GEOLOGY OF THE KLAPPAN COALFIELD IN NORTHWESTERN BRITISH COLUMBIA (104H/2, 3, 6, 7)

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INTRODUCTION

The Klappan Coalfield straddles the junction of the Tahtsedle Creek (104H/2), Sweeny Creek (104H/3), Klappan River (104H/6), and Buckinghorse Creek (104H/7) map sheets in northwestern British Columbia (Fig. 32-1). An open file map of the detailed geology of the Klappan Coalfield at scale 1:50 000 was released in January, 1986. The coalfield is approximately 150 kilometres northeast of Stewart and 500 kilometres northeast of Prince Rupert. The British Columbia Railway subgrade line, which runs across the northeastern part of the coalfield, is used as an access road. Gulf and Esso conducted active coal exploration for anthracite in the coalfield during 1985.

Coal in northwestern British Columbia occurs in four major sedimentary successions. These are the Early to Middle Jurassic Laberge, the Middle to Late Jurassic Bowser Lake, the Early to Late Cretaceous Skeena, and the Late Cretaceous to Tertiary Sustut-Sifton Groups. The Late Jurassic and Early Cretaceous successions contain coal seams which are potentially economic at present; coal measures in the Mount Klappan area occur within one of the successions, which has been referred to as the Mount Klappan succession (Koo, 1983, 1984, 1985).

During the summers of 1983 and 1984, the Mount Klappan succession was mapped in the central part of the Klappan Coalfield; fieldwork during the summer of 1985 completed the mapping of the succession in the remaining parts of the Klappan Coalfield. The present report summarizes results of the geological mapping.

SEDIMENTARY STRATIGRAPHY

The Klappan Coalfield is underlain by a 1 300 to 1 500-metre-thick succession of conformable marine and non-marine sedimentary strata — the Mount Klappan succession. It can be divided into five mappable stratigraphic units (Figs. 32-1 and 32-2).

Unit 1, which is the lowest 200-metre stratigraphic interval of the Mount Klappan succession, consists of claystone, siltstone, fine to coarse-grained sandstone, and conglomerate; marine bivalves and trace fossils occur in siltstones and sandstones. Unit 1 comprises coarsening upward cycles resulting from successive progradation of delta channels over fine-grained prodelta sediments. It is a typical marine deltaic sequence.

Unit 2, which is 350 to 420 metres thick, is the coal-bearing sequence of the Mount Klappan succession; it consists of two mappable sub-units, the lower and upper coal sequences.

The lower coal sequence in turn is made up of two distinct stratigraphic intervals. The lower interval, which is 200 to 270 metres thick, consists of coal seams, claystone, siltstone, and fine to coarse-grained sandstone. This interval is characterized by stacked, coarsening upward cycles containing marine bivalves and trace fossils. It is the type of succession deposited in a constructive deltaic system with subaerial delta plains and intermittent coal swamps. The upper interval, which is 100 to 150 metres thick, consists of coal seams, claystone, siltstone, fine to medium-grained sandstone, and conglomerate. This interval contains mainly fluvial cycles that are interlayered by several marine cycles. The environment of deposition changed between marine deltaic and non-marine fluvial conditions. The youngest of the marine cycles marks not only the top of the lower coal sequence but also the youngest marine tongue in the Mount Klappan succession.

The upper coal sequence of unit 2 comprises 100 metres of coal seams, claystone, siltstone, sandstone, and conglomerate. It consists of stacked, fining upward cycles deposited in a fluvial channel and backswamp environment.

Unit 3 comprises 220 metres of coaly claystone, mudstone, sandstone, and conglomerate in as many as 20 fining upward cycles. The sequence of rocks in unit 3 was deposited in a transitional environment from fluvial plains to distal alluvial fans.

Unit 4 ranges in thickness from 280 to 300 metres. It consists mainly of coarse to medium-grained sandstone and conglomerate; however, it also contains minor amounts of fine-grained sandstone and mudstone. There are as many as eight fining upward cycles. This unit represents an environment in which a system of braided river channels crossed a series of distal alluvial fans.

Unit 5 reaches 170 metres in thickness. It consists mainly of conglomerate and coarse to medium-grained sandstone but there are minor amounts of fine-grained sandstone and mudstone. This unit represents an environment in which streams with braided channels dissected proximal to intermediate alluvial fans.

The Mount Klappan succession is an accretional, coarsening upward megacycle; it resulted from a major marine regression in the Klappan basin. The rocks in the succession reflect a gradual transition from marine deltaic through fluvial to alluvial environments. Peat swamps were developed on the subaerial deltaic and fluvial plains during deposition of unit 2.

POST-SEDIMENTARY DEFORMATION

A major southeasterly plunging synclinorium embraces the whole Mount Klappan succession in the Klappan Coalfield (Figs. 32-1 and 32-2). The major synclinorium has gently folded limbs and a vertical axial surface. Its axial surface strikes north 45 degrees west and the axis plunges 10 to 20 degrees to the southeast. The northeast and southwest limbs of the synclinorium dip 20 degrees to the southwest and 15 degrees to the northeast, respectively. The synclinorium has many associated smaller scale folds and faults.

Minor folds within the synclinorium vary in amplitude from 200 to 400 metres, and in wavelength from 100 to 400 metres; their limbs vary in dip from 25 to 85 degrees. The folds are open and upright to tight and overturned. Axes of the minor folds plunge 10 to 20 degrees to the southeast, parallel to the axis of the synclinorium. The folds fan outward from the core of the synclinorium; many, if not all, of the fold limbs and axial surfaces dip southwest on the northeast limb of the synclinorium and northeast on the southwest limb.

The minor folds in the coarse-grained sandstones and conglomerates of units 4 and 5 are mostly open and nearly symmetrical; however, in relatively thick zones of fine to medium-grained sandstone and mudstone, they form box-shaped folds.

The minor folds in units 1, 2, and 3 are usually of tight, asymmetric, chevron style. Steeply dipping and generally overturned limbs of the minor folds are associated closely with thick layers of

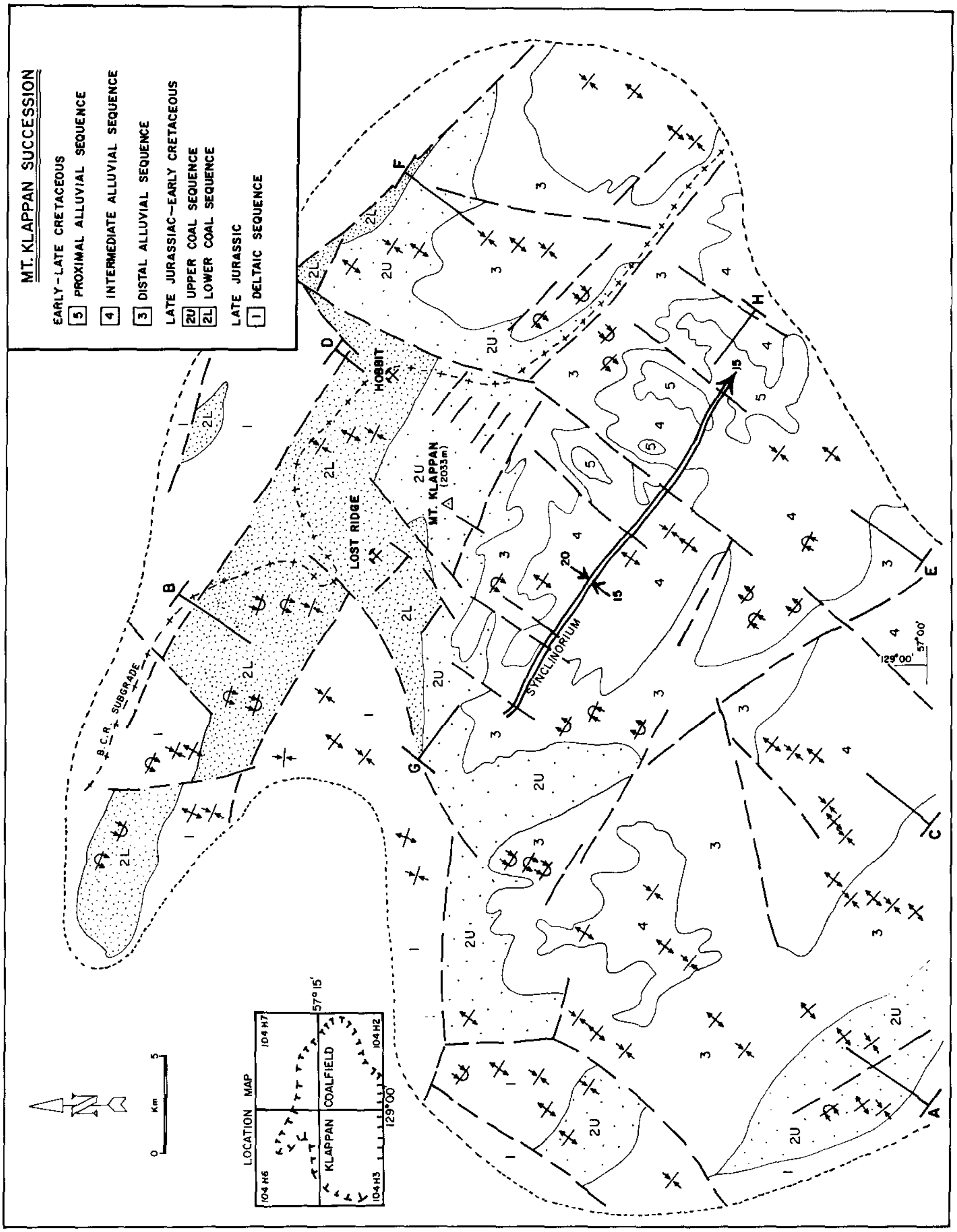

Figure 32-1. Geology of the Klappan Coalfield.

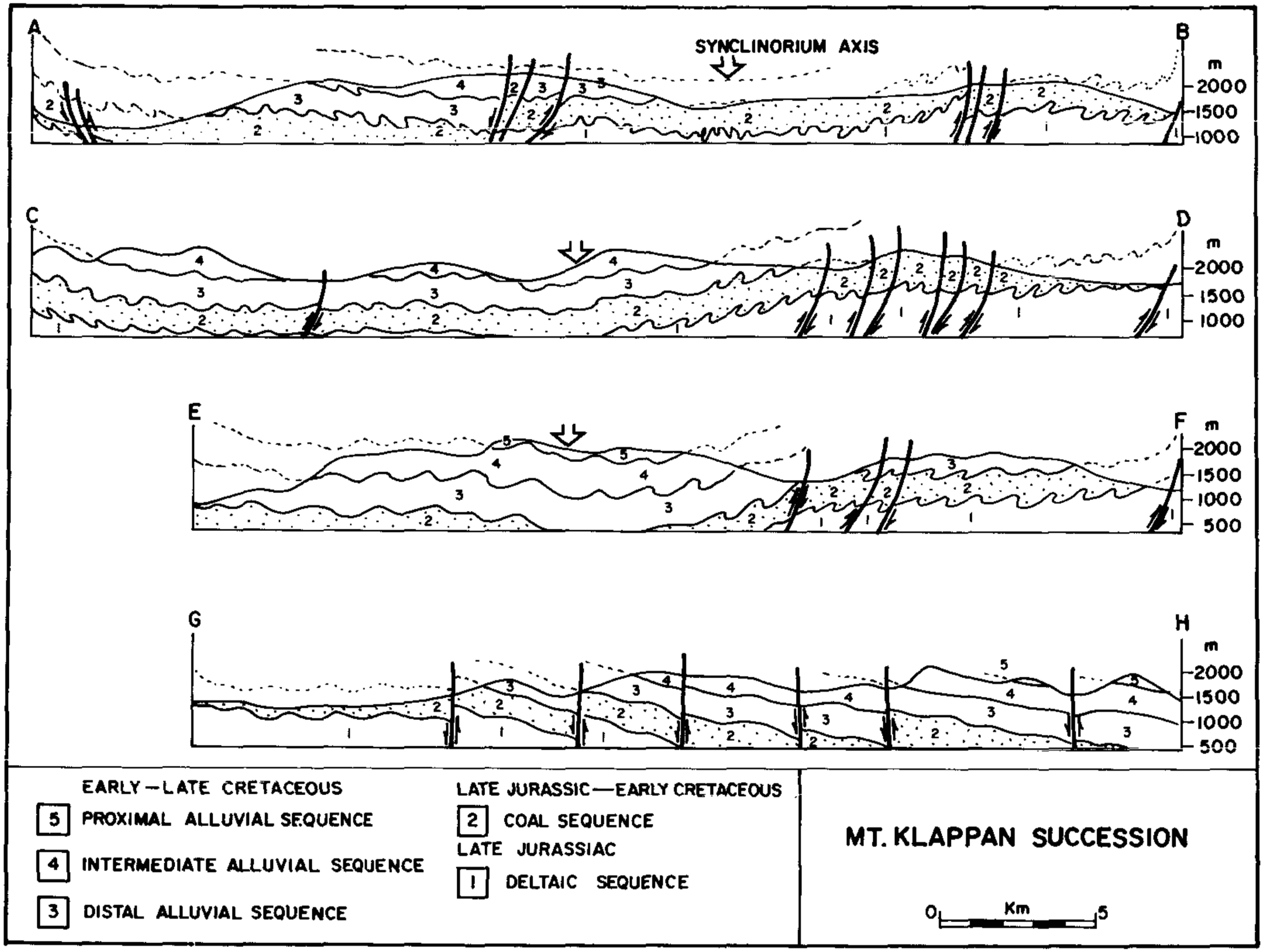

Figure 32-2. Geological cross-sections of the Klappan Coalfield.

incompetent claystone, siltstone, and fine-grained sandstone. In contrast, gently dipping normal limbs of the minor folds occur in the competent stratigraphic intervals that are ruled by conglomerate and coarse to medium-grained sandstone. It is the gently dipping limbs that are the locations of potentially mineable coal seams as well as the foci of economic interest.

In places, the minor folds in units 1, 2, and 3 accompany subsidiary folds. Box-shaped or open symmetric subsidiary folds are present in the layers of competent conglomerate and coarse to medium-grained sandstones, whereas smaller disharmonic subsidiary folds formed in the layers of fine-grained sandstone and mudstone.

Faults and shear zones are developed in some steeply dipping limbs and axial planes of the minor folds in the less competent layers in units 1, 2, and 3. The shear zones, which commonly grade into sets of faults, are up to 300 metres wide. The fault and shear zones strike north 40 to 70 degrees west and dip 40 to 85 degrees either southwest or northeast, depending on which limb of the synclinorium they occur on. Movement on the faults is generally reverse and ranges from a few metres to 300 metres. The faults and shear zones resulted from continued deformation after formation of the synclinorium and its associated minor folds.

Northeasterly or northerly trending faults also cut the northwesterly trending synclinorium, minor folds, faults, and shear zones. Displacements on these later cross-faults are mainly vertical, and locally are up to 500 metres. Cross-folding accompanies these later faults. The folds include a series of southeasterly dipping monoclines in the competent units 4 and 5, and open symmetric to tightly angular chevron folds in the less competent units 1, 2, and 3. Axial surfaces of the later folds strike north 5 to 40 degrees east and dip 40 to 85 degrees northwest. Amplitudes range from 50 to 400 metres; wavelengths from 300 to 2 000 metres. Amplitudes increase and wavelengths decrease toward the northwest part of the Klappan Coalfield. These later folds are superimposed on the northwesterly trending folds; consequently, axial traces of the earlier folds curve and axes are doubly plunging; early fold axes now plunge 10 to 35 degrees either southeast or northwest.

COAL DEPOSITION

Twenty coal seams occur in the lower and upper coal sequences of unit 2 in the Klappan Coalfield. As many as 16 coal seams occur in the lower coal sequence, where individual seams can be 5 metres thick and are 5 to 50 metres apart. Some of the coal seams in the lower interval of the lower coal sequence are associated closely with marine mudstones which typically contain significant amounts of iron sulphides. Gulf's Lost Ridge and Hobbit Creek pits are in coal seams that lie in the upper interval of the lower coal sequence of unit 2.

Four or more coal seams occur in the upper coal sequence of unit 2. They can be 2 metres thick and are 6 to 35 metres apart.

The coal seams formed during the transitional period between deposition of marine and non-marine sequences of the Mount Klappan succession. Seams of the lower coal sequence formed from coal swamps developed under marine deltaic and fluvial conditions. Seams of the upper coal sequence represent swamps developed under entirely non-marine, fluvial conditions. Marine conditions ended at the top of the lower coal sequence of unit 2. This boundary may approximately separate Jurassic and Cretaceous sequences; thus the coal seams may range in age from Late Jurassic to Early Cretaceous. The lower coal sequence correlates with the upper part of the Middle to Late Jurassic Bowser Lake Group. The upper coal sequence may correlate with the lower part of the Early to Late Cretaceous Skeena Group.

Potentially mineable coal seams occur mainly in the gently dipping limbs of the northwesterly trending minor folds in the unit 2 sequence because they are amenable to extraction by surface mining methods. Rocks of unit 2 are exposed in a 375-square-kilometre area in the Klappan Coalfield, and this area should be thoroughly explored for all potentially mineable, near-surface coal seams.

Coal seams in the northwesterly trending faults and shear zones are stretched and dismembered into lenticular bodies. Quartz, carbonate, and sulphide veins are widespread in the intensely deformed coal seams, and the veins are common in most of the fault and shear zones. In places, deformation in unit 2 coal seams is further complicated by the cross-folding and faulting. All the complicating aspects of deformation should be taken into consideration for successful exploration in the Klappan Coalfield.

Unit 2 coal seams consist of semi-anthracite, anthracite, and meta-anthracite; their mean maximum reflectance values of vitrinite in oil range from 2.5 to 5.0 per cent. Similar anthracite and meta-anthracite were produced during thermal metamorphism of Early Cretaceous coal seams by Late to Tertiary granodiorite and quartz monzonite stocks in the southern Bowser Basin. Late Cretaceous to Tertiary rocks are widespread in the Stikine Terrane, and many are also exposed north and south of the Bowser Basin. Although no stocks are exposed in the Klappan Coalfield, the high ranks of the coal seams must have been achieved due to high heat flows; perhaps these heat flows originated from buried intrusions under the coalfield.

CONCLUSIONS

The Klappan Coalfield is underlain by five mappable stratigraphic units of the Mount Klappan succession. The succession is an accretional, coarsening upward cycle that resulted from a major marine regression in the Klappan Basin. Facies in the Mount Klappan succession reflect a gradual change from marine deltaic through fluvial to alluvial environments. The potentially economic coal seams occur in the transitional unit between the marine and non-marine units. The thickest, more continuous coal seams were developed during the transitional period between deposition of marine deltaic and non-marine fluvial sequences within the coal-bearing unit.

Two major phases of post-sedimentary deformation resulted in folding, faulting, cross-folding, and cross-faulting of the Mount Klappan succession. Deformation was most intense in the coal-bearing unit because it is less competent than all other units in the Mount Klappan succession. Nevertheless, locally, low angle, near-surface fold limbs provide favourable potential sites for surface mining of contained coal seams.

Coal ranks range from semi-anthracite to meta-anthracite indicative of high heat flows responsible for coalification in the Klappan Coalfield.

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