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Connected by Origin

The distribution of lignite deposits in Poland turns out to be closely related to tectonic boundaries and the occurrence of salt deposits. What mechanism underlies the connection between these elements?

The Bełchatów Lignite Mine

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Lignite deposits are common across large areas of Central and Western Poland, and they are connected with relatively late Miocene sediments. In the 1990s, researchers noticed that the vast majority of them can be found in regions also characterized by underlying salt deposits of the Zechstein saline formation. These deposits cannot be observed directly, as they are found at depths of a few thousand meters below the surface. This formation covers around 60% of Poland (almost the entire Polish Lowlands) and is approx. 1000 meters thick. The Zechstein saline deposits arose as a result of the long-term precipitation of salt and gypsum out of high-salted seawater following evaporation.

Although rock salt appears to be hard and robust, under high pressure from the younger overburdening rocks it becomes ductile. The great thickness of the salt deposits themselves causes them to undergo liquification, resulting in the formation of diapir intrusions breaking through overlying rocks to the surface. These structures present as salt domes (diapirs), pushing upward through overburdening rock layers or piercing up into the soil surface.

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Salt domes of Zechstein deposits stretch along a narrow belt of the Mid-Polish Swell. They are most common in the Kujawy region, where they are a source of natural salt springs previously used as a source of salt through evaporation. The region is known as the mid-Polish area of salt extrusions.

Mechanisms of co-occurrence

From the perspective of the origin of lignite deposits, the accumulation of large volumes of phytogenic matter requires the preservation of long-term balance between the rate of accumulation of phytogenic matter and the rate of subsidence of the depositional surface, which must remain relatively slow and steady. For thick deposits of lignite, such balance has been

GLOSSARY

Diapir-overburden / diapir-marginal / inter-diapir deposits – deposits formed in tectonic depressions in the proximity of salt domes – situated directly above a salt structure, in the immediate vicinity of such a structure, or in between two or more such structures, respectively

Gravitational tectonic depressions – depressions formed as a result of the stretching of the surrounding rocks and sinking of their fragments due to gravitational displacements.

Miocene – the first geological epoch of the Neogene (the Cenozoic era) preceding the Quaternary. Its fauna and flora resembled those found today. In Poland, the Miocene climate was significantly warmer than it is recently, supporting lush vegetation whose remains eventually gave rise to major lignite deposits.

Phytogenic sediment – sediment comprising plant matter, coalified to a greater or lesser degree

Salt dome (diapir) – a vertical salt structure (pillar) formed as a result of salt domes rising to the surface.

Zechstein formations – a complex of sediments from the Upper Permian (Zechstein) age exhibiting a high proportion of salts.

Zechstein salts – a thick complex of halite and potassium salts formed as a result of gradual evaporation of the ancient Zechstein Sea which covered a large part of the European Lowlands (including Western Poland). Such deposits can be found a few kilometers below the Earth's surface.

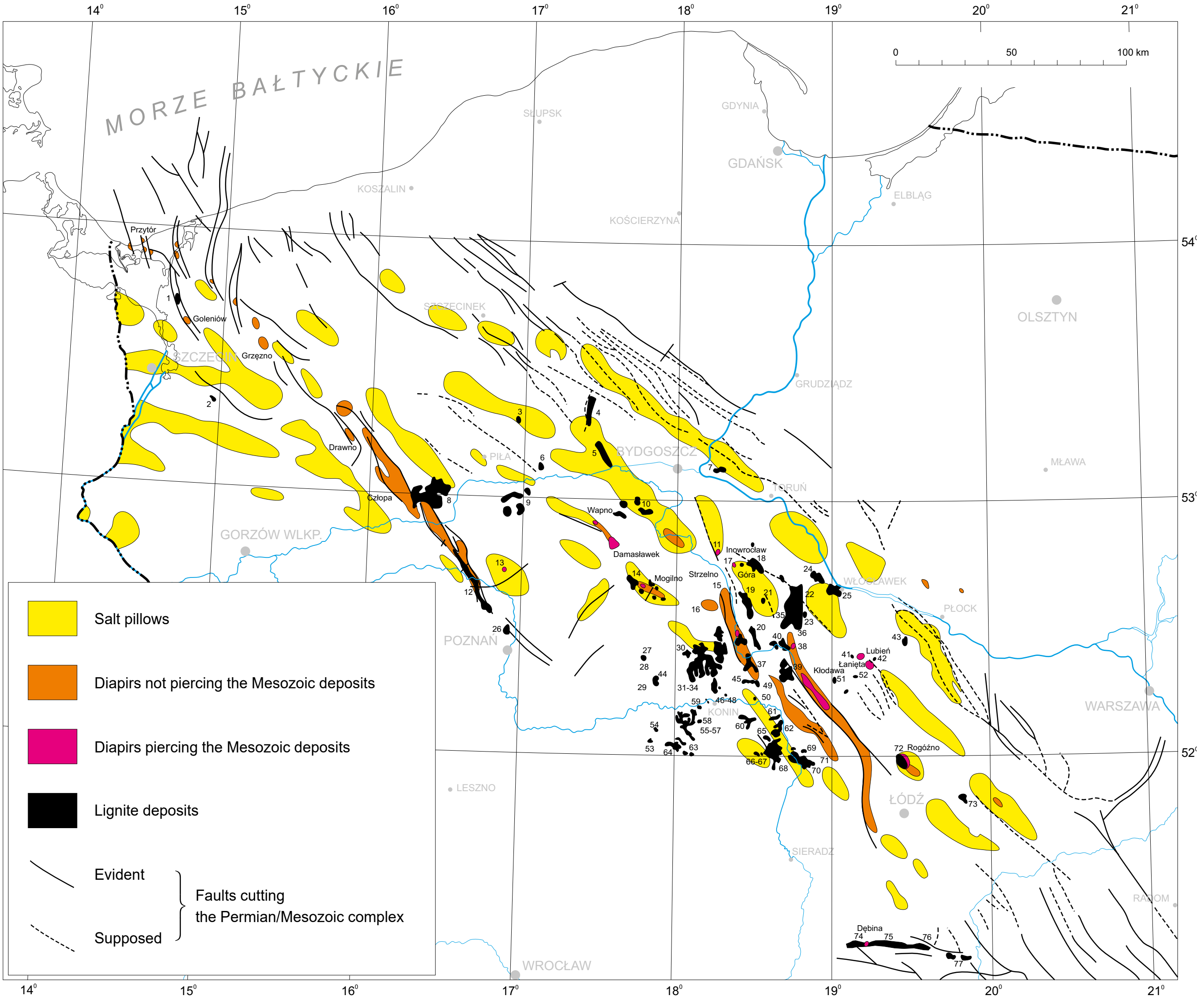
maintained for millions of years; for example, the time of accumulation of phytogenic matter which gave rise to Miocene lignite deposits in the Lower Rhine valley (over 100 m thick) is estimated at approximately 11 million years.

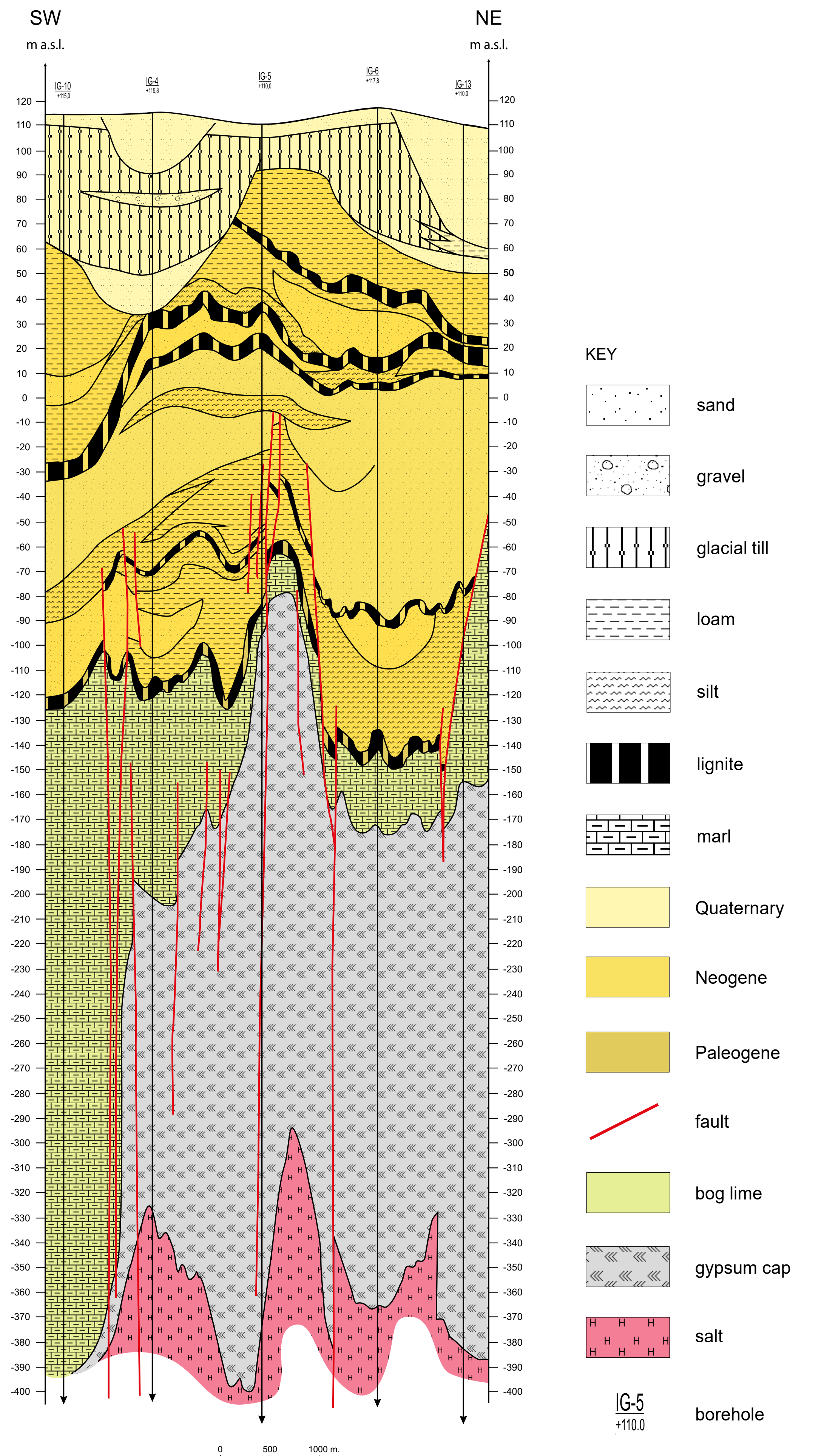
This raises the question of how the sedimentary conditions of phytogenic matter were maintained for so long, during a comparable period, in close neighborhood to active salt structures, where the sedimentation environment is extremely dynamic by definition. A stable rate of sedimentation could have been maintained at a farther distance from salt structures, in particular in regions between two of them. This is the origin of the lignite deposits seen at sites including Trzcianka, Chełmce, Piotrków Kujawski, Tomisławice, Ościsłowo, and deposits in the Pątnów region.

However, sedimentation of phytogenic deposits may also have taken place directly above salt structures, since their accumulation generally resulted in the formation of anticlines. As rock layers stretch, gravitational tectonic depressions form in the joints of such anticlines above salt domes. This process has given rise to the lignite deposits seen at Więcbork, Nakło, Szamotuły, Radziejów, Morzyczyn, Lubstów, Dęby Szlacheckie, Szczerców, Bełchatów, Kamieńsk, and Łęki Szlacheckie. Upper layers of halite deposits are also related to underground leaching of salt (subrosion) or salt leakage along fault lines, leading to the gradual subsidence of the soil surface above the salt intrusions; in turn, this leads to the origin of depressions, and the natural degradation of salt intrusions is reflected on the surface. It is likely the subrosion mechanism that is responsible for the origin of the deposits found above salt intrusions at Goleniów, Lubień, Łanięta, and Rogóźno.

The uplift of salt structures also resulted in the formation of small depressions next to the intrusions due to the flexing of strata layers as salt rises to penetrate the surface. Local depressions which make conditions supporting the accumulation of phytogenic matter are

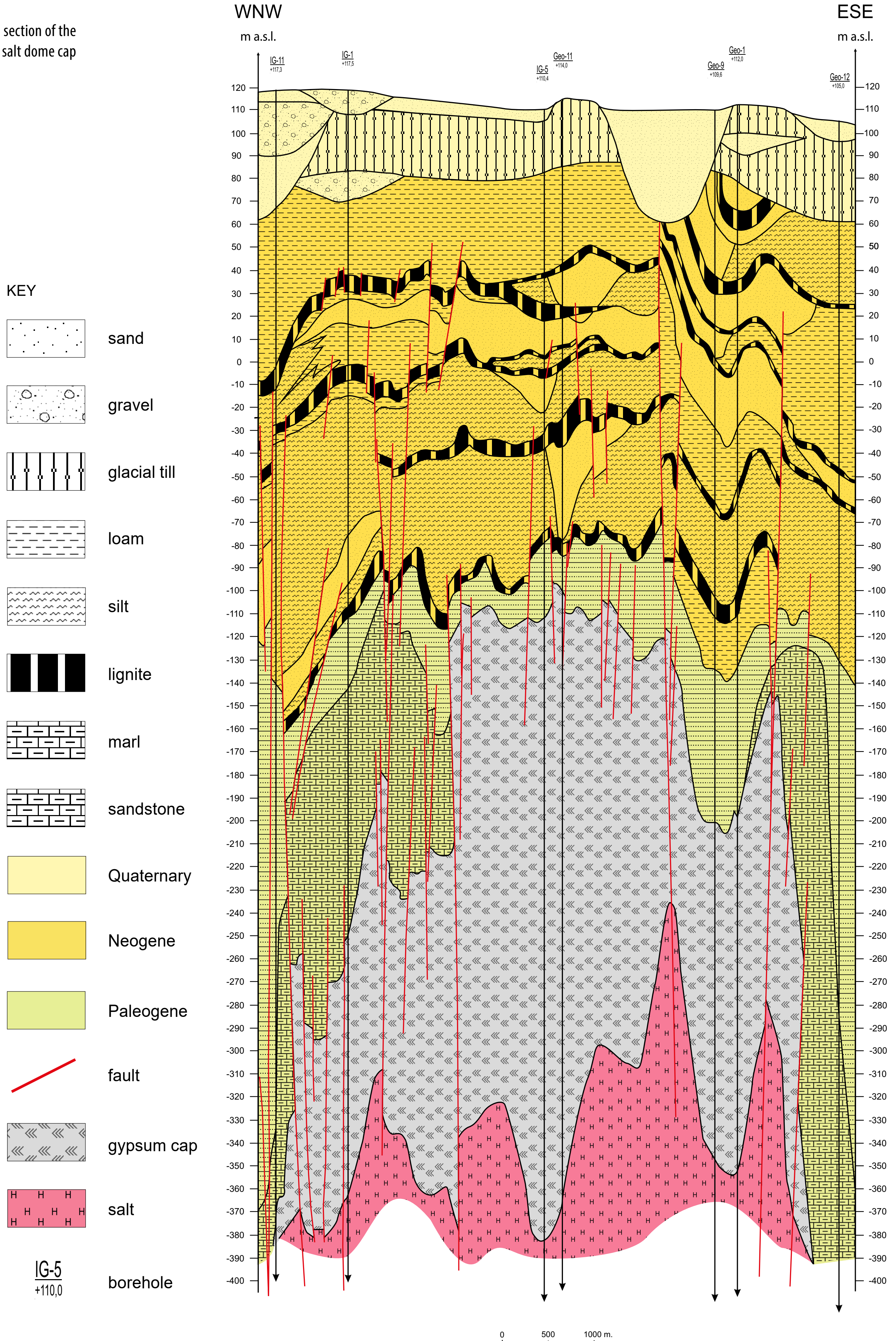
Deposits and other important lignite sites in relation to the distribution of salt domes





Deposits and other important lignite sites in relation to the distribution of salt domes

Geographical section of the Damasławek salt dome cap



Distribution of lignite deposits related to salt structures

Type of deposit	Number		Surface area of deposit		Deposit resources	
	nr	%	km^2	%	mln ton	%
Deposit at diapir overburden	4	5.2	22.21	2.9	737.8	8.7
Deposit at diapir marginal depression	12	15.6	100.56	13.3	725.1	8.6
Deposit above salt structure	11	14.3	147.76	19.6	4095.4	48.5
Interdiapir deposit	14	18.2	256.47	33.9	1484.6	17.6
total	**41**	**53.2**	**527.00**	**69.7**	**7042.9**	**83.3**
Other lignite deposits	36	46.8	228.72	30.3	1408.2	16.7
overall	**77**	**100.0**	**755.72**	**100.0**	**8451.1**	**100.0**

found near many intrusions. The occurrence of lignite formed through this mechanism appears in smaller regions and is relatively small.

Lignite deposits

We conducted a statistical analysis of the relationship between the position of salt structures and the occurrence of lignite deposits. Two variants were developed, with consideration of (1) the surface of lignite deposits and (2) the resources of the deposits. We also classified lignite deposits related to salt structures in depressions into three types, those occurring above, those adjacent to, and those in between salt domes (which we have termed diapir-overburden, diapir-marginal, and inter-diapir deposits, respectively). Our analysis also included other types of lignite deposits which show no links with the development of halite deposits.

Our research reveals that the occurrence of lignite deposits on the Polish Lowlands which show a relationship with salt structures is only slightly higher than those that do not; however, both the surface area and resource volume of the first group are significantly greater. As such, the migration of salt masses (known as halokinesis) is understood to have been a significant cause of the formation of numerous lignite deposits in Poland.

Lignite deposits occurring directly above salt intrusions (diapir-overburden deposits) are extensive and have very good geological and mining parameters (with a ratio of 8.7% resources to 2.9% of deposit surface area and, therefore, also of lignite thickness). Deposits formed in depressions adjacent to salt intrusions (diapir-marginal deposits) are also considerable in size (8.6% of resources to 13.3% of surface area), thus sites adjacent to halite structures should be regarded as having a high resource potential of lignite. Such regions include Rogoźno and Kłodawa, as well as Damasławek, Góra, Inowrocław, Izbica Kujawska, Lubień, Łanięta, Mogilno, and Strzelno. Lignite deposits can be found above salt intrusions in three of these regions (Damasławek, Lubień and Łanięta), and in depressions adjacent to intrusions in four (Góra, Inowrocław, Izbica Kujawska and Strzelno). In Mogilno, lignite deposits occur in both positions.

Conclusions

The neighborhood of salt domes turns out to be closely connested with the occurrence of lignite deposits, and their origins are closely related to the dynamics of their development. The highest concentration of lignite deposits has been found in depressions located next to salt structures (i.e. diapir-overburden, diapir-marginal, and inter-diapir lignite deposits). Potential lignite deposits exhibiting the highest ratio between surface and coal thickness (therefore with the greatest potential economic value) have the greatest volumes with diapir-overburden deposits However, due to the highly dynamic nature of the environment, such deposits also show the greatest variability in lignite seam geometry and in chemical and technological composition, and they are frequently contaminated with sulfur or salt. In this group, the deposits of Damasławek, Łanięta, and Lubień have the highest economic potential. Damasławek and Łanięta appear to be the leading lignite deposits related to salt domes. However, due to their specific geological setting and insufficient data, they still require deeper exploration.

Diapir-marginal deposits are far more accessible, although they exhibit a lower ratio of surface to coal thickness. Additionally, their relatively small sizes make them less attractive for mining. ■

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Further Reading

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