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NOTES

Brucite identified as crystallizing from a natural cold alkaline spring gel*

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THIS note presents evidence for the natural low temperature crystallization of brucite, and also indicates the possibility of ambient temperature serpentinization.

Water issuing from Complexion Spring, Lake County, California, is presently precipitating a yellowish-gray gel which is high in Mg and Si. The water itself is cold (10°C), is low in Mg, and has a pH of 12·07. Further details on the chemistry of the spring water and gel may be found in Barnes *et al.* (1971).

The presence of brucite is clearly shown by the X-ray diffractograms in Fig. 1. Microscopic examination revealed that minute ($1\,\mu m \times 1\,\mu m$ up to $2\,\mu m \times 20\,\mu m$) generally tabular crystals were embedded in some areas of the gel. The crystals were identified as brucite – uniaxial positive, $\epsilon = 1{\cdot}56$, $\omega = 1{\cdot}58$. The first X-ray diffractogram taken showed no evidence of crystallinity, because of the uneven distribution of crystals in the gel; however, further X-ray and optical examination was encouraged by an i.r. spectrum.

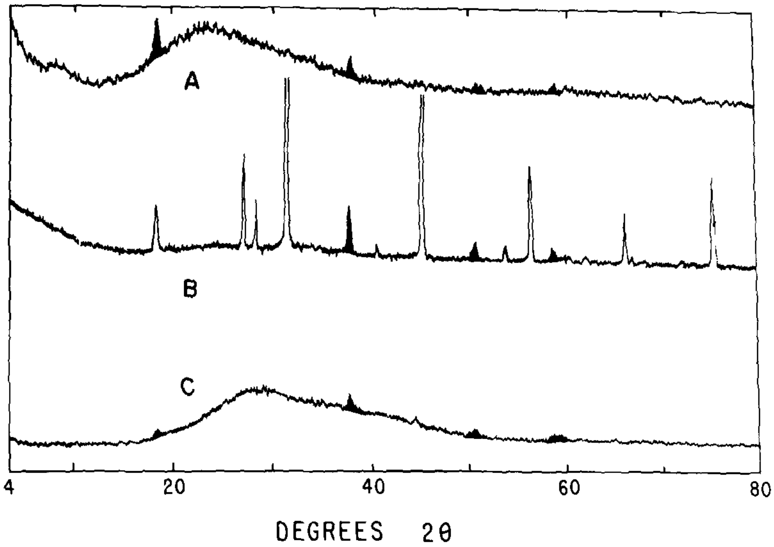

Fig. 1. X-ray diffraction patterns for Complexion Springs gel. Shaded peaks are brucite. A and B are of air-dried samples on glass slides. C is of undried gel. A and C have been leached of halite and sylvite (unshaded peaks) still found in B.

The presence of brucite was indicated because of the position and sharpness of several i.r. bands, particularly the O–H stretching band found at 3700 cm^{-1}. Mara and Sutherland (1953) and Coblentz (1905) commented that brucite was anomalous in having such weak hydrogen bonding that the bond is found at this extremely high wave number. The possibility of a protoserpentine forming in the gel is suggested by a comparison of the infrared spectrum of the Complexion Spring gel with the spectra of brucite and serpentine varieties (Fig. 2). To facilitate comparison, a dashed line shows the spectrum after bands for molecular water and carbonate (sorbed from the atmosphere by the wet gel) have been eliminated. The gel spectrum has all the bands of brucite plus a doublet in the 900 cm^{-1}–1200 cm^{-1} region where Si–O bonds absorb. This doublet, 998 cm^{-1} and 1065 cm^{-1}, is nearly identical with that of antigorite, 990 cm^{-1} and 1080 cm^{-1}, and is at lower wave numbers than commercial silica gel (Benesi and Jones, 1959). One cannot determine with certainty from the i.r. data whether a protoserpentine or a silica gel of unknown structure is mixed with brucite. The suggestion of Martin and Fyfe (1970) that serpentine

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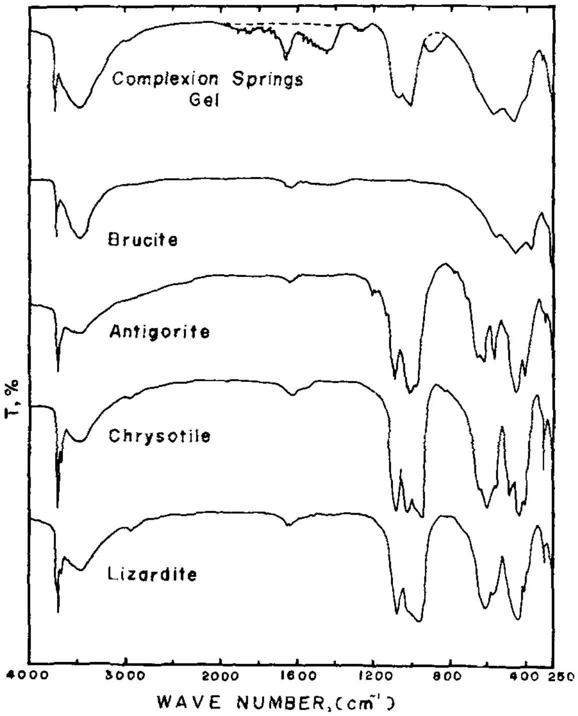

Fig. 2. I.R. spectrum of Complexion Springs gel compared with spectra of brucite and serpentine varieties. Dashed line shows trace where i.r. bands from water and carbonate impurities have been eliminated.

may nucleate on a brucite surface certainly seems reasonable, but the kinetics of such a reaction at low temperatures are unknown.

The identification of brucite in the Complexion Spring gel supports thermodynamic arguments (Barnes and O'Neil, 1969; Barnes *et al.*, 1967) for expecting brucite and serpentine to form at ambient temperatures. In addition, it calls attention to the fact, demonstrated experimentally by Gulbrandsen and Cremer (1970), that brucite need not crystallize only under higher temperature "hydrothermal" conditions, as many mineralogy textbooks imply.

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Geological Division
U.S. Geological Survey
Menlo Park, Calif. 94025
U.S.A.

ROBERT W. LUCE