- Scientific investigations

The exploration by foreign geologists began in the 19th century (Wanner, 2011). Due to the smallness of the country, there is no geological nor geographical institute, but individual researchers with foreign scientific affiliations publish very good work. From time to time, Liechtenstein was even represented at international scientific meetings. We recently found in our family archive a document related to the 19th and 21st International Geological Congress (Fig. 8)[5]. As an example of scientific investigation by foreign institutes we ay evoke the developement of the fluid inclusions studies by the *Centre d'étude des Inclusions*" in Paris in the middle of the 20th century (Poty, 2017).


Es wird hiermit bestätigt, dass Dr. G. DEICHA, der seit der 19. Session Liechtenstein bei dem Internationalen Geologischen Kongress vertreten hatte, weiter als unser Delegierter (Head Delegate) bei der 21. Session in Kopenhagen teilnehmen wird.

Vaduz, 8. August 1960

FUERSTLICHE REGIERUNG

Fig. 8. The document signed by Prime Minister Alexander Frick, certifiyng participation of Liechtenstein in at least two International Geological Congresses (authors' archives).

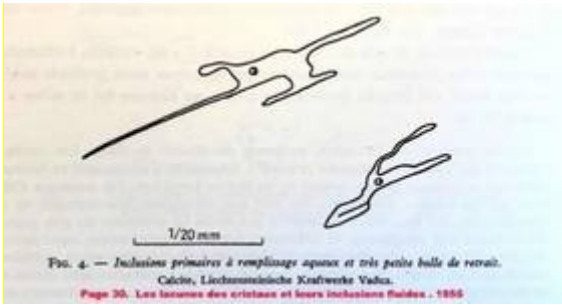

Fig. 4. — *Inclusions primaires à remplissage aqueux et très petite bulle de retrait.*
Calcite, Liechtensteinische Kraftwerke Vaduz.

Fig. 9. Aqueous filling and a small gas bubble inside of a calcite crystal from Vaduz illustrating the first French reference book on inclusions (Deicha G., 1955, p. 30).

Georges Deicha (1917-2011), the precursor of the european studies on fluid inclusions illustrated his reference book with materials from Liechtenstein (Fig. 9) (Deicha G., 1955, p.30).

2.3- Outreach activity

In the general public the interest of geosciences is almost always associated with domestic geography, archaeology, mountain sports, or environmental concerns. Geology as a science, was poorly represented in previous years. For instance in museums there are very few exhibits. In the school curricula, basics in Geology did not appear as an own scientific matter, but together with geographical or environmental items. In the fifties there were some *Strahler* (rockhounters) who sold crystals to tourists, those who quoted honestly the origin of the stones could help scientists.

Nowadays we can say, that there is a trend to develop seriously scientific knowledge, and geosciences are in progress. In the last decades geology was the theme of several installations in the public space in Malbun[6] also in Bendern (" Stone Path") or around a fountain in Vaduz (Fig. 10).


Fig. 10. The "Fountain of the County of Vaduz" (der Grafschaftsbrunnen) is an installation where each rock comes from one of the villages in the neigbourhood (photo by the authors).

3.1- 3- Institutional Actors

Associations

Interested local scholars meet and publish in

[5] Liechtensteiner Vaterland 26.07.2017 p. 8 „Bezug zu Liechtenstein noch unerforscht" in „Dr. Deicha hält die Eröffnungsrede»; https://deicha.li/application/files/4715/0425/1492/2017Vaterland26JuliAusschnitt.jpg

[6] The agency Liechtenstein Tourismus recommends Daniel Miescher's geological trail in the alpine resort Malbun: https://www.outdooractive.com/de/route/themenweg/liechtenstein/geologiepfad-malbun/61853184/

different generalist associations, who edit bulletins, also with contributions about earth sciences. Let's cite three of these associations, devoted to history, to alpinism and to science. They all have a rich fundus of literature, they can be useful to prepare a field research, and they are a meeting place of the best connoisseurs of the region.

Der Historische Verein für das Füstentum Liechtenstein (HVFL)[7] is the historical association of the country, one of the oldest learned societies, landowner of some historical sites and editor of an annual bulletin *Jahrbuch des Historischen Vereins* (The first studies *Liechtenstein's Geology* were issued there in 1951 and 1952) (Allemann, 1956).

Der Liechtensteiner Alpenverein (LAV) [8] is the national mounaineering club, member of the international network *Arc Alpin*, landowner of two mountain huts and editor of a quarterly bulletin *Enzian* and an annual report *Bergheimat*. LAV is the editor of the reference book *Geologie Liechtensteins* by Daniel Miescher.

Das Naturwissenschaftliche Forum (NWF)[9] is the Liechtenstein Scientific Society, for science outreach, and relations to international academic organizations (European Physical Society EPS, International Astronomic Union IAU, European current research on fluid inclusions ECROFI, International commission on History of Geosciences INHIGEO). NWF is the editor of the latest bibliography on history of geosciences (Deicha C., 2022).

3.2- Collections

In the catalogue of the local museum visitors are warned that « scientific collections and museums are usually associated with research institutions or carry out the research themselves. However, Liechtenstein does not have its own institute or higher education institution for natural science disciplines. For this reason, the natural history research of the country before 1970 was limited to more or less accidental works? »[10].

In Vaduz, the *Landesmuseum* principally devoted to the local history and archaeology has a small geological exhibition constituted by nine polished blocks used as seatings for visitors, three fossils and a table alowing visitors to touch various stones... not even all of local origin ! (Fig. 11). There are also regional collections (Fig. 12) not limited by the boundaries of the Principality. Private collections can be preserved if the family takes care of them (Deicha S., 2019), but generally they are not accessible to public.

Fig. 11. The small permanent exhibition devoted to geology in the Landesmuseum Vaduz (photo by the authors).

Fig. 12. Regional collection with calcite containing fluid inclusions (Deicha, 1952), quartz from Swizerland, and gypsum from Liechtenstein. The private collections can be preserved if the family takes care of them.

[7] www.historischerverein.li
[8] www.alpenverein.li
[9] https://dachverband.li/naturwissenschaftliches-forum
[10] www.landesmuseum.li

3.3- Governmental actors.

There are only 70 geological samples in the Natural History Collection of the Office of Environment (*Naturkundliche Sammlungen / Amt für Umwelt*). We notice that there are far more numerous artefacts about Zoology and Botanics than about Geology. To our knowledge there is no accessible collection, but field research can be easyly performed by every young scientist who wants to gather samples by himself in the new outcrops. Almost as an anecdote, there is a sample of lunar rock in the showroom of the "Treasure Chamber" in the center of Vaduz. It is very popular among tourists, but infortunately it is not accessible to scientists, because it is encapsulated in a glass sphere !

The Liechtenstein Government[11] operates an archaeological office (Amt für Kultur) who has a certain legal control of the heritage of hidden treasures in the soil, and their scientifically correct handling. This office is established for archaeologists, but can also be useful for geologists.

A geological map was realized by Franz Alemann in the fifties and is currently re-edited by the government (Fig. 13): "*Geologische Karte Liechtensteins*" (Cadisch, 1953). All Liechtenstein-relevant literature is systematically collected by the National Library (Landesbibliothek)[12] and can easily be consulted there by everyone.

4- Comparison with the neighbours

4.1- Geosciences beyond boundaries

The country is inbedded in a regional Landscape, that includes the Swiss cantons St. Gallen and Grisons in the South and West, and the Austrian federal Land Vorarlberg in the North and East. They form together a coherent region of the German-speaking cultural space with strong ties to cities with Universities and Institutes (Innsbruck, Zürich), over-regional specialized learned societies (Geological Societies, Mineralogical Societies, Geographical Societies) and enough readers to satisfy scientific editors.

The Principality of Liechtenstein belongs to the eight *Alpine countries*, and is member of the Alpine Treaty Convention[13]. Most of the field activity (investigations of geologists or geographers, paedagogic excursions of schoolclasses, *etc.*) ignore the national boundaries, especially to the two neighbours: Austria and Swizerland

4.2- Austria

The Geological Map of Vorarlberg includes also Liechtenstein, whose upper tectonic nappes are an extension of the austrian Austoalpin. Most regional books and publications and also the Association of Vorarlberg Friends of Nature deal with this subject[14].

4.3- Switzerland

The visit of the *UNESCO-heritage Tektonik Arena Sardona* beginning only few kilometers south-west from the Swiss-Liechtenstein frontier can be recommended. The operators are rightly proud to say: *"*This region is unique in the world: nowhere else are the results of the processes that led to the formation of mountains as evident as they are here*".* This large national park (twice the area of Liechtenstein) is indeed a vivid museum of the alpine geological history[15].

5- Conclusion

Let us underline that, according to Josef Biedermann, until 1970 Liechtenstein was still a *terra incognita* on the map of investigations in natural sciences (Biedermann, 2022). In so far as the history of geosciences in Liechtenstein has never been described, there are certainly plenty

[11] www.llv.li
[12] www.landesbibliothek.li
[13]: https://www.alpenverein.at/portal/natur-umwelt/av-naturschutz/alpenkonvention/liste-ak/01_geschichte-ak.php
[14] https://vorarlberg.naturfreunde.at/
[15] www.unesco-sardona.ch

of opportunities for the next generations of scientists. Perhaps the name Liechten-Stein may catch the attention, because in German *Stein* means stone![16]

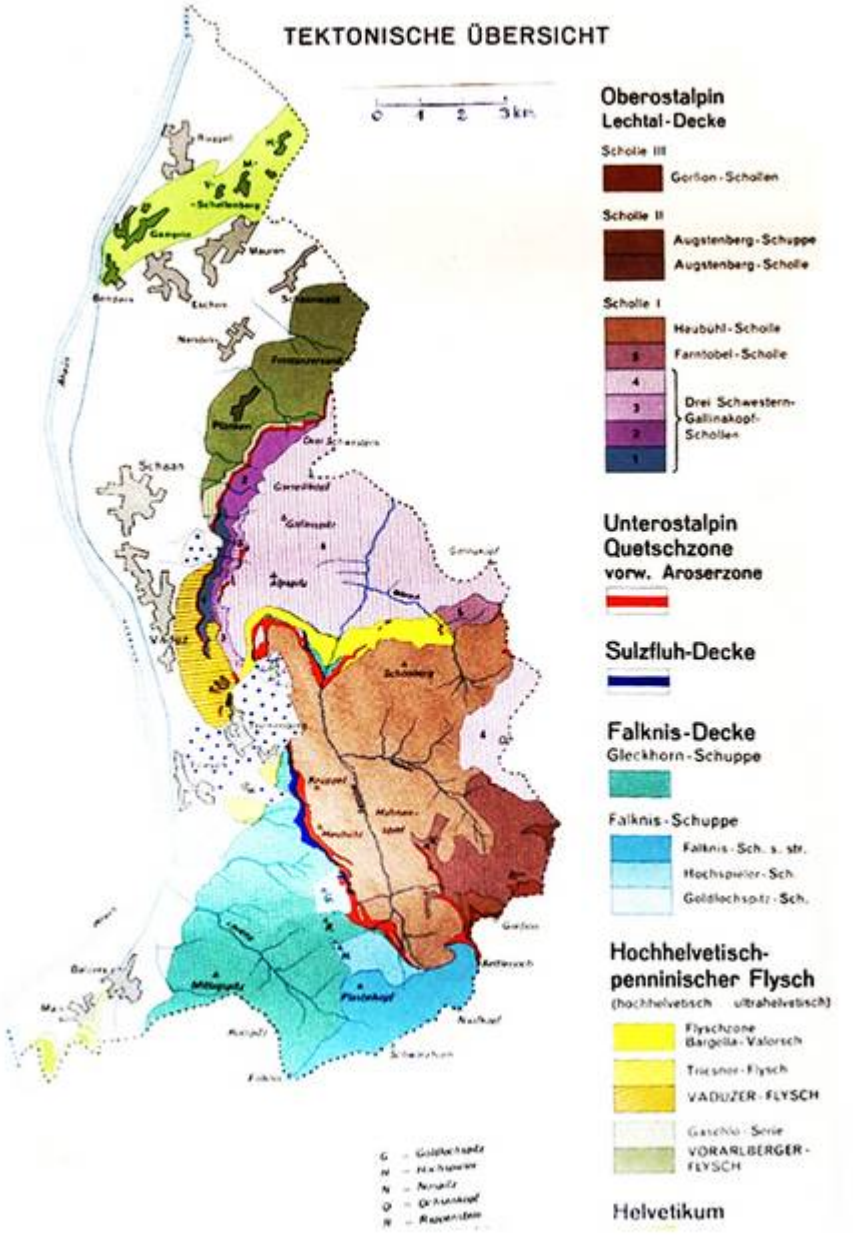

Fig. 13. Tectonic map of Liechtenstein (Cadisch, 1953).

[16] Liechtenstein is the family name of the reigning house. It originates from Burg Liechtenstein, which lies since 1130 deep in Lower Austria. It is not Schloss Vaduz, which the Liechtenstein family bought in 1712 from another noble family that had gone bankrupt. There are several hypotheses for the etymology of the name: either a mansion built of light-coloured limestone or of a light material (leichter Stein), or the founder of the dynasty discovered a luminous precious stone (Licht-Stein). In any case, there is no link with Liechtenstein's geology.

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