A REMARKABLE OCCURRENCE OF FUSAIN AT
LUNGCHUANHSIEN, CHEKIANG PROVINCE

BY

C. Y. HSIEH* & K. CHANG**

(Cooperation from the Siniwan Fuel Laboratory of the Geological Survey, No. 7b).
(with two plates and one text figure)

1. INTRODUCTION.

During his short visit to the Geological Institute of Academia Sinica in Shanghai in 1931 the senior author noticed among the coal collection there some remarkable specimens of fusain collected several months ago by the junior author. These specimens in the size of several centimeters square or more, are made up of homogeneous fusain which shows to the naked eye a silky luster of black and dull color and a distinctly cellular structure. According to the junior author, the fusain occurs as lenticular bodies or pockets in a volcanic series, which fact indicates beyond doubt that it has been formed from the charring of woods following the volcanic eruption. As there has been within recent years controversy theories and serious discussions about the origin of fusain, a finding showing its undisputed origin is therefore highly interesting and is worthy of mentioning.

2. OCCURRENCE.

The fusain lenses are found on the slope of Chenkanshan (陳坑山), five li North of Taotaichén (達日鎮) or 2 or 3 li west of Yangtousin (陽頭村), in eastern Lungchuanhsien (龍泉縣) at a distance of about fifty li from the district city, Chenkanshan is a hill of about 300 m. in elevation with an upper steeper slope and a lower gentle one. Fusain, in the forms of pockets, veins or lenticular layers is exposed at the base of the upper steeper slope. Largest pockets so far observed show a length of about 8-9 m. with a maximum thickness of about 10 cm. It is intercalated in greenish tuffaceous rhyolite.

Similar coal seams are reported to occur at about 10 li West of Taotaichén at a place called Chikoutsu (溪口村). Although this occurrence was

* Manuscript receive in August 1932.
*** Member of the Geological Institute of Academia Sinica.
not visited personally, it seems very likely that it belongs to the same type of deposit as found at Chenkanshan.

Fig. 1 is a sketch of the Chenkanshan section showing the successive layers of rhyolite and the intercalated pockets of fusain. The lowest rock exposed at this hill is a grey rhyolite (a) containing some quartz phenocrysts and above it is a layer of brown rhyolite (b) with practically no quartz grains visible to naked eyes. The uppermost formation is a greenish tuffaceous rhyolite forming here a steeper slope than the other two. Fusain lenses are found nearly in the lowest part of the tuffaceous rhyolite; at the contact between the fusain and the rhyolite, the rock is frequently marked by a black color of glassy appearance which indicates probably the result of rapid chilling with at the same time the introduction of coaly matter as intermixtures.

Lithologically, the formation just described bears a close resemblance with the great rhyolite formation of Western Chekiang, its geological age has been determined on paleontological ground to be Upper Cretaceous. Similar age may therefore be assigned to the rhyolite series of Lungchuanhsien.

3. PHYSICAL AND CHEMICAL CHARACTERS.

The fusain forms rather compact and coherent mass, but on breaking, it is easily separable into fibrous or powdered forms. The color is black with a
Hatch & Chang:—A Remarkable Occurrence of Fusain

dull but a somewhat silky luster. Fibrous structure is distinctly observable to
naked eyes. Determination of specific gravity and porosity by Miss T. C.
Hung gives the following results:

True sp. gravity = 1.960
Apparent sp. gravity = 1.950
Porosity = 1.53 %

According to Lange¹ the specific gravity of fusain varies from 1.272—
1.86. In the report of the U. S. Bureau of mines, Davis² determined the spe-
cific gravity of one sample of fusain to be 1.53. From this record, we can see
that our specimen of fusain has the highest specific gravity, a fact, evidently
to be explained by the presence of abundant infiltration of mineral matter essential-
ly quartz.

Chemical analysis of the fusain shows the following composition:

<table>
<thead>
<tr>
<th>Analysis by Geological Institute of Academia Sinica</th>
<th>Moisture</th>
<th>Volatile matter</th>
<th>Fixed carbon</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.39%</td>
<td>11.58%</td>
<td>50.90%</td>
<td>28.64%</td>
<td></td>
</tr>
</tbody>
</table>

4. MICROSCOPICAL STUDY.

Both polished section and thin section of the fusain show under the
microscope well preserved woody structure. Fig. 1 Plate I shows a horizontal
section of the specimen, in which the radial arrangement of the woody cells is
very well shown. One characteristic feature is the extremely small sizes of the
woody cells which amount to 15 μ in tangential and 12 μ in radial directions.
The thickness of the cell wall is about 3 μ. The lumens are almost entirely
filled by quartz, which shows in polished section a gray color and a slightly

1. The. Lange, Die praktische Bedeutung und der technische Wert der Faserkohle in
2. Joseph D. Davis, Fusain, Information Circular No. 6115, Bureau of Mines, original-
higher relief as compared with the woody matter. Medullary ray is not distinct on the horizontal section. There are abundant radial lines closely resembling rays, but as they have been all replaced by quartz, exact determination of their nature is not possible. It is believed that narrow rays are certainly present, but as a result of mineralization, they have been mostly obliterated.

The thin section of the fusain shows equally well the woody structure. Here the infiltrations or veinlets of quartz becomes admirably shown. Another way to identify quartz infiltration is by immersing crushed fragments of fusain in oil; then, the rod-like, prismatic form of the quartz, a pseudo-form derived from the woody cells, is very characteristically shown.

The structure of annual growth can be very well seen from the horizontal section. It is marked by alternation of more crushed spring wood and the less crushed autumn wood, the latter, is, as a rule much narrower.

Fig. 3, plate II is a longitudinal section of the fusain, showing somewhat crushed and distorted tracheids. The pitting has been mostly mineralized and are therefore obliterated. In certain rare cases, pits resembling bordered pits are observed as shown in the accompanied illustration. These pits are extremely small, not exceeding $3 \times 4 \mu$ in diameter.

It is certain that the wood here with described belongs to some kind of Conifer; owing to advanced mineralization and imperfect preservation of detailed structures, its specific determination is almost impossible.

5. Origin.

In recent years there has been much discussion among coal petrographers in regard to the possible origin of fusain. According to one school fusain is nothing but charcoal that has been burned during forest fire. This fire was brought about incidently by lightening, spontaneous combustion or other natural causes, a phenomenon occurs not infrequently also in the present time. The other school maintains, however, that origin other than forest fire is equally

3. O. Stutzer, Fusin, Vorkommen, Entstehung und praktische Bedeutung der Faserkohle (fossile Holzkohle), 1929.
feasible for the formation of fusain. As it has been proposed for instance, that dehydration or decay under deep burial i. e. under anaerobic condition may eventually convert woody components of the coal into fusain. Recently, Laupper\(^4\) has demonstrated that “Heukohle” i. e. hay charcoal may be produced in hay stacks by prolonged decay and decomposition. Such hay charcoal often shows well preserved cellular structure and therefore quite similar to fusain. The action of sulphuric acid on wood will also produce charcoal-like substance, although the presence of such acid in appreciable quantity in swamps is yet to be proved. On the other hand, Bode\(^5\) has recently summarized all the arguments and evidences favoring the forest-fire theory which according to him should be the only possible explanation of the origin of fusain.

By the forest-fire theory, fusain may be considered as primary in origin, i. e. to say fusain has been already in existence while the coal was in formation, whereas by the latter theory, fusain formed simultaneously with the coalification process of the coal bed, in other words, it is of secondary origin.

The occurrence of lenticular layers or pockets of fusain in volcanic series at Lungehsansien in Chekiang province has provided us an undisputed evidence in favour of the first hypothesis, namely, fusain has been formed not through the chemical reaction, but by the action of burning. Instead of forest fire brought about by lightning etc. as the only cause, our case has shown that volcanic eruption may under certain condition produce sufficient heat for the conversion of wood into charcoal.

We may therefore interpret our occurrence in the following words: During upper Cretaceous time there occurred repeated volcanic eruptions and the stream of lava encountered in the vicinity of Chenshan some drifted woods. As the lava was so hot, that the wood became at once charred to form natural charcoal or fusain. When later lava or tuff coming down, the fusain will be buried and finally became included in the volcanic series. Since the woods


\(^5\) H. Bode, Die Fusibildung vom Standpunkt der Waldbrandtheorie, Glückauf, no. 7, Jahrgang 1930.
were of drifted origin and were distributed usually in scattered and irregular manner, so the fusain formed is necessary in the form of lenticular layers or pockets; no regular and persistent beds are therefore to be expected from this kind of deposit. During or after the process of carbonization, solution carrying SiO₂ from the lava gradually worked into the cellular spaces of the wood and there be deposited as quartz infiltrations. This explains why we have in this specimen an exceptionally abundant quantity of quartz impregnations.
Explanation of
Plate I.
Fig. 1. Several lenticular bodies of fusain (marked by hammer) occurring in a volcanic series of Upper Cretaceous age. Chenkanshan, Taotaichê, Lungchuanhsien, Chekiang Province. Photographed by K. Chang.

Fig. 2. Fusain occurring in more or less continuous layers in volcanic series. Same locality. Photographed by K. Chang.
Fig. 1.

Fig. 2.
Explanation of
Plate II.
PLATE II

Fig. 1. A piece of fusain showing rather distinctly its fibrous structure. Reduced about one half.

Fig. 2. Microphotograph of polished section of fusain showing distinctly the cellular structure which represents clearly a horizontal section of the wood of the Coniferous variety. $\times 160$.

Fig. 3. Longitudinal section of the wood showing extremely small bordered pits. $\times 120$. 
