Urol Res (1983) 11:155–158

Urological Research

Siliceous Deposits in Human Urinary Calculi – an E. M. Study

K. M. Kim, R. David, and F. B. Johnson[1]

Department of Pathology, V. A. Medical Center, Baltimore, and University of Maryland, Baltimore, and
[1] Armed Institute of Pathology, Washington, DC, USA

Accepted: March 14, 1983

Summary. Silica calculi in man are extremely rare; only 12 cases have been reported. In an electron microscopic study of human urinary stones, siliceous deposits were encountered in three out of 180 stones as a discrete component of stones. There were no histories of magnesium trisilicate administration in these cases. Morphology of the deposits was distinctive from any other components of the stones and bore some resemblance to animal silica calculi. Siliceous deposits in human urinary stones appear to be more common than generally recognized.

Key words: Silica calculi, SEM, X-ray Analysis.

Introduction

Siliceous urinary calculi are common among herbivorous animals such as cattle and sheep [5, 11]. However, silica (Si) calculi in humans are known to be extremely rare [7]. In a series of electron microscopic studies of human urinary stones, discrete siliceous deposits were encountered in 3 out of 180 stones. The deposits differred in their morphology from any other components of urinary stones.

Materials and Methods

Stones were cracked with a razor blade and a hammer. For scanning electron microscopy (SEM) and electron probe microanalysis (EPM), portions of the stones were mounted cracked surfaces up onto aluminum stubs with conductive glue, carbon or gold coated, and analyzed by SEM and EPM.

For transmission electron microscopy (TEM) and electron diffracton (ED), representative portions of the stones were ground with a mortar and pestle. The resultant powder was transferred to formvar coated grids and an additional carbon coating was applied. ED was performed on each crystal with distinctive morphology using a gold sputtered grid as control. Selected stones were analyzed by x-ray diffraction (XD) using Debye-Scherrer diffraction camera.

Results

Bilateral ureteral stones were removed with a basket from a recurrent calcium oxalate stone former; one contained weddellite, ammonium acid urate and calcium apatite, and the other consisted predominantly of ammonium urate. In the latter, layers of granular particles were detected near the periphery of the stone which yielded Si upon EPM (Fig. 1).

A small uric acid stone was passed by a recurrent uric acid stone former. Among equant (block shaped) uric acid crystals, patches of granular particle aggregates containing silicon were found. Trace amounts of potassium and calcium were also detected from the granules. The particles tended to conglomerate into mammillary tuberosities (Fig. 2).

In a stone which consisted of brushite by XD and ED, peculiar leaf shaped structures containing silicon were visualized by SEM and EPM on the surface of the brushite mass (Fig. 3).

None of the above three stone formers had a previous history of magnesium trisilicate therapy. Trace amounts of silicon and other trace elements such as Al, S, Cl, and K were detected in additional stones. The trace elements appeared to be associated mainly with organic crystals. Precise location of the trace amounts of silicon in stones, however, was not possible to determine because of the limit in the resolution and sensitivity of the method used.

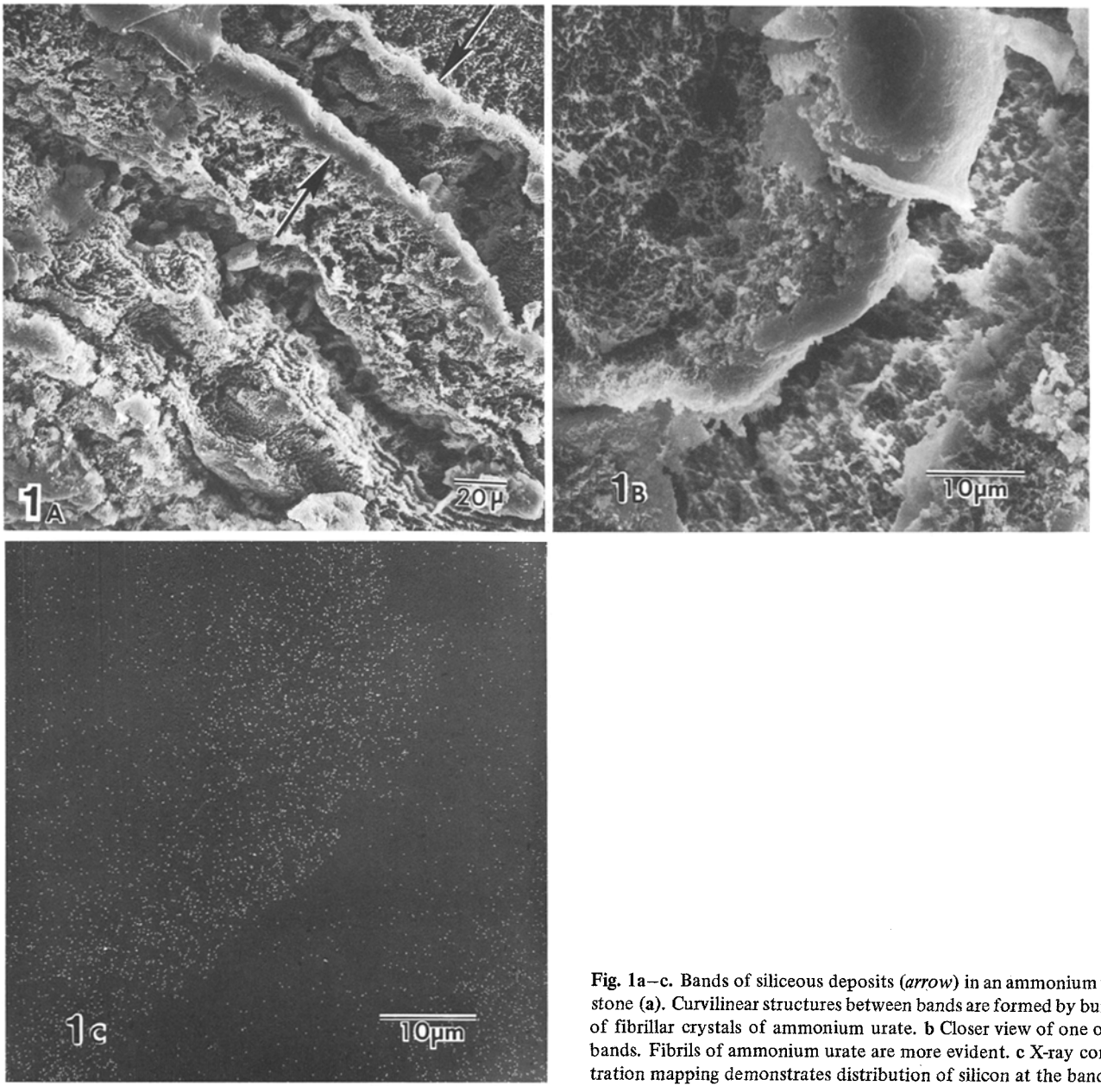

Fig. 1a–c. Bands of siliceous deposits (*arrow*) in an ammonium urate stone (**a**). Curvilinear structures between bands are formed by bundles of fibrillar crystals of ammonium urate. **b** Closer view of one of the bands. Fibrils of ammonium urate are more evident. **c** X-ray concentration mapping demonstrates distribution of silicon at the band

Discussion

As many as 4% of range steers wintered in the northwestern plains of North America develop silica calculi with urethral obstruction. The high incidence of silica in these animals has been attributed to the consumption of forage with a high content of SiO_2. The grass in certain areas may contain up to 8% of silica on dry weight basis and a large number of steers in these areas develop silica calculi [1]. Precipitation of silica in the urine of these animals tends to occur when their urine level of silicon exceeds 70 to 80 ppm. However, following an experimental increase of silicon in steer urine silica calculi failed to develop and, therefore, it has been postulated that proteinaceous matrix plays a role in silica calculi formation [5]. It is most interesting that an epidemic of canine silica calculi made a sudden appearance in the United States. These stones were frequently jack-stone shape. Diet and natural water contaminated by silica were suspected to be the origin of the canine silica calculi [8].

Although silicon in trace amounts of less than 1,000 ppm. is found in every human kidney stone [6], only 12 cases of silica calculi have been described in humans, following prolonged magnesium trisilicate therapy for the treatment of gastric hyperacidity [3, 4, 6, 7, 10]. Page, et al. have, indeed, affirmed that trisilicate can be absorbed through the gastrointestinal tract and excreted in the urine [10]. The origin of the silica in the absence of trisilicate therapy, as observed in this study, is obscure. In view of a high silica content in vegetables and the high incidence of silica calculi among herbivorous animals, it is conceivable

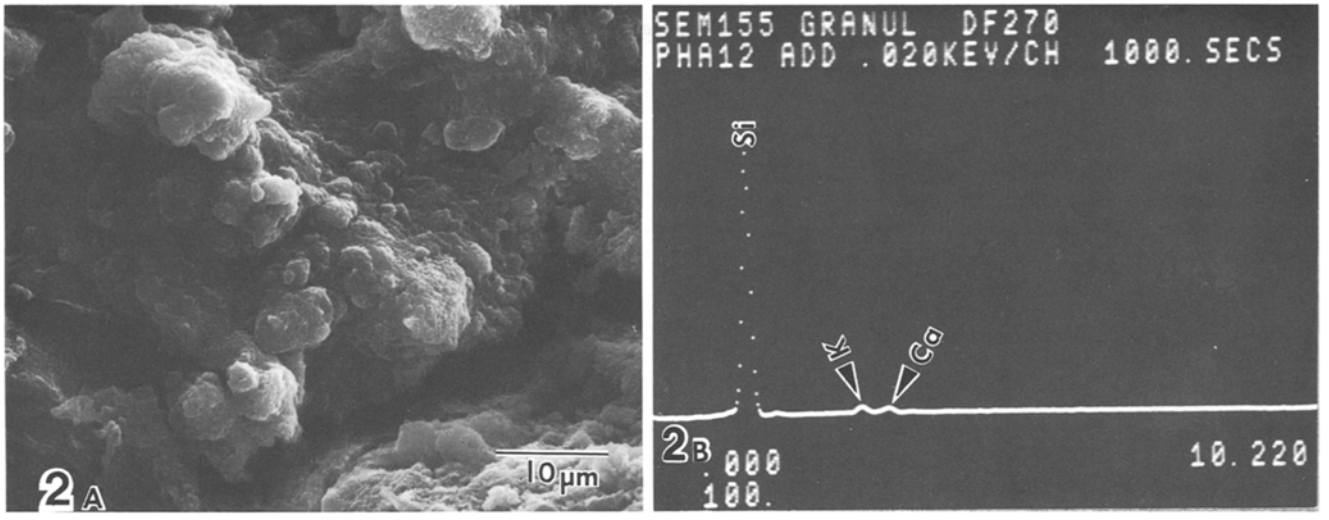

Fig. 2a, b. Deposition of granular particles with mammillary tuberosities in a uric acid stone (a). X-ray analysis of the deposit yielded silicon and trace amounts of potassium and calcium (b)

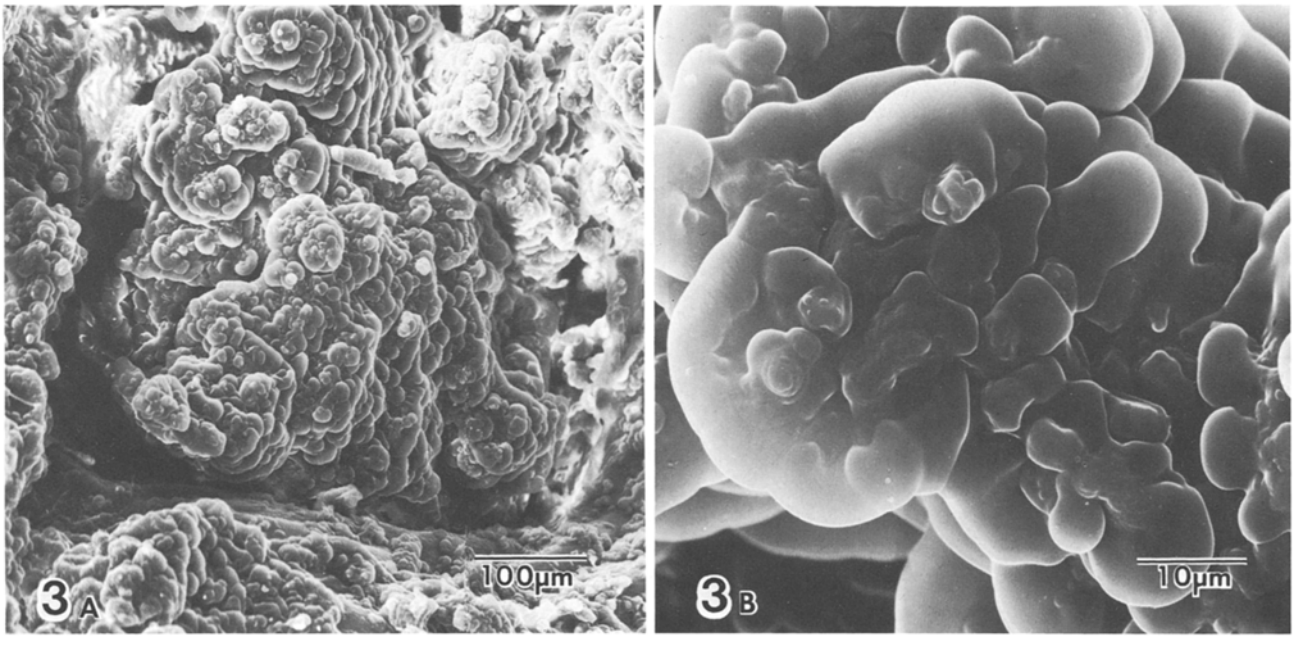

Fig. 3a, b. Peculiar leaf shaped deposits on the surface of a brushite stone (*not shown*). X-ray analysis of the leaves yielded only silicon

that a diet rich in certain vegetable(s) is the source of silica.

Failure to detect silica either by ED or XD indicates that the siliceous deposits described are amorphous, which is in agreement with previous reports. The silica in human and animal urinary calculi is known to be amorphous opaline silica [2–4, 7, 8, 10]. Although the number of cases studied is too small, morphology of the siliceous deposits was distinctive from any other components of the urinary stones and bore some resemblance to the animal silica calculi [1]. The significance of the frequent coexistence of other trace elements such as aluminum, sulfur and potassium with silicon is not known. Similar findings were described in canine silica calculi [12].

This study demonstrates an advantage of EM methods in the detection of amorphous components of stones. Siliceous deposits in human urinary stones appear more common than they have generally been recognized to be, and are not necessarily related to magnesium trisilicate therapy.

References

1. Baily CB (1972) A scanning electron microscope study of siliceous urinary calculi from cattle. Invest Urol 10:178–185
2. Forman SA, Whiting F, Connel R (1959) Silica urolithiasis in beef cattle. 3. Chemical and physical composition of uroliths. Can J Comp Med 23:157–162
3. Herman JR, Goldberg AS (1960) New type of urinary calculus caused by antacid therapy. JAMA 174:1206–1207
4. Joekes AM, Rose GA, Sutor J (1973) Multiple renal silica calculi. Br Med J 1:146–147
5. Keeler RF (1963) Silicon metabolism and silicon-protein matrix interrelationship in bovine urolithiasis. Ann NY Acad Sci 104:592–611
6. Lagergren C (1962) Development of silica calculi after oral administration of magnesium trisilicate. J Urol 87:994–996
7. Levinson AA, Nosal M, Davidman M, Prien EL Sr, Prien EL Jr, Stevenson RG (1978) Trace elements in kidney stones from three areas in the United States. Invest Urol 15:270–274
8. Medina JA, Sanchidrian JR, Delatte LC (1981) Silica in urinary calculi. In: Smith LL, Robertson WG, Finlayson B (eds) Urolithiasis, clinical and basic research. Plenum Press, New York, pp 923–927
9. Osborne CA, Hammer RF, Klauser JS (1981) Canine silica urolithiasis. Am J Vet Med Assoc 178:809–813
10. Page RC, Heffner RR, Frey A (1941) Urinary excretion of silica in humans following oral administration of magnisum trisilicate. Am J Dig Dis 8:13–15
11. Takemoto M, Itatani I, Kinoshita K, Yachiku S (1978) Silica calculi. Jpn Urol Assoc J 69:664–668
12. Truman NA, Stacy BD (1969) Ovine urolithiasis: some mineralogic and physiologic observations. Invest Urol 7:185–191

Dr. K. M. Kim
Department of Pathology
V.A. Medical Center
Baltimore, Maryland 21218
USA