# Banded iron formations formed rapidly

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A banded iron formation (BIF) is a sedimentary rock characterized by alternating bands of iron oxide and chert. Individual bands may vary in thickness from less than a millimetre to metres, and the overall succession of bands may be hundreds of metres thick. The principal iron minerals are the iron oxides hematite and magnetite.[1] BIFs have a chemical composition unlike any sedimentary material being deposited in significant quantities on the modern earth.[2]

BIFs are economically important since over 95% of iron resources of the world occur in BIFs.[3] They are the principal source of iron for the global steel industry. BIFs have been found on all continents except Antarctica.[1] Giant (100,000 billion tonnes or more) BIFs are located in South Africa, Australia, Brazil, Russia, and Canada. Smaller but still significant BIFs are found in many other places including in the USA, India, Ukraine, and China (figure 1).[4]

Although BIFs are widespread geographically in Precambrian provinces, they have a limited occurrence in time, being principally found in Archean and Paleoproterozoic 'age' provinces,[5] with a few smaller occurrences in Neoproterozoic 'age' provinces.[6] BIFs are absent from Mesoproterozoic 'age' provinces (figure 2).[7]

The Algoma, Superior, and Rapitan types are the three main types of BIFs and are named after locations in Canada.[8] Algoma-type BIFs are chiefly found in volcano-sedimentary sequences of Archean greenstone belts. These BIFs are stratigraphically linked to or interlayered with submarine-emplaced volcanic rocks in greenstone belts and, in some cases, with volcanogenic massive sulphide (VMS) deposits.[4] Typical Algoma-type iron formations rarely extend for more than 10 km along strike and are less than 50 m thick. Algoma-type and Superior-type iron formations are similar in mineralogy.[4]

Superior-type deposits are by far the most economically important type of BIFs globally, and are situated in relatively undeformed continental margin sedimentary basins around unconformable contacts on granite-greenstone terrains around the Archean/Proterozoic boundary.[9] These BIFs are large in size (over 100 km in lateral extent and more than 100 m in thickness).[10] The Paleoproterozoic Hamersley Basin in Western Australia contains one of the world's largest areas of BIFs. The basin itself outcrops over an area of about 100,000 km$^2$. The chemical and lateral stratigraphic continuity of these BIFs on a variety of scales is quite extraordinary. Microbands (about 1 mm thick) can be traced for hundreds of kilometres. In addition, the broad alternation and concordance of BIFs with other sedimentary rocks (mainly shale and carbonate) and volcanics (including dolerite and rhyolite) can be easily recognised over the whole area of the outcrop.[2]

Rapitan-type iron formations are interbedded with what is commonly interpreted in the mainstream literature as Neoproterozoic 'glacials'.[7] These iron formations are found in extensional grabens that are associated

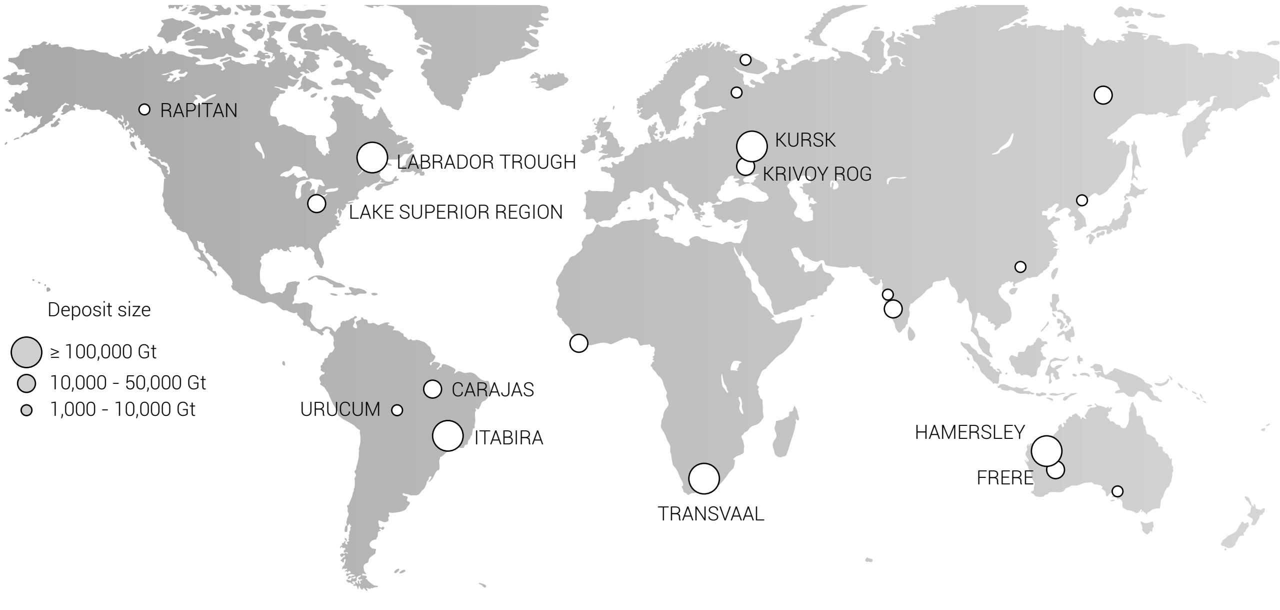

**Figure 1.** Global occurrence and size of large Precambrian BIFs. Gt = $10^9$ tonnes or billion tonnes (after Bekker *et al.*[4]).

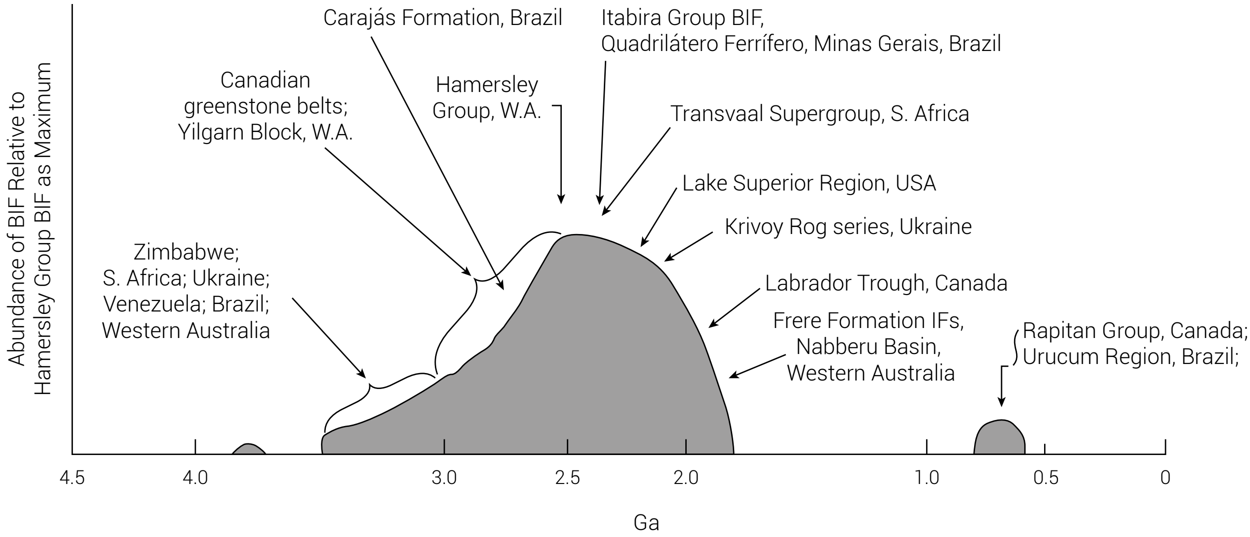

**Figure 2.** Schematic diagram indicating the relative volume of BIFs over time. A number of the major BIFs or major BIF regions are shown. Refer to figure 1 for many of their locations. Estimated abundances are relative to the Hamersley Group BIF volume which is taken as a maximum. Ga = billion years ago radiometric time (from Klein[7]).

with the initial breakup of the Rodinia supercontinent,[11] and are commonly found in association with mafic volcanics.[12]

## BIF deposition

Earlier models of BIF formation invoked the slow deposition of annual micro-laminations (chemical varves) over millions of years.[13] However, modern interpretations consider BIFs as deep-sea sediments with iron and silica sourced from reactions between circulating seawater and hot mafic to ultramafic rocks as hydrothermal systems vented onto the sea floor. Hot acidic hydrothermal fluids would *immediately* precipitate colloidal particles of iron hydroxide and iron silicates on quenching by cold neutral seawater. Episodic and rapid deposition of turbidity and density currents may have only lasted a few hours to days![9] Laboratory studies show that colloidal solutions rapidly precipitate into regular and ordered bands.[14]

Laboratory studies also show that the rate of chemical reactions increases exponentially with temperature.[15] This explains why various mineral assemblages and petroleum can form rapidly under hydrothermal conditions. High-temperature fluids can extract and transport large quantities of silica and iron from mafic igneous rocks.[9]

Episodic deposition of giant early Precambrian iron formations is emphasized by geochronologic studies, since their formation is coeval with, and genetically linked to, time periods when large igneous provinces (LIPs) were emplaced.[4] Neoproterozoic BIFs are also associated with periods of intense magmatic activity.[4]

Evidence has been put forward[16] that the thickest and most extensive Paleoproterozoic BIFs in the Hamersley Basin formed along with pulses of intense magmatism (including the emplacement of a large igneous province comprising more than 30,000 km$^3$ of volcanic rocks) driving a period of enhanced submarine hydrothermal activity. Emplacement of such an enormous volume of volcanic rocks is beyond anything happening in today's world (for example, the famous Mt St Helens on 18 May 1980 erupted only 1.2 km$^3$ (0.3 mi$^3$) of ash.[17] The description of high-energy processes, such as huge and intense volcanic activity along with enhanced hydrothermal activity, is in stark contrast to the description in the same paper of the rate of BIF deposition being compared with the gentle rate of the settling of fine sedimentary particles in the modern open ocean.

## A young-earth-creation framework for BIFs

The chemical make-up, common fine lamination, and the lack of detrital components in most BIFs suggest that they resulted from deposition as chemical sediments, below wave base, in the deeper anoxic parts of ocean basins.[7] The rare-earth element profiles of almost all BIFs, with generally pronounced positive Europium anomalies, indicate that deep ocean hydrothermal activity admixed with seawater was the source for the precipitation of the iron and silica.[7]

> *"I was there when he set the heavens in place, when he marked out the horizon on the face of the deep"* (Proverbs 8:27 NIV).

> "*Now the earth was formless and empty, darkness was over the surface of the deep, and the Spirit of God was hovering over the waters*" (Genesis 1:2 NIV).

The earth had its first global ocean (the deep) on Days 1 and 2, before the gathering of waters and appearance of land on Day 3 (Genesis 1:2–10). In Genesis 1:2 the earth would have appeared from space like a relatively smooth formless watery ball, without obvious features or landmarks such as mountains protruding above the water.[18]

> "*Or who shut in the sea with doors when it burst out from the womb*" (Job 38:8 ESV).

A common iron oxide mineral in BIFs is hematite ($Fe_2O_3$) and this may have appeared blood-coloured as if from the womb.[18] I consider that the earlier Precambrian iron formations (Algoma and Superior types) formed early in the Creation Week by catastrophic pouring out of volcanics and associated banded iron formations.[18]

The second and only other global ocean was during the peak of Noah's Flood (Genesis 7:19–20).[18] Rapitan-type iron formations are interbedded with Neoproterozoic mixtites and these mixtites are considered to represent mass flows early in Noah's Flood.[18] Geochemical data indicates that Neoproterozoic iron formations result from mixing between a hydrothermal and detrital component, while rare earth element data indicates substantial interaction with seawater.[12] I infer that the Flood's fountains, that rifted the crust open, would have provided the hydrothermal component,[19] and erosion of land caused by the Flood's rain[20] would have supplied the detrital component.

## Conclusions

Modern evidence[9] indicates that BIFs formed rapidly in deep water by catastrophic precipitation from volcanic and associated silica-rich and iron-rich hydrothermal fluids. This is consistent with my young earth model correlation of BIFs with the Bible's two occasions of globe-covering ocean—early Precambrian BIFs forming in the early Creation Week and late Precambrian BIFs forming in the initial phase of Noah's Flood.[18] BIFs are clear-cut examples of non-uniformitarianism in the earth's history;[5,6] modern analogues are unknown[4] and BIFs are restricted in time to the Archean, Paleoproterozoic, and Neoproterozoic.

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