

Disintegration of road aggregates along parts of the Gurun-Alor Setar and Ipoh-Changkat Jering Highways

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Summary: The Gurun-Alor Setar and Ipoh-Changkat Jering Highways form part of the proposed North-South Highway stretching from Bukit Kayu Hitam in the north to Johor Baru in the south. Soon after the completion of these two stretches of the Highway, brownish streaks were seen on the road surfaces.

X-ray diffraction studies showed that these brownish streaks contained pyrites with some softer secondary minerals such as goethite, hematite, melanterite, jarosite, sulphur, mica, kaolinite and illite.

Petrographic studies carried out on quartzite and hornfels from a quarry near Gurun and on granite from an abandoned quarry near Pahang Rengas which supplied aggregates for the construction of the Gurun-Alor Setar and the northwestern portion of the Ipoh-Changkat Jering Highways respectively showed that pyrites are present within the interstices of the rocks.

Oxidation of the pyrites produces iron sulphates and sulphuric acid which react with other minerals in the rock aggregates to form soft secondary minerals with a brownish stain and a large volume increase. When vehicles run over these stained pounced-up spots, the soft secondary minerals break up, causing the aggregates to disintegrate, leaving behind small cavities.

Ringkasan: Lebuhraya Gurun-Alor Setar dan Ipoh-Changkat Jering merupakan sebahagian dari Lebuhraya Utara-Selatan. Lebuhraya ini memanjang dari Bukit Kayu Hitam di utara ke Johor Baru di selatan. Tidak lama setelah kedua bahagian Lebuhraya ini disiapkan, tompokan jaluran berwarna perang telah kelihatan di permukaan jalan.

Kajian dengan kaedah Belauan Sinar-X menunjukkan yang jaluran berwarna perang mengandungi mineral pirit dan mineral sekunder yang lembut seperti goetit, hematit, melantrit, jarosit, sulfur serta sedikit mika, kaolinit dan illit.

Kajian petrografi yang dijalankan ke atas sampel-sampel batuan dari kuari-kuari yang membekalkan agregat untuk pembinaan Lebuhraya Gurun-Alor Setar dan bahagian utara Lebuhraya Ipoh-Changkat Jering iaitu sampel batuan kuartzit dan hornfel dari satu kuari berhampiran Gurun dan granit dari kuari yang berhampiran dengan Padang Rengas menunjukkan kehadiran mineral pirit di dalam batuan berkenaan.

Proses pengoksidaan mineral pirit menghasilkan sulfat besi dan asid sulfid yang akan bertindak balas dengan lain-lain mineral di dalam agregat batuan. Tindakbalas ini menghasilkan mineral sekunder yang lembut dengan tompokan yang berwarna perang dan mengakibatkan pertambahan isipadu yang besar pada agregat. Apabila kenderaan melalui di bahagian tompokan perang yang membengkak ini, mineral sekunder yang lembut pecah menyebabkan agregat berkenaan terurai meninggalkan lubang-lubang kecil pada permukaan jalan.

INTRODUCTION

The Ipoh-Changkat Jering and Gurun-Alor Setar Highways form part of the proposed North-South Highway which will stretch from Bukit Kayu Hitam in the north to Johor Baru in the south. Soon after the completion of these two stretches of the Highway, brownish spots of a few millimetres in diameter appeared on some parts of the road surface. The brownish spots were poughed up and cracks were subsequently formed. When vehicles passing by hit these spots, materials from these spots were broken up, leaving behind small cavities. Rainwater running on the road surface washed the brownish, earthy material from these cavities, forming streaks along the direction of water flow.

The Geological Survey was requested by the Malaysian Highway Authority to carry out an investigation to determine the cause leading to the formation of these brownish spots. Site visits were made to the Gurun-Alor Setar Highway in March 1987 and February 1988, and to the Ipoh-Changkat Jering Highway in January 1988.

LOCATION OF INVESTIGATION SITES

The Gurun-Alor Setar Highway is located at the northern end of the Malay Peninsular (Fig. 1). For most parts of the tarred Highway, except for a 6-km stretch just after the Gurun Toll Gate which was concreted, brownish streaks of iron stains were present.

The tarred Ipoh-Changkat Jering Highway forms the stretch in the middle portion of North-South Highway and is located in the state of Perak (see Fig. 2). The part of the Ipoh-Changkat Jering Highway affected by the stains stretches from near the Kuala Kangsar Toll Gate to the Changkat Jering Toll Gate.

METHOD OF INVESTIGATION

The brownish streaks of iron-stains were examined in detail and powdered samples of the brownish material were collected for X-ray diffraction studies. Rock samples from the quarries which supplied aggregates for the construction of these two Highways were collected for petrographic examination.

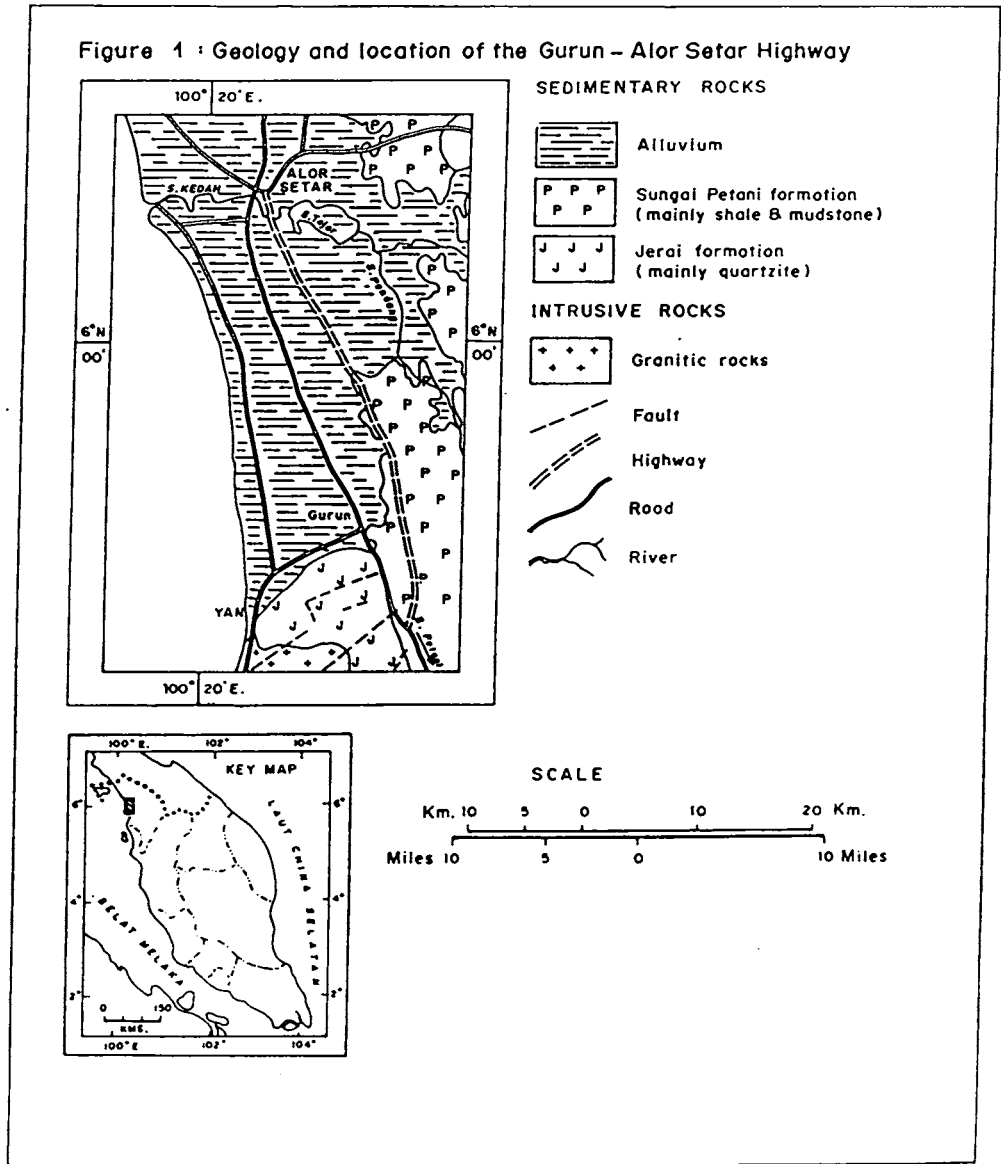
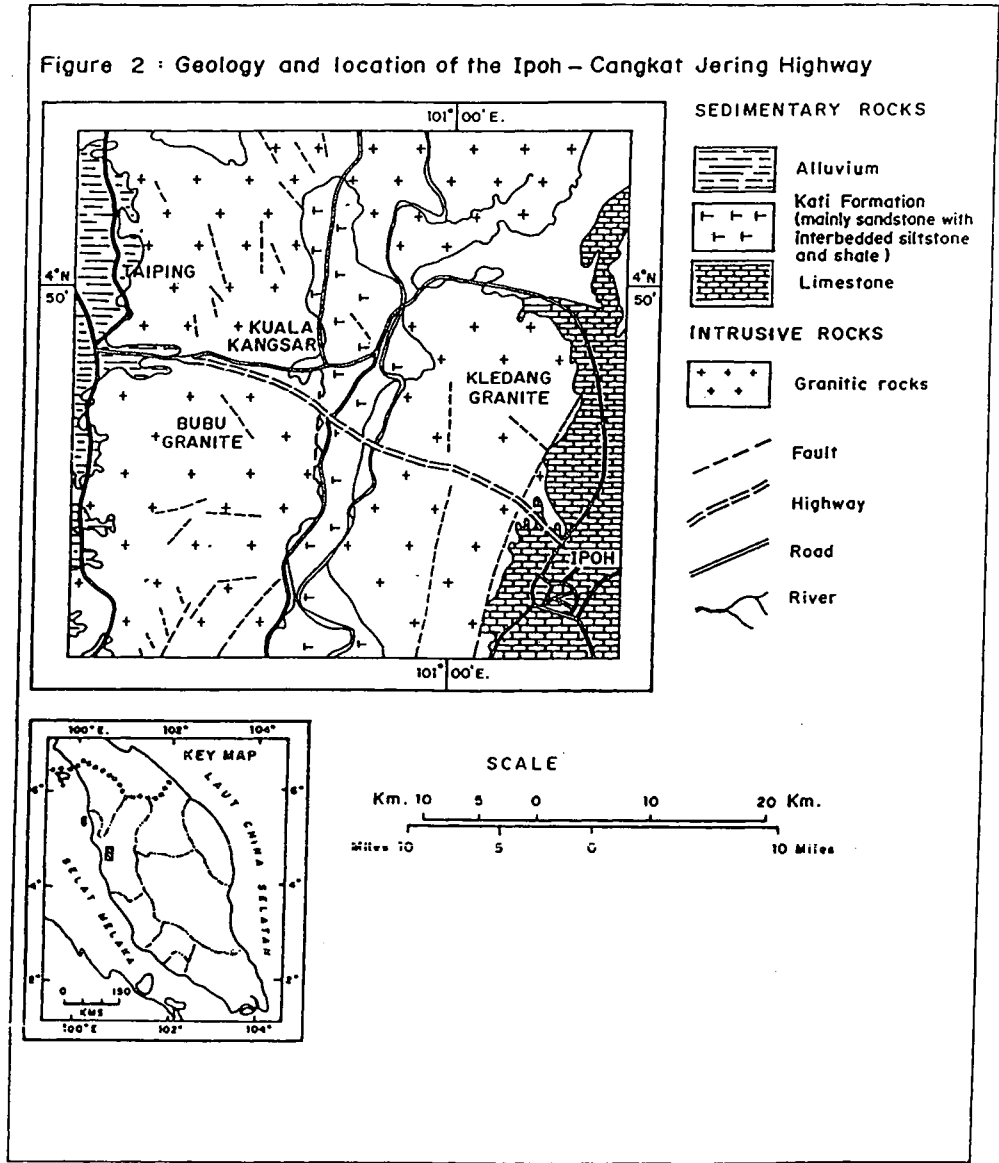


Fig 1. Geology and location of the Gurun-Alor Setar Highway



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Fig 2. Geology and location of the Ipoh - Changkat Jering Highway

THE GURUN-ALOR SETAR HIGHWAY

Geology of area

About 70 percent of the Gurun-Alor Setar Highway passes through Quaternary marine and continental unconsolidated sediments. The remaining portion of the Highway passes through low and undulating hills underlain by the Ordovician-Carboniferous Sungai Petani Formation which comprises mainly shale and mudstone. West of the town of Gurun, is the Jerai Formation, believed to be Cambrian in age. The Jerai Formation comprises mainly quartzite with some hornfels. Rock aggregates from a quarry near Gurun were used to construct the Gurun-Alor Setar Highway.

Petrography of rock aggregates

The rocks found at the quarry near Gurun were interbeds of quartzite and calc-silicate hornfels.

Under microscope, the quartzite comprises fine-grained quartz with sutured boundaries. The calc-silicate hornfels comprise mainly hornblende, quartz and epidote with garnet, mica, zircon and ilmenite as accessory minerals. Pyrites are found within the interstices between minerals in both the quartzite and hornfels.

X-Ray diffraction studies

Eight samples of secondary, powdered minerals were scrapped from road aggregates along the Gurun-Alor Setar Highway. Of these eight, four samples (nos. 1 to 4) were collected in 1987 and the remaining four (samples 5 to 8), in 1988.

X-ray diffraction results (Table 1) showed that samples 1 and 3 contained mainly quartz with minor amounts of mica and kaolinite. Samples 2 and 4 contained mainly pyrite (FeS_2) with minor amounts of melanterite ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$). Sample 7 contained mainly quartz whereas samples 5 and 6 contained mainly quartz and pyrite and sample 8, quartz and goethite ($\alpha\text{-FeO(OH)}$). Varying minor amounts of calcite, feldspar, mica, gypsum, kaolinite, hematite and amphiboles are found in these samples.

Another three samples of secondary powdered minerals were scrapped off from the tarred road surfaces. XRD analyses (Table 2) showed that the brownish coating along the road surfaces comprised mainly quartz and jarosite ($\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$) with minor amounts of kaolinite and illite. The whitish powder on the road surface contained mainly quartz and feldspar with minor amounts of illite.

Table 1: XRD results of secondary powdered minerals on surfaces of road aggregates along the Gurun-Alor Setar Highway

Sample Number	XRD results	
	Main composition	Minor composition
1	Quartz	Mica and kaolin
2	Pyrite	Melanterite
3	Quartz	Mica and kaolin
4	Pyrite	Melanterite
5	Quartz and pyrite	Mica, gypsum, kaolin and feldspar
6	Quartz and pyrite	Calcite, feldspar, mica and gypsum
7	Quartz	Mica, kaolin, hematite and feldspar
8	Quartz and goethite	Amphibole, kaolin and feldspar
Analysed by: Mineral and Petrology Section		

THE IPOH-CHANGKAT JERING HIGHWAY

Geology of area

The south eastern end of the Ipoh-Changkat Jering Highway is sited over alluvium and mined-out sand tailings. Further westwards near to the Jelapang Toll Gate, the Highway crosses the Kledang Granite which stretches to just beyond the Perak River. From here to near Kuala Kangsar, the Highway is sited over the Kati formation which is Carboniferous in age and comprises mainly sandstones with interbeds of siltstone and shale. Beyond Kuala Kangsar to Changkat Jering, the Highway crosses again another granitic batholith, the Bubu Granite.

The Kledang and the Bubu Granites are Mesozoic in age and both granites are coarse-grained and porphyritic in texture. One of the granite quarries sited near to Padang Rengas supplied aggregates for the construction of the northwestern portion of the Highway. Rock derived from the blasting of the Menara Tunnel and from nearby road cuttings were used for the construction of the southeastern portion of the highway.

Petrography of rock aggregates

Rock aggregates from the abandoned quarry near to Padang Rengas are greyish, coarse-grained porphyritic granitic. Quartz and feldspar are the

Table 2: XRD results of secondary powdered minerals on tarred road surface along the Gurun-Alor Setar Highway

Sample Number	Characteristic	XRD results	
		Main composition	Minor composition
1	Brown coating on road surface	Pyrite	-
2	Yellow, earthy coating on road surface	Quartz and jarosite	Kaolinite and illite
3	Whitish powder (from decomposed feldspar)	Quartz and feldspar	Illite

Analysed by : Mineral and Petrology Section

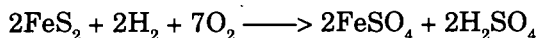
major minerals with minor amounts of mica. Pyrites are often found within the interstices of minerals and occasionally are included within the biotites.

X-Ray diffraction studies

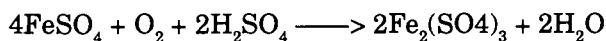
Eight samples of yellowish to brownish and another three whitish powdered secondary minerals were collected. XRD results showed that the eight yellowish to brownish samples comprised mainly quartz, jarosite, marcasite and in some cases, goethite, illite and sulphur. The remaining three whitish samples contained mainly quartz, feldspar, illite and kaolinite.

CHEMICAL REACTION

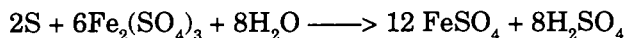
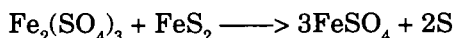
Pyrites which are present in rock aggregates utilised for the construction of both the Gurun-Alor Setar and northwestern portion of the Ipoh-Changkat Jering Highways are readily oxidised to produce iron sulphates and sulphuric acid.



Further oxidation produces:



The product of this reaction can then further oxidise pyrite.



Once the products of pyrite have been released there will be further reaction with other naturally occurring minerals in the calc-silicate hornfels or granite. For example, calcareous minerals in the hornfels may react with

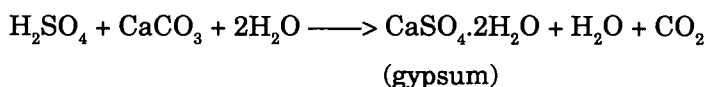
Table 3: XRD results of secondary powdered minerals on surfaces of road aggregates along the Ipoh-Changkat Jering Highway

Sample Number	Mineral Constituents
A1	Quartz, jarosite and marcasite
B1	Quartz, jarosite, marcasite and sulphur
B3	Quartz, calcite and feldspar
C1	Quartz, jarosite and goethite
D2	Quartz, jarosite, sulphur, illite and marcasite
D4	Quartz, feldspar, kaolinite and illite
E1	Quartz, jarosite and sulphur
D1A	Quartz, jarosite and marcasite
AK-1	Quartz, feldspar, illite and kaolinite

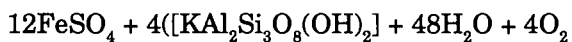
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Note : Tar is a complex compound of C, H, O and S

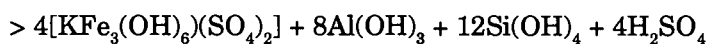
the acid sulphate to give rise to gypsum, and the feldspar to form illite and kaolinite, which subsequently undergo further reaction with the acid sulphate to form melanterite and jarosite.



or



(illite)



(jarosite)

DISCUSSION

The change in mineralogy due to oxidation of the pyrites resulted in the formation of a number of secondary minerals. It has been proven that there is a large increase in volume when sulphide minerals are converted to hydrated sulphates. Penner et al. (1973) quoted a volume increase of 115% when pyrite is replaced by jarosite.

This process causes the oxidised parts of the road aggregates to pouch up followed by the formation of cracks. When vehicles passing by hit these stained, pouch-up spots, the soft secondary minerals break up, causing the aggregates to disintegrate, leaving behind small cavities. Rainwater running on the road surface washed these secondary minerals from the cavities, forming yellowish to brownish streaks.

CONCLUSION

Rocks with pyrites as accessory minerals should not be used as aggregates for the construction of tarred roads. Oxidation of the pyrites produces iron sulphates and sulphuric acid which reacts with other minerals in the rock to form secondary minerals such as gypsum, illite, sulphur, kaolinite, goethite, marcasite, melanterite and jarosite. Other than producing unsightly yellowish or brownish spots, secondary hydrated sulphates are soft, have lesser densities and hence, larger volumes. The increase in volume produces stresses which may cause 'heaving' or 'pouching'. When vehicles run over these stained spots, the soft secondary minerals break up easily causing the aggregates to disintegrate, leaving behind small cavities.

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