

Brandenburg. Geowiss. Beitr.	Cottbus	Bd. 31/2024	S. 29–34	2 Abb., 10 Lit.
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Halotectonic Lineaments on both sides of Odra Valley

Halotektonische Lineamente auf beiden Seiten des Odertals

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Introduction

It is widely accepted, that the waxing and waning of large Pleistocene Ice Sheets caused halotectonic movements of the salt structures in Northern Central Europe. For the North-West-Polish Basin GRANICZNY (1991, 1992) as well as PIOTROWSKI (1999, 2007) described associated mechanisms and landforms, while LANG et al. (2014) and SIROCKO et al. (2008) tested these movements for the North-German Lowlands. Both regions are part of the North-Central-European Basin (STACKEBRANDT & BEER 2010). The infill consists of quite comparable sediment sequences including thick salt series of Permian age. The formation of the salt structures itself started at least from the Jurassic Period (STACKEBRANDT & BEER 2010).

Recently, HARDT et al. (2021) described lineaments – so called „surface cracks“ – in Northern Germany. They were interpreted as halotectonic features: Salt structures present in the subsurface therefore reacted plastically to changing stress conditions with the transgression and regression of the ice sheets. The salt movements paused in the form of “surface cracks”/lineaments up to the Earth’s surface. Nevertheless, the origin of these lineaments is somewhat disputable as yet. KARASZIEWICZ et al. (2024) published comparable “cracks” in North-Eastern Poland – where salt deposits are missing. This points out to different causes in the genesis of such forms.

Of the more than 15 known occurrences, this article focuses on six clusters of lineaments on both sides of Lower Odra Valley (Fig. 1). While three clusters are situated in North-Eastern Brandenburg, the other three are located in North-Western Poland (Western Pomerania). The term “lineaments” is used by the authors to summarize relatively narrow and elongated hollow forms that differ significantly from Glacial Channels/Tunnelvalleys in their inventory of forms. In the ideal type, their course can be described as linear to bow-shaped.

Both regions belong to the Young Moraine Area which was covered by the last Scandinavian Ice Sheet. The oc-

currences of Barlinek, Friedrichswalde and Thomsdorf are situated directly at the terminal moraines of the Pomeranian Phase. The lineament clusters of Böckenberg, Dobra and Goleniów are part of the formerly glaciated backland.

Western Pomerania

Three areas in North-Western Poland are presented in which there are spatial relationships between landforms on the surface and salt structures in the subsurface. These relationships are clear despite the relatively large thickness of Cenozoic sediments, reaching 150–300 m above of the Permian-Mesozoic complex (PIOTROWSKI 1999, 2007).

A - Dobra (SE of Nowogard)

The example of Dobra area (Fig. 2-A) comes from the tectonically most active part of the Permian Szczecin Basin, from a sequence of semi-penetrated salt columns and ridges in the central zone of the basin (PIOTROWSKI 1999, 2007). The observed lineaments indicate the renewal of deep faults and dislocation zones during the Pleistocene. About 60 % of lineaments correlate with manifestations of historical and contemporary seismicity (GRANICZNY 1991, 1992). Glacioisostatic stresses and related salt movements and their effects on morphology of the area occurred primarily during the deglaciation and immediately after its completion.

The terminal moraines around Dobra and Lake Woświn (Fig. 2-A) mark the extent of the Szczecin subphase on the NE border of the Odra lobe. A series of terminal moraine hills (the highest form reaches 132 m above sea level) is located to the SE of the tunnel valley of Lake Woświn. The longitudinal axis of the lake is consistent with the direction of the tectonic fault.

Further on, the above-mentioned moraine hills coincide spatially with the salt structures of Grzęzno (northern structure in Fig. 2-A) and Oświno (south-eastern structure)

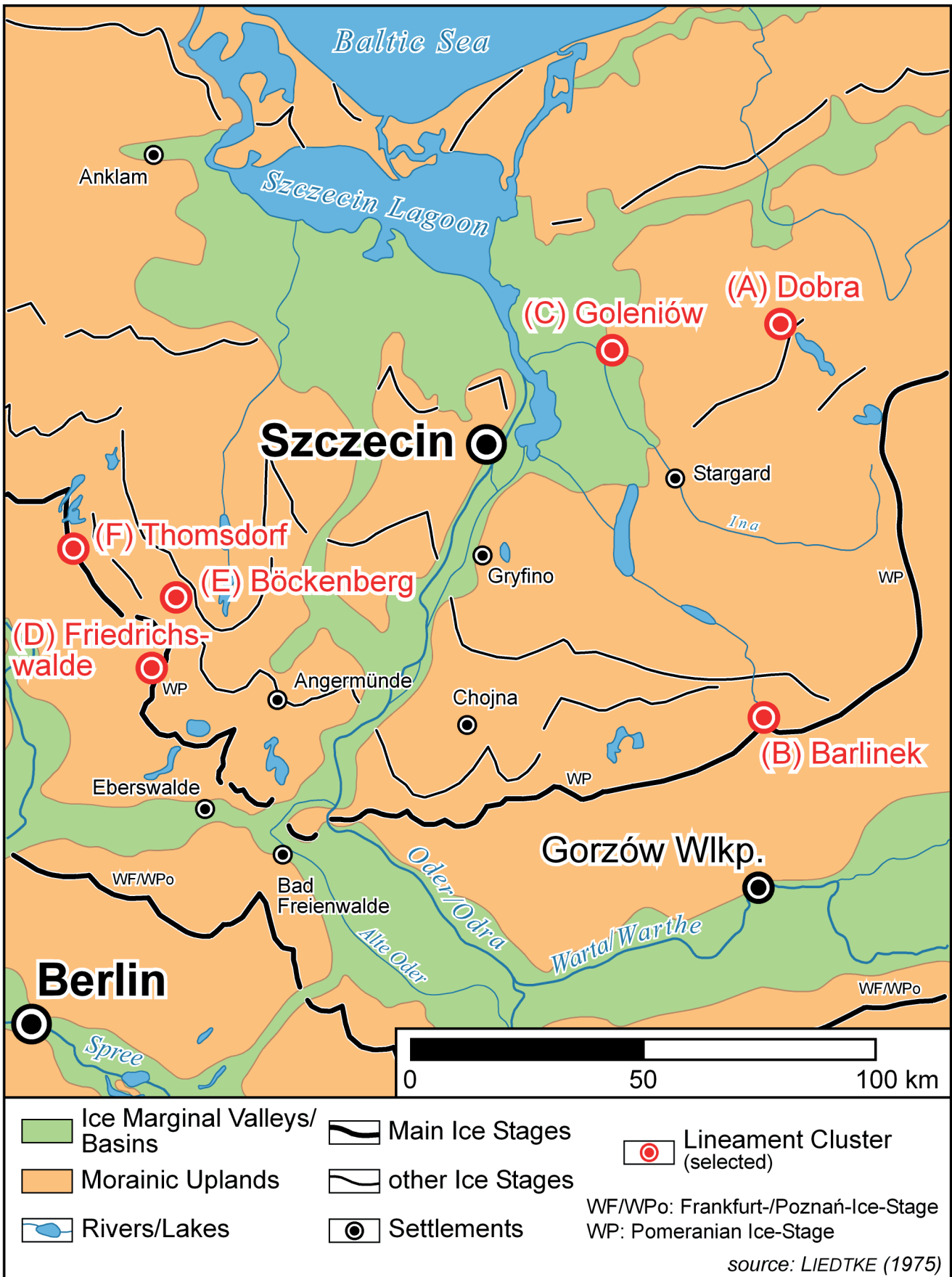


Fig. 1: Geological-morphological overview of Western Pomerania and North-Eastern Brandenburg. The positions of the six lineament clusters presented here are marked.

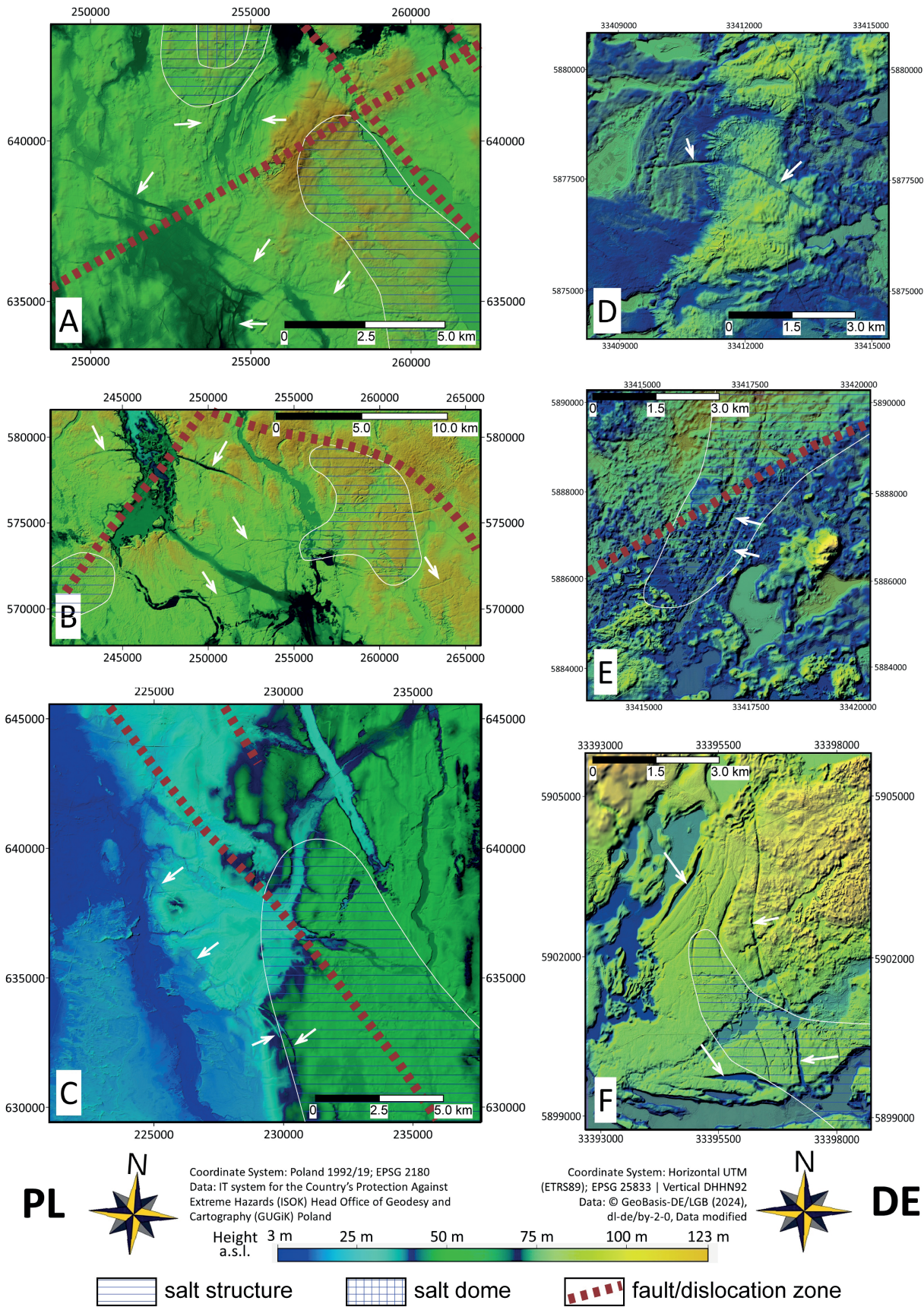


Fig. 2: DEM of six lineament clusters in Western Pomerania and North-Eastern Brandenburg. For locations of the clusters compare Fig. 1. The same height scale is used for all locations, the length scales are variable (please note separate km scales). Halotectonic structures and fault/dislocation zones are drawn in. Selected lineaments are marked with white arrows.

and the fault zone separating them (PIOTROWSKI 1999). The lineaments are especially visible in the close vicinity of NW part of the Oświno salt structure and intersecting faults, which is visible in Fig. 2-A.

In the surrounding of Dobra several sub-clusters of lineaments can be detected. The prominent cluster in southern neighbourhood to Dobra runs from north to south, but curvature is strong. The single lineaments run parallel to each other, up to 4.5 km long. Additional lineaments can be detected further south, on the south-western flank of the Oświno salt structure. These lineaments are comparably stretched (length up to 13.5 km) with smooth curvature. Smaller lineaments cross them at right angles.

B - Barlinek

The Barlinek and Pełczyce area (Fig. 2-B) is situated at the border of ground moraine plateaus to the north and extensive outwash plains and lakes to the south: lake Barlineckie and lake Pełcz. Both lakes are typical Channel-lakes. Close to Barlinek are the terminal moraines of the Pomeranian Phase.

In the deeper subsurface the Dębno-Złocieniec (running SW-NE) and Rostock-Krzyż (running NW-SE) dislocation zones as well as the Karsko (western structure in Fig. 2-B) and Żabicko salt pillows (eastern structure) were detected. Most of the lineaments occur between the above-mentioned salt structures. Nevertheless, the lineament cluster is widely scattered and forms several subgroups, even outside the section in Fig. 2-B. A number of morphological types of lineaments can be distinguished: a single lineament with strong curvature and steep slopes; several groups of less pronounced lineaments that run parallel, as well as spreading bundles of lineaments. The single lineament mentioned is one of the most prominent lineaments described by the authors.

For age estimation it is worth mentioning that most lineaments are clearly visible on the huge outwash plain in the south. But they are less pronounced or missing within a younger meltwater valley.

C - Goleniów

The Goleniów area (Fig. 2-C) is situated at the border of till-covered uplands to the east and the low lying Odra basin to the west, which is covered by glaciofluvial to fluvial fine sands and periglacial dunes. Some terrace levels occur there. The till-plateau to the east is partly covered by glaciofluvial sands and gravels.

The sub-ground is characterized by the Maszewo salt ridge in the area of the Ina Syncline. To the NNE of Goleniów occur the Wierzchosław and Zielonczyn semi-pierced salt columns. The NNW-SSE orientation of the structures coincides with the axis of the lineament structures.

The lineaments are visible on the edge of the morainic upland. They are not visible within the Odra basin! This gives a relative dating. The lineaments form a bundle of elongated channels and stretch over approximately 9 km. A special characteristic of this lineament group is the repeated occurrence of crossings and branchings of the lineaments. While the northern lineaments tend to be straight, those to the south are bow-shaped.

North-Eastern Brandenburg

In contrast to Western Pomerania, only two of the three selected lineaments in North-East Brandenburg are linked to salt structures in the subsurface. This relationship is valid for all lineament-like structures in Brandenburg as well. Although the majority is located on or directly atop a salt structure, this does not apply to all of them. The list starts with one of the lineaments that are far from a salt structure.

D - Friedrichswalde

The lineament close to Friedrichswalde is directly crossing the Pomeranian ice margin (Fig. 2-D). However, the associated terminal moraine is rather indistinct in this section. While a relative height of about 10 m is reached in relation to the outwash plain further west, the till covered plateau to the east is practically at the same altitude. Both, the surface of the outwash plain in the foreland and the ground moraine surface in the backland are slightly undulating.

Overall, the lineament-like structure bears a pronounced resemblance to the single structure close to Barlinek mentioned above: it is a single lineament, the orientation here is also from west to east following a bow-shaped course. With approximately 4.4 km it is not as long. The fluctuations in width and depth range between approximately 40 m and 120 m in width and between 0 and 5 m in depth. In the central and eastern parts, the lineament is indistinct.

This lineament of Friedrichswalde is showing the almost maximum possible distance to surrounding salt structures (according to STACKEBRANDT & BEER 2010). Perhaps its formation can be explained by salt movements as well, in this case with a migration from the lineament location towards the salt structures. However, the exact genesis remains speculative.

E - Böckenberg

The lineaments of Böckenberg (Fig. 2-E) are located directly atop of the Flieth salt structure. The NNE-SSW-orientation of the salt pillow in the subsurface and the orientation of the lineaments at the surface are matching almost perfectly. In addition, the Sub-Permian bedrock is disturbed by a fault line also running NE-SW through the area.

The three lineaments of Böckenberg are running entirely in the backlands of the Pomeranian ice margin, which here is mainly composed of till. The undulating ground moraine surface is topped by isolated kame hills.

All lineaments run remarkably parallel to each other. The western structure intersects a kame, so that an age sequence can be deduced here as well. In total, the lineament-like structures approximate a length of 5.7 km, with their lengths decreasing from east to west.

The width varies between approximately 50 and 100 m, the depth between 0 and 7 m. However, the lineaments are partly filled with peat and mud over long stretches reasonably suggesting that the original depth and its fluctuations were certainly greater. Due to their peat filling the lineaments are under grassland use at present, thus standing out also very conspicuously in the landscape.

F - Thomsdorf

The Thomsdorf lineaments are located on a salt pillow, here on the Klaushagen salt structure. Unlike the lineaments of Böckenberg, however, they are not located directly above the top but in the slope area. Furthermore the orientation of the salt structure and that of the most prominent lineament bundle is not parallel but roughly at right angles.

The area to the west and south of the village of Thomsdorf is located directly on the Pomeranian Ice Margin (Fig. 2-F). As in the Friedrichswalde area, the terminal moraines are indistinct here as well but both the outwash and the till plains are well developed. The region is crossed by several Glacial Channels/Tunnelvalleys.

The lineaments south of Thomsdorf form a complex, triangle-shaped structure. The main lineaments are running from north to south.

It is worth mentioning there are two different types of lineament-like structures occurring here. They differ significantly in size, both in terms of width and depth. The flatter structures are typically elongated and bow-shaped. Their maximum depth is 8 m, usually 2 to 4 m only; the width rarely exceeds 60 m. The deeper structures are also elongated but straight. The strong, sharply accentuated shapes are up to 150 m wide and 16 m deep, irrespective of the organic infill.

General characterization of the lineaments

The lineaments described here show an overall high degree of similarity in shape. They often, but not always, occur in clusters. The lineament-like structures exhibit almost no relationship to the existing glacial relief but they are completely absent in Ice-Marginal-Valleys and in extensive Holocene lowlands such as floodplains. The lineament-like

structures must have been formed in the time window between the ice retreat of the Weichselian Glacial period and the extensive phase of the periglacial processes in the Late Glacial period.

The vast majority of lineaments is located on or directly above salt structures. This applies to five of the six cases presented here. Therefore, the genetic interpretation as halotectonic lineaments is reasonable for these five structures. Nevertheless, some questions remain unanswered. Especially, this is why, on the one hand, there are lineaments without recognizable relationship to salt structures, and on the other hand, there are no lineaments on every salt structure. There is still a great need for further investigations in this area.

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