

## A very special Fractal: Gingko of Jena

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Received: September 23, 2013; accepted: October 03, 2013; published on line: December 11, 2013

### Resumen

Después de una breve explicación sobre el significado de los fractales en las Ciencias de la Tierra, se presenta una modificación de la famosa iteración de Mandelbrot. El resultado tiene un cierto parecido con una hoja de gingko, el cual es una especie de árbol singular, no solo en la botánica sino en la cultura y la filosofía oriental. Se presentan algunas de las características inusuales del nuevo fractal "hoja de gingko".

Palabras clave: fractales en geofísica, conjunto de Mandelbrot, gingko biloba, iteración de la hoja gingko.

### Abstract

After shortly explaining the significance of fractals in the geosciences I present a modification of the famous Mandelbrot iteration. The result bears a certain resemblance to a gingko leaf. The gingko tree is special in botany, in cultural history and in philosophy. Some unusual features of the new gingko-leaf fractal are presented.

Key words: fractals in geophysics, Mandelbrot set, gingko biloba, gingko leaf iteration.

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## Introduction

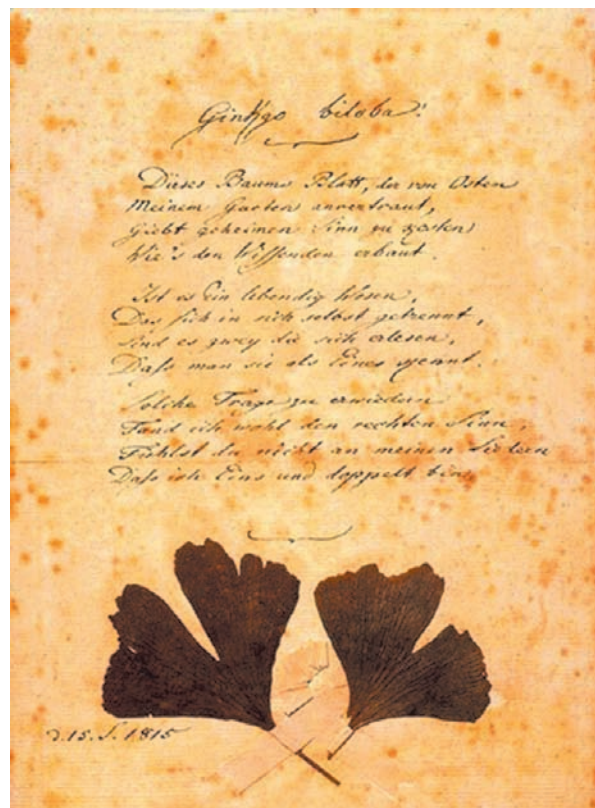
This special article out of competition does not directly concern geophysics but indirectly by presenting a special new fractal (the ginkgo-leaf fractal) and beyond that by enabling the view on beauty of science and connections to philosophy, art, and nature.

It is well-known that fractals surround us everywhere [see e. g. Mandelbrot (1977) and Barnsley (1988)]. The concept of fractals was introduced into science by Mandelbrot (1967) in a geological context. Later it became more and more evident that fractals are very important for geophysics and geology. That is small wonder because following Scholz and Mandelbrot (1989) one possible broad explanation of the role of fractals in geophysics may be found in probabilistic limit theorems, and in the existence of classical "universality classes" related to them. A second possible explanation may come from deterministic chaotic dynamics. Additionally, Turcotte (1989) pointed out that scale invariance has long been recognized as an important feature of many geological problems. A fractal distribution is the only distribution that is scale invariant. Thus it is not surprising that many geological and geophysical data sets are fractals. In this context, fractals are a method of empirically correlating a variety of quantitative observations. But in addition to being appropriate for empirical correlations fractals also result from several classes of theoretical studies. Dimri has devoted the first chapter of his book [Dimri (2005)] the fractals in geophysics and seismology. The applications in seismology range from the size-frequency distribution of earthquakes, Omori's law and the analysis of aftershock data even up to the forecasting of tsunamis. For completeness, we cite here also two articles which analyse the fractal geometry and seismicity in the Mexican subduction zone [Angulo-Brown *et al.* (1998)] and fracture arrays in Baja California Sur, Mexico, by using fractal analysis [Nieto-Samaniego *et al.* (2005)].

One of the most prominent fractals is without doubt the Mandelbrot set. After Taylor and Spratt (2008) Mandelbrot saw this set for the first time at 1 March 1980. It must have been an indescribably great feeling to see that whole cosmos of wonderful and unimaginably fragile structures. The author of the present article was also surprised in suddenly seeing the ginkgo-leaf fractal (see Figure 2) for the first time about 25 years ago. It has not those fine ramifications and complexity of the Mandelbrot set which is following Dewdney (1985) "the most complex object in mathematics". But the ginkgo-leaf set is complex enough and has its own specialities and beauties as we will see later. We start with a short description of the ginkgo tree's prominence.

## The ginkgo tree

It is well known that the ginkgo tree (*Ginkgo biloba*) is a "living fossil" because of its special botanic history. It is a medical plant with botanical and historico-cultural significance. The German curatorship "Baum des Jahres" (tree of the year) has declared it as the "tree of the millennium". It is a great symbol for our world, a tree of the world and a symbol of strength and hope. The far eastern philosophy considers the tree, among other things because of its split leaves, as an incarnation of the famous Ying-Yang principle and connected with that it is also considered as a symbol for harmony and fertility. Last but not least the people are fascinated from the special beauty of the leaves. Nobody less than Johann Wolfgang von Goethe (1749-1832) was also fascinated from this tree and its leaves and initiated the growing of a ginkgo in the botanical garden in Jena, which is now the oldest ginkgo tree in Thuringia. He even wrote a poem "Gingo Biloba" [Goethe (1819)] which he devoted to his muse Marianne von Willemer (1784-1860) (see Figure 1) and whose rough English translation is (see [en.wikipedia.org/wiki/Ginkgo\\_biloba](http://en.wikipedia.org/wiki/Ginkgo_biloba)):



**Figure 1.** Facsimile of Goethe's poem *Gingo biloba* devoted to M. v. Willemer.

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