The Origin of the Amber found at Gough's Cave, Cheddar, Somerset

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In 1953 in these *Proceedings*, Professor E. K. Tratman reported on a large piece of amber which had been found at the palæolithic level at Gough's Cave near Cheddar. Dr. H. J. Plenderleith had examined the specimen at the British Museum and had found that its

> "general appearance [is] consistent with it being amber of Baltic origin, [this] is confirmed by hardness 2·3, specific gravity 1·10, burning test and ultraviolet fluorescence".

Unfortunately, none of these properties are uniquely characteristic of amber of the Baltic zone; all are shared to varying degrees by fossil resins from other regions of Europe. Even Helm's (1885) celebrated test for succinic acid, which has been widely and confidently applied to identify amber of Baltic origin but which was apparently not used on the piece under discussion, cannot be considered reliable. Dr. M. H. Hey (1963) has listed more than forty European fossil resins, and although there are many doubtful species and mere varietal names among them, their very profusion is an indication that few of them have been studied sufficiently thoroughly to distinguish them from one another.

Thus there were, at the time of the first chemical investigation of the amber from Gough's Cave, no reliable means of identifying Baltic amber with certainty. Dr. Plenderleith is, of course, well aware of these facts and exercised all necessary and proper caution in stating that the properties of the amber from Gough's Cave are "consistent with it being amber of Baltic origin", but not that this sample could not have come from another of the European deposits of fossil resins.

Because the solution of this general problem is of some consequence to European archæology, we have for some time tested a variety of analytical techniques which might serve to determine the provenance of fossil resins. Among the methods examined are infrared spectroscopy, pyrolysis followed by gas chromatography and analysis for trace elements.

Happily, the first result has been to discover in the infrared spectra

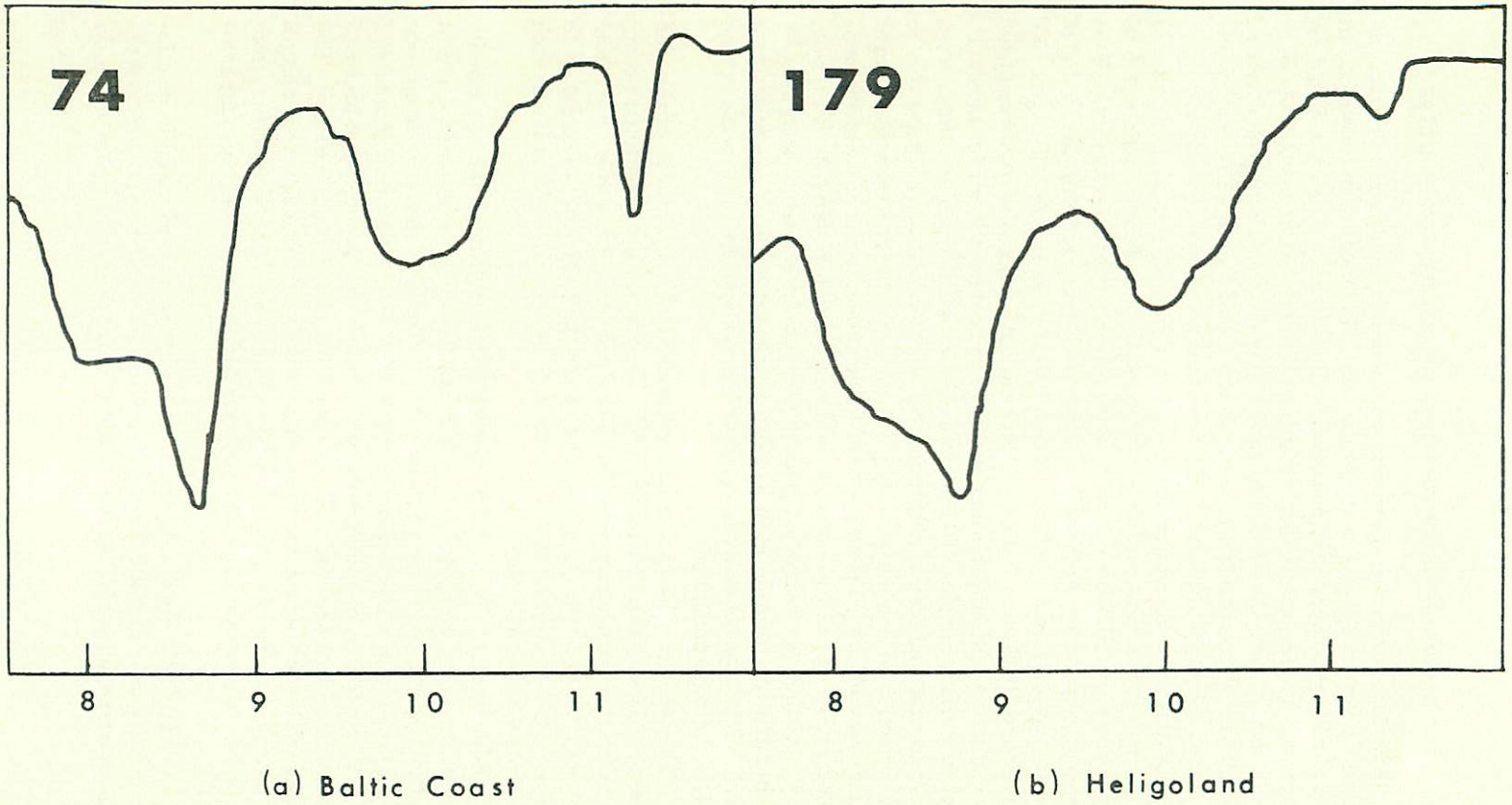

Fig. 63.—Infrared Spectra of Baltic Amber from 7.5 to 12.0 Microns

of whole Baltic amber an absorption band which is highly characteristic, and which we have not found in any of the non-Baltic fossil resins tested so far. A preliminary account published earlier (Beck *et al.*, 1964b) was based on some 120 samples; our confidence in the reliability of this method has since risen, for we have now recorded nearly 500 spectra of amber and related fossil resins of every variety. Sample spectra of two specimens of Baltic amber in the range from 7·5 to 12·0 microns are shown in *Fig.* 63.

Of the three absorption bands in this region, the one between 8 and 9 microns is the most significant. It consists of a distinct peak at 8·6 to 8·7 microns preceded by a broad shoulder of about 0·5 micron width. This shoulder is perfectly horizontal in many well-preserved samples of Baltic amber (*Fig.* 63a), but in others it slopes more or less steeply (*Fig.* 63b). We have found (Beck *et al.*, 1964a) that this change is related to exposure of the sample to oxygen; amber which has been in contact with air for millennia, such as surface samples of beads found in Etruscan chamber tombs, often show so much additional absorption between 8·0 and 8·5 microns, due to the formation of new carbon–oxygen bonds, that the spectra are no longer clearly recognizable as being those of Baltic amber. Since none of the non-Baltic European fossil resins have similar absorption patterns in this region, we can confidently assert that Baltic amber can be positively identified by its infrared spectrum between 8 and 9 microns *if a sample can be procured which has not suffered extensive oxidative degradation.* In our experience that is almost always possible.

The other two absorption bands shown in *Fig.* 63 are less reliable and have only limited value for identification. The broad band centring at about 10 microns is particularly variable. The band at 11·3 microns varies from a sharp peak to a weak shoulder, and its intensity appears to decrease with exposure to air. Moreover, it is found in some non-Baltic fossil resins such as Sicilian amber (simetite).

With these results in hand, we very much welcomed the opportunity to obtain a small sample of the amber from Gough's Cave during a recent visit to England, and to record its infrared spectrum. A summary description of the method of analysis may be appropriate here. Two milligrammes of resin and 200 mg. of pure potassium bromide are thoroughly mixed and ground in a stainless-steel vial by means of a dental amalgamator. The resulting powder is pressed into a clear pellet in an evacuable die using a hydraulic press, and the pellet is used to record the infrared spectrum from 2·5 to 16·0 microns with a Perkin–Elmer Model 237 grating spectrophotometer.

In *Fig.* 64 the part of the spectrum which has proved useful in identification is shown. The broad band at 10 microns is rather weak here, and the peak at 11·3 microns has been reduced to a shoulder of very low intensity,

but the absorption between 8 and 9 microns is quite indistinguishable from that of the amber from Heligoland (*Fig.* 63b). There is thus no doubt but that the amber from Gough's Cave is of Baltic origin, in full confirmation of the conclusion drawn by Dr. Plenderleith on more general evidence.

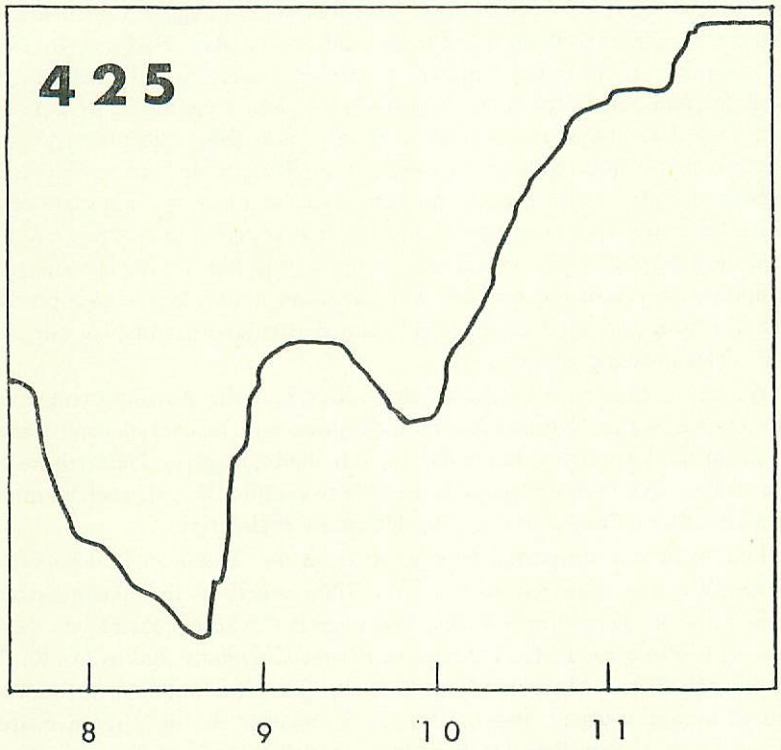

Fig. 64.—Spectrum of Amber from Gough's Cave

As Professor Tratman (1953) has pointed out, this assignment still leaves much uncertainty as to the exact location whence this piece of amber may have been brought to Somersetshire. Baltic amber has been scattered widely by Tertiary, glacial and alluvial geological events. It is now found in a very large area reaching from the eastern Baltic to the North Sea and including southern Scandinavia, the North German plain, the Dutch coast as far west as the former island Urk in the Zuider Zee and the east coast of England (cf., for example, Meyn, 1876). All these deposits are believed to have been formed originally in a hypothetical amber forest in Fenoscandia. They constitute a single mineralogical species called succinite, and they cannot be distinguished from one another by their chemical composition or by their inclusions.

It would obviously be of interest to record the infrared spectra of other palæolithic amber artifacts. In his paper Professor Tratman has referred to the amber carvings found at Isturitz (Basses-Pyrénées) and Aurensan (Hautes-Pyrénées). While a strictly local Pyrenean origin of these pieces is held to be unlikely, a Baltic origin would certainly require confirmation by spectroscopic analysis, since another plausible source suggests itself nearer at hand, viz. the large deposits of fossil resin in the Basses-Alpes. In 1886 L. Bonnemère (1886) found "amber" so common there that the inhabitants used it for fuel and called it, in local dialect, "peira cremarela", or burning stone. Buddhue (1938) has studied a sample from this region in 1938 and has found that it does not differ sensibly from Baltic amber, or succinite, in hardness, density, melting point or behaviour on burning. He claimed a positive "succinyl–fluorescein test", but this test (Feigl, 1960) is positive for all 1,2-dicarboxylic acids, and Buddhue did not isolate crystalline succinic acid upon pyrolysis of the sample. Therefore Dr. M. H. Hey (1963) prefers to list the resin, which Buddhue had named pseudo-succinite, as one not classified for succinic acid content.

We have procured a sample of this resin from the Roebling collection of the United States National Museum (Smithsonian Institution) and found that its infrared spectrum is similar to, but distinguishable from, those of Baltic amber. We therefore hope to be able to sample the palæolithic amber finds of southern France in order to determine their origin.

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