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Clinical Records

A case of rhinolithiasis in Botswana: a mineralogical, microscopic and chemical study

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Abstract

A case of rhinolithiasis in Southeast Botswana was treated and after removal in hospital, the rhinolith was subjected to macroscopic and microscopic examination, X-ray diffraction analysis, electron microscope analysis and partial botanical analysis.

The rhinolith consists of a strongly elliptical core of calcium stearate ($C_{36}H_{70}CaO_4.H_2O$), surrounded by approximately 30 elongated concentric growth rings, consisting of sodium-containing whitlockite ($Ca_{18}Mg_2(Na,H)(PO_4)_{14}$). The different layers have various degrees of porosity and red staining, probably due to traces of amorphous iron oxide. The origin of the rhinolith started with a piece of plant material, lodged in the nose, which was replaced by calcium stearate, leaving some remnants of resistant epidermal plant tissue. During subsequent years, thin layers of whitlockite were deposited periodically around the core with the reddish brown bands representing deposition during the dry season when atmospheric dust rich in amorphous iron oxide is at its highest in Botswana.

Key words: Nose; Foreign Body; Mineral Fibres

Introduction

A rhinolith is a mineralized mass, that has grown over many years around an (exogenous) foreign body, but sometimes around an endogenous body such as an ectopic tooth or a bone fragment in the nasal cavity or paranasal sinuses.[1–3] The medical term for this condition is rhinolithiasis. Rhinoliths are rare and usually reported in single-case reports. A recent Medline search has shown only 63 reports since 1964. This paper presents detailed mineralogical, chemical and microscopic properties of a rhinolith from Botswana.

Case report

A 80-year-old Botswana lady presented herself at the ENT clinic of the Bamalete Lutheran Hospital in Ramotswa (Botswana) with a unilaterally, foetid-smelling, blocked nose (Figure 1). She could not specify for how many years this problem had persisted. On visual inspection, a large (2.5 × 2.5 × 2.0 cm) rhinolith was found in the left nasal cavity protruding from her nostril. The (para) nasal X-ray showed the radiopaque object filling up the anterior half of the nasal cavity. The rhinolith was readily dislodged and removed under general anaesthesia (Figure 2). The sample was subsequently submitted to the Mineralogy Section of the Geology Department of the University of Botswana, Gaborone, Botswana.

FIG. 1

Rhinolith protruding from the patients nose.

Analysis

Sample procedure

The rhinolith was first cut into six slices, perpendicular to the long axis of the stone, each of about 1–2 mm thickness, using a small 10 cm diameter diamond saw-blade. These slices were subjected to:

1) microscopic analysis, carried out on a thin section of one of the slices;

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FIG. 2
The rhinolith after removal.

2) X-ray powder diffraction analysis;
3) semi-quantitative electron microprobe analysis.

Macroscopic description

Figure 3 shows the appearance of the different slices. They consist of a strongly elliptical core of white waxy material reminiscent of candle grease. In this material, a few thin membranes of organic material were found under the stereomicroscope, that were at a later stage examined by the Department of Biological Sciences of the University of Botswana. Around the waxy core, more or less concentric elliptical growth rings are seen of hard stony material alternating in colour between whitish grey and several shades of reddish brown, suggesting that the rhinolith must have been growing for a very considerable period of time.

X-ray powder diffraction analysis

X-ray powder diffraction (XRD) analysis was carried out using a Philips PW 3710 based XRD unit, operated at 45 kV and 40 mA, applying copper radiation and a graphite monochromator. A Pentium 166 Mhz processor was applied to run an 'X-pert' data processing software. The software package consists of an organizer, data collector, and graphics and identification modules, which permit control of the diffractometer, data collection, storage of data, identification and graphical presentation. Mineral identification utilized ASTM (American Society of Testing Materials) data files.[4]

The waxy core. The XRD pattern of the waxy core material (Figure 4) shows this material to be calcium stearate, a salt of the material candle grease, with the chemical formula $C_{36}H_{70}CaO.H_2O$. The thin membrane, mentioned previously could not be scanned, due to insufficient sample material.

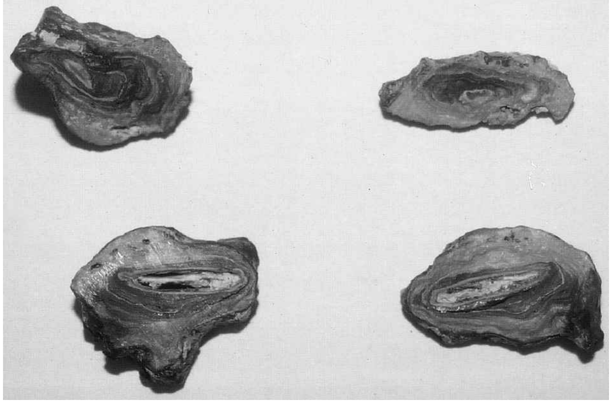

FIG. 3
The internal appearance of the rhinolith in different slices.

The hard stony growth rings and bands. XRD analysis revealed this material to be a calcium phosphate. A total of 20 calcium phosphates are listed in the ASTM files, whose XRD patterns are all very similar, making it virtually impossible to distinguish between the various possibilities. From a mineralogical point of view, the material is identical to the natural mineral whitlockite with the chemical formula $Ca_{18}Mg_2H_2(PO_4)_{14}$, ASTM code nr. 42-0578, (Figure 5). Similar results have been reported on previous studies of rhinoliths.[5,6] It must be noted however, that the ASTM files contain three other whitlockite patterns which are all slightly different, corresponding with different chemical formulae:

$HCa_8FeP_6O_{25}.10H_2)$	code nr. 15-0389
$(Ca,Mg)_3(PO_4)_2$	code nr. 13-404
$Ca_3(PO_4)_2$	code nr. 9-169

A different mineralogy for the light and dark bands was not indicated from the X-ray diffractograms.

In order to clarify the real composition of the growth rings, chemical analyses had to be carried out. This was done by semi-quantitative electron microprobe analysis, carried out at the Faculty of Earth Sciences of Utrecht University, the Netherlands.

Electron microprobe analysis

One of the rhinolith slices was polished, and six different points of several microns across were chemically analysed.

All six scans gave identical results, for both the whitish grey bands and the brown bands, which confirms the same observation made by XRD analysis. Figure 6 shows one of these scans, resulting in the following conclusions:

(1) iron could not be detected;
(2) the differences in colour between the different growth rings are not due to different chemistries, but most likely to differences in porosity, although the role of trace elements can not be excluded.
(3) The major elements are calcium, phosphorus and oxygen, as was to be expected, but in all six sample portions, minor quantities of sodium and magnesium were clearly detectable.

These results eliminate the three above mentioned whitlockite varieties, with code nrs. 15-0389, 13-404 and 9-169.

The combination of XRD analysis and the electron microprobe analysis then leads to the phosphate compound $Ca_9MgNa(PO_4)_7$, (ASTM code nr. 45-0136), that does not occur as a natural mineral. However, if in the whitlockite ionic structure of $Ca_{18}Mg_2H_2(PO_4)_{14}$ some of the hydrogen is replaced by sodium, this leads to the chemical formula $Ca_{18}Mg_2(Na,H)(PO_4)_{14}$. In the latter case, the compound may be characterized, from a mineralogical point of view, as a sodium-containing whitlockite. The theoretical stoichiometric composition of this compound is: 33.93 per cent calcium; 1.08 per cent sodium; 2.25 per cent magnesium; 0.05 per cent hydrogen; 62.68 per cent phosphorus.

Such a composition tallies well with the semi-quantitative electron microprobe results.

Microscopic structure of the rhinolith

A thin section of the rhinolith was cut to a thickness of about 50 microns so that the internal structure could be

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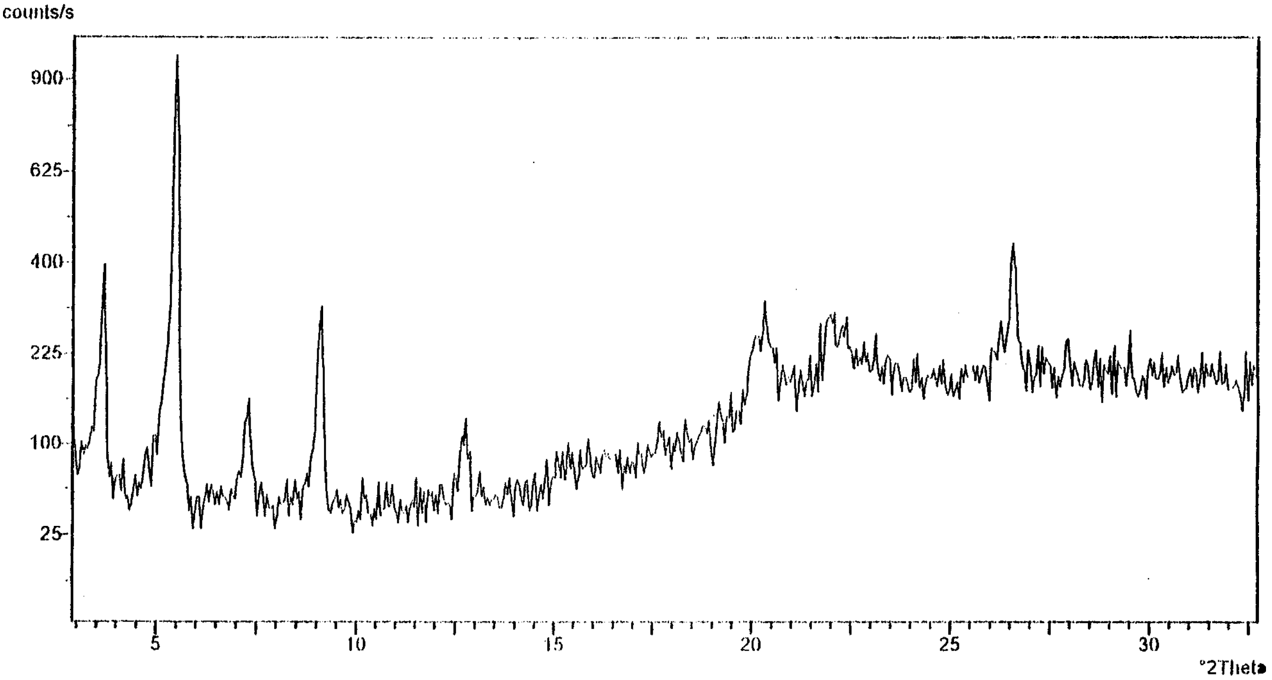

FIG. 4
X-ray diffractogram of the waxy core. All peaks belong to calcium stearate.

observed under a Leitz polarizing microscope. Observations in plane polarized light indicate that the rhinolith has at least 30 fine concentric bands, on average 0.2 mm across, defined by at least 15 dark bands (different shades of reddish brown) and 15 lighter bands (grey to greenish grey). These features of the rhinolith are shown in Figure 7, that shows a field of view from close to the core (X) to the outer margin (Y). The inner waxy core is of a colourless grey material which is mantled by the first reddish brown band A (Figure 7). Unlike any other part of the rhinolith, this band shows a wavy texture at an angle to the margins of the band. Towards the outer margins of this band are a series of fine (<0.1 mm) bands defined by different shades of reddish brown. Bright white areas observed in the photomicrograph are voids within the rhinolith. Towards the outer margin of the rhinolith, alternating reddish brown and pale greenish grey bands are observed as at D (Figure 7). The outer margin of the rhinolith, as seen at Y, is dominated by the lighter grey material.

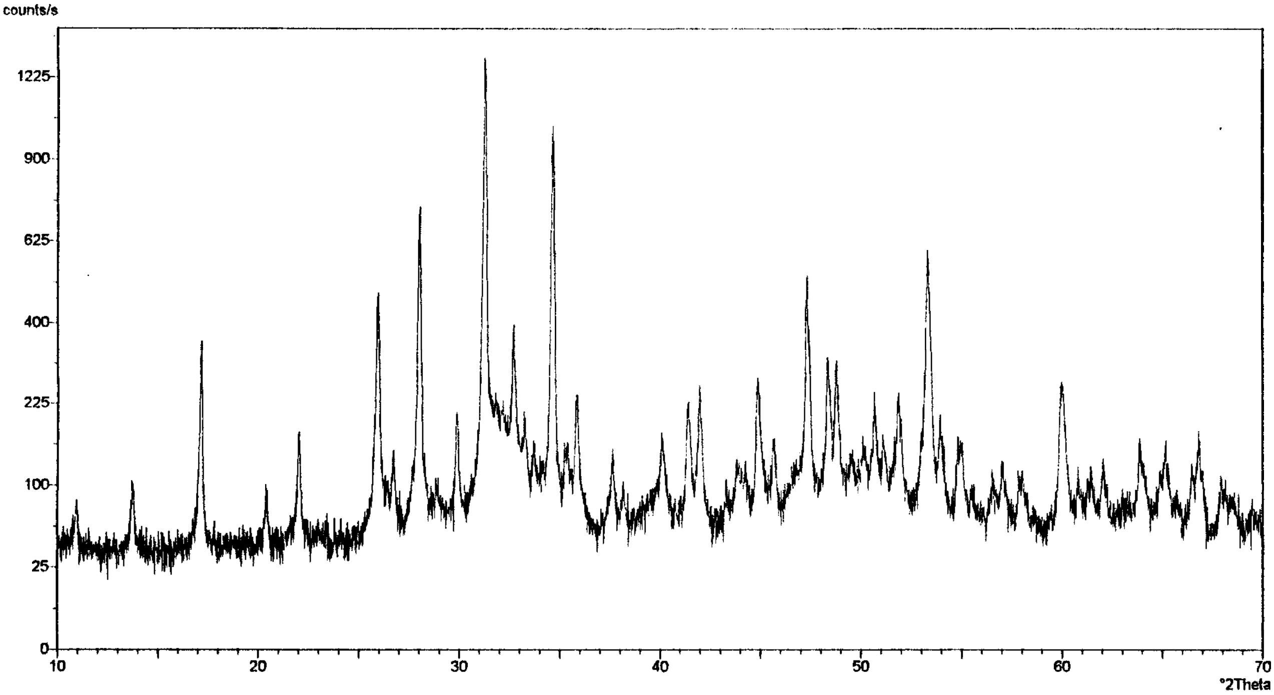

FIG. 5
X-ray diffractogram of the concentric rings around the waxy core. All peaks belong to the phosphate mineral whitlockite.

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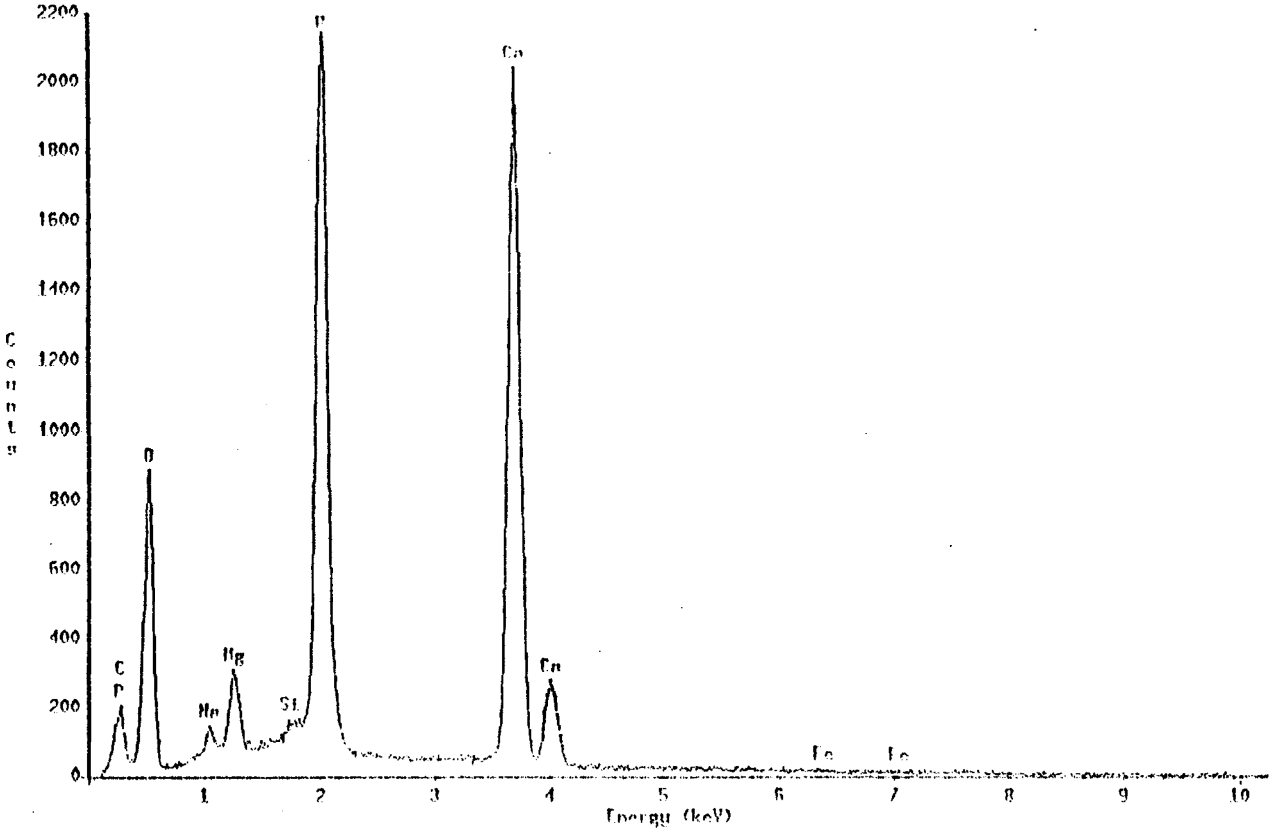

FIG. 6

Electron microprobe scan of the whitlockite, showing the major and minor chemical elements in the sample.

The membranes in the waxy core

The thin pieces of membrane, found in the waxy core, were submitted to the Department of Biological Sciences at the University of Botswana for microscopic examination.

Preliminary examination of the specimen, using a dissecting microscope showed the specimen to consist of an inner transparent and membranous cellular structure surrounded by a hard opaque part. The membranous structure was either stained directly or it was first treated with absolute xylene to dissolve any waxy material, which might interfere with the viewing of the cells, air-dried and stained in aqueous toluidine blue stain for 30 seconds. The specimen was rinsed in distilled water to remove excess stain and mounted on a slide in a drop of water with a cover slip. It was then examined using a Leitz Biomed photomicroscope, using ×10 and ×40 objective lenses.

Microscopical examination then showed that the specimen appears to be a plant specimen, possibly from the outer part (the epidermis) of a stem or a leaf-like modified stem. The specimen was made up of a one cell layer thick membrane, which appears to have formed a thin layer over

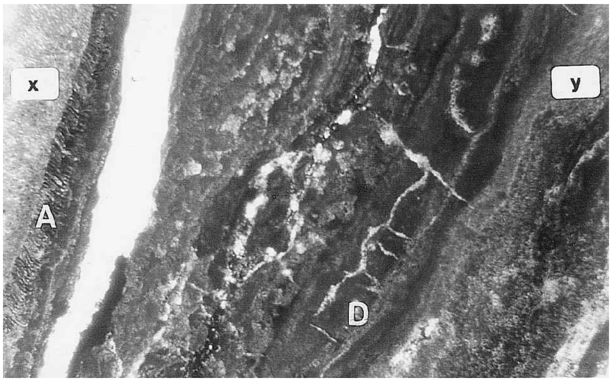

FIG. 7

Photomicrograph of a 50 micron thick thin section of the rhinolith in plane polarized light showing a field of view from close to the centre (X) to the margin (Y). Light and dark bands are clearly observed (×20).

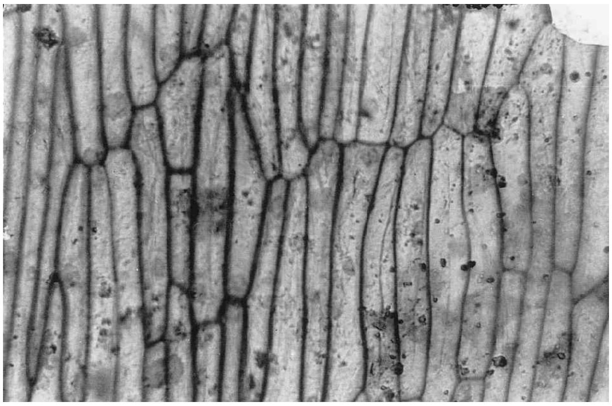

FIG. 8

Epidermal cells of resistant plant material in the membrane left behind in the waxy core of the rhinolith. Note the intact, well-preserved cells with thick cell walls, typical of plant material. Sample was stained for 30 seconds with aqueous toluidine blue stain (×400).

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the plant structure. The cells were intact and well preserved with no apparent distortion of the cell shape. The cell walls stained readily purple/pinkish with toluidine blue stain, indicating that cellulose, hemicellulose and pectic material were the major components of the cell wall. The epidermis – the outer covering of plant structures – is usually a strong tissue, which is resistant to decay. In this case it appears that all other parts of the structure were destroyed or replaced by calcium stearate, $C_{36}H_{70}CaO_4.H_2O$, leaving the epidermal cells well preserved. Figure 8 shows a series of these epidermal cells. The plant formed the core of the rhinolith around which other materials, (whitlockite), were deposited. However, the identity of the plant could not be established.

Conclusions on the origin of the rhinolith

The allover picture that emerged is that the patient had once had a piece of a stem of a plant trapped in her nose. Most of the plant material of cellulose composition decayed and was replaced by waxy stearate, in which remnants of resistant epidermal plant tissue were preserved. The strongly elliptical shape of the core of the rhinolith probably indicates an elongated piece of stem of an unidentified plant.

Over time calcium phosphate with the mineralogical composition of sodian whitlockite was deposited around the core in more or less concentric elliptical rings and bands. It is not possible to estimate with any certainty the duration of this process, leading to the size of the rhinolith that was found and removed. Unfortunately, the patient, who was in her eighties, could not remember when the problem started. But it is known that similar processes in natural surface environments take place very slowly, and the rhinolith reported here, may well have been growing for several decades.

The origin of the reddish coloration of the darker bands is a problem. Although this colour is typical for iron-rich minerals such as haematite, iron was below the detection limit of the electron microprobe and no iron minerals such as haematite could be detected by XRD analysis. None of the chemical components of sodian whitlockite, which make up the bulk of the rhinolith could give a red coloration. A likely explanation for this is that the iron only occurs in trace amounts and is in an amorphous form. Trace amounts of iron commonly impart a reddish brown colour to normally colourless minerals such as quartz.

If the dark reddish brown bands of the rhinolith are a result of traces of fine amorphous haematite, they may represent seasonal periods of growth. A very fine haematitic dust is very common in the atmosphere over Botswana during the dry season, especially the windy months of August and September, prior to the rains. These bands may therefore represent periods when the patient was inhaling large amounts of fine dust through her nose, traces of which were incorporated into the growing rhinolith. If these are seasonal bands, it would suggest the rhinolith took 15 years to grow.

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