but their thin, smooth, single walls, and multiple hyphal attachments render them easily distinguishable from those of *G. occultum*.

In some keys to the Endogonaceae (e.g., Gerdemann & Trappe, 1974; Hall & Fish, 1979), hyaline-spored *Glomus* spp., such as *G. occultum*, may key out to *G. fasciculatum* or *G. microcarpum*. However, neither of these species produces hyaline spores at maturity, and collections of such spores should be compared with the description of *G. occultum* and other hyaline-spores species such as *G. clarum*, *G. pallidum*, and *G. albidum*.

Spores of *G. occultum* could easily be overlooked in soil sievings. Their small size, lack of color, and often subangular form, make them difficult to distinguish from sand grains. I have found *G. occultum* spores to be more easily seen if only incident illumination is used when examining sievings under a dissecting microscope, rather than the combination of incident and transmitted light recommended by Mosse & Bowen (1968).

Sieves with openings no less than 100 μm often are used for wet-sieving and decanting endogonaceous spores, and since most *G. occultum* spores are smaller than this, they will be lost through such sieves. In view of the wide distribution of this species, it may be common, but might have been overlooked in the past.

THE NEW STATUS

Another *Glomus* sp. found in Iowa is *G. macrocarpum* var. *geosporum*. This species has been reported from various parts of the United States (Pfeiffer & Bloss, 1980; Gerdemann & Trappe, 1974; Nicolson & Schenck, 1979); from Great Britain (Nicolson & Gerdemann, 1968), from India (Thapar & Khan, 1973) and from the southern hemisphere (Hall, 1977; Hayman, 1978). I propose raising this variety to species rank. The differences between it and *G. macrocarpum* var. *macrocarpum* sensu Gerdemann & Trappe (1974) are at least as great as, for example, the differences between *G. fasciculatum* (Thaxter sensu Gerdemann) Gerdemann & Trappe and *G. macrocarpum* var. *macrocarpum*, or between *G. microcarpum* Tul. & Tul. and *G. fasciculatum*. Similarly, *G. constrictum* Trappe is as different from *G. macrocarpum* var. *macrocarpum* as is *G. macrocarpum* var. *geosporum*.

Nicolson & Gerdemann (1968) erected three varieties of *Endogone macrocarpa* (Tul. & Tul.) Tul. & Tul., based on resemblance to the specimens used by Thaxter (1922) in his classical contribution to the taxonomy of the group. Later, Gerdemann & Trappe (1974) raised *E. macrocarpa* var. *caledonia* Nicolson & Gerdemann to full species status and placed it in the genus *Glomus*. The absence of sporocarps, the septal occlusions of the subtending hypha, and the long extension of spore-wall thickening into the subtending hypha in *G. macrocarpum*

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var. *geosporum* are, I believe, sufficiently different from the features of *G. macrocarpum* var. *macrocarpum* to merit raising the former to the level of species. The re-description following is based on an examination of the type collection from the Farlow Herbarium, Harvard, and of specimens collected from Iowa, Georgia, Arizona, Mexico. The Netherlands, and Great Britain.

GLOMUS GEOSPORUM (Nicolson & Gerdemann) Walker stat. nov.
(Figures 3 & 4)

≡ *Endogone macrocarpa* (Tul. & Tul.) Tul. & Tul. var. *geospora* Nicolson & Gerdemann. *Mycologia* 60: 318-319. 1968.

≡ *Glomus macrocarpum* var. *geosporum* (Nicolson & Gerdemann) Gerdemann & Trappe. *Mycologia Memoir* No. 5; 55-56. 1974

Sporocarps unknown. *Chlamydospores* formed singly in soil, globose to subglobose or broadly ellipsoid, 110-290 µm, smooth and shiny or with a dull appearance, or roughened from adherent debris; light yellow-brown and transparent to translucent when young, becoming dark yellow-brown to dark red-brown at maturity.

Spore walls totalling 4-18 µm in thickness, 3-layered, with a thin, hyaline, tightly adherent outer wall (< 1 µm), most easily observed in young spores (Figure 3E) and sometimes absent from mature specimens; a yellow-brown to red-brown laminated middle wall (3-16 µm); and a yellow to yellow-brown inner wall (<1 µm) that appears membranous and that forms a septum separating the spore contents from the lumen of the subtending hypha (Figure 3 D, E, F). Walls often becoming perforated with age, probably due to attack by micro-organisms.

Spores with one straight to recurved, simple to slightly funnel-shaped *subtending hypha* up to 200 µm long (or rarely two adjacent attachments), 10-24 µm diam, with yellow to dark yellow-brown wall-thickening that extends 30-100 µm along the hypha from the spore base. Occasional spores lacking a subtending hypha due to breakage close to the spore base. Such specimens may be mistaken for spores in the genus *Acaulospora* (Figure 3B).

Spore contents of uniform oil droplets when young (Figure 3A), becoming increasingly granular in appearance with age (Figure 3F); cut off by a thick septum that protrudes slightly into the subtending hypha. Germination by regrowth through the subtending hypha after rupture of the septum (Figure 3F).

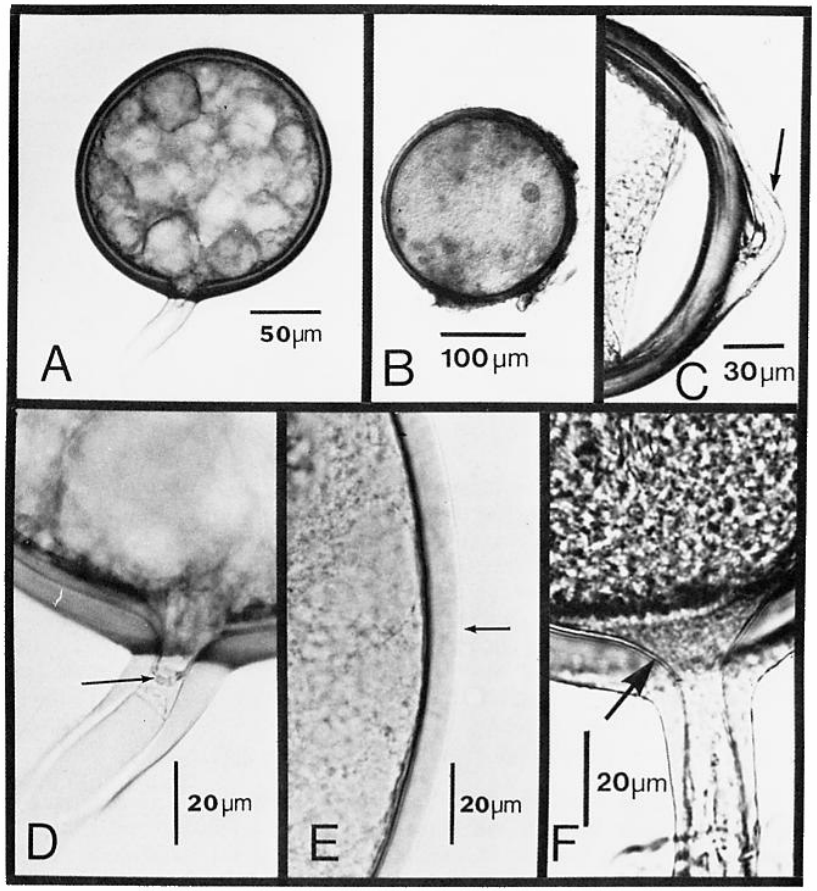

Figure 3.

Chlamydospores of *Glomus geosporum* from the holotype collection. A) A young spore showing spore contents. B) A mature spore with a short, broken subtending hypha that lies beneath the spore and is consequently masked by the opaque walls. C) A spore with a short, recurved subtending hypha. Plasmolysis has left a gap between the spore contents and the spore wall. D) Details of a thickened subtending hypha with the septum (arrowed) (from the spore in 3A). E) Wall detail, showing the hyaline outer wall (arrowed) in this young specimen. F) In this specimen, the septum formed by the inner wall (arrowed) has been ruptured as the germ tube emerged through the subtending hypha.

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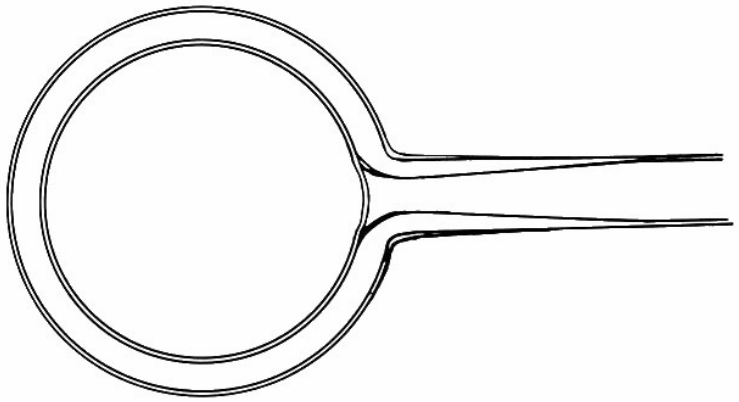

Figure 4

Stylized drawing of a chlamydospore of *Glomus geosporum*. Note the three-layered wall structure, the septum formed by the inner wall, and the wall-thickening extending down the subtending hypha.

Young (lightly colored) spores becoming slowly deep red in *Melzer's reagent*. Older (darker) spores reacting variably to this reagent, usually darkening in color, or becoming orange-brown. In *cotton blue*, very young spores cyanaphilous; becoming less so with age, resulting in a greenish-yellow wall color in spores of intermediate age, and no staining of walls in fully mature spores. Subtending hypha staining blue at all stages of maturity.

It should be stressed that the description here is based on features observable through the light-microscope on whole or crushed spores without the benefit of sections or special staining (other than by cotton blue). It is likely that ultrastructural studies will reveal the wall-structures to be much more complex than they seem at this level of observation. In particular, it is very difficult to interpret the inner wall of *G. geosporum* with the light-microscope, and it is unclear if it truly is membranous in the sense of such walls in *Gigaspora* and *Acaulospora*, or if it is merely a specialized inner lamina of the middle wall.

The most likely species to be confused with *G. geosporum* is *G. constrictum*. The color ranges of these species overlap, and spores of *G. geosporum* may be red-brown and opaque at maturity, but they do not become black and shiny as do spores of *G. constrictum*. Some spores of *G. constrictum* lack the typical constriction of the subtending hypha at the spore base (Trappe, 1977), and could therefore be confused with *G. geosporum*. Conversely, the subtending hypha of *G. geosporum* is not always straight and thickened for a long distance along the subtending hypha. In addition, some *G. geosporum* spores have a slight constriction in the subtending hypha at the spore base. However, spores of *G. geosporum* possess an inner (membranous) wall that forms a septum closing off the spore contents – a feature not shared with *G. constrictum*. Similarly, although spores of *G. macrocarpum* may be the same size and color as those of *G. geosporum*, the lack of an inner wall and a septum in the former distinguishes it from the latter. *G. macrocarpum* spores have their contents sealed off by spore-wall thickening. In addition, both *G. constrictum* and *G. macrocarpum* may have spores formed in loose clusters in the soil whereas it seems that *G. geosporum* is entirely ectocarpic, and its spores are thus formed only singly in the soil.

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