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Post-glacial activity and earthquakes of the Great Glen Fault (Scotland)

Attività postglaciale e terremoti della Great Glen Fault (Scozia)

PICCARDI L. (*)

ABSTRACT - The article describes geologic evidence, derived from field survey, remote sensing analysis and study of digital terrain models, for post-glacial movement on the Great Glen Fault (GGF), the most pronounced tectonic structure in Scotland. It describes evidence of recent slip on the fault, which is to be found not only at one spot, but along the entire length of the structure. Fluted terrain morphologies related to the Last Glacial Maximum (ca. 28 to 18 ka BP) are truncated by slip on the fault. Moraines and fluvial deposits related to the Ardesier and Loch Lomond readvance glaciers (ca. 13 and 10 ka BP, respectively), as well as active alluvial fans, are faulted. The fault also appears capable of moderate earthquakes, like the events of 1901 (M=5) or 1816 (M=5.1).
Ancient local legends are interpreted as indicating historical seismicity of this fault. In addition, it appears that memories of an earthquake on the GGF, with epicentre between Loch Ness and Inverness, here referred to as the "St. Columba earthquake", are preserved in the 6th century legends of the journey of St. Columba in Scotland.
Activity of this fault appears to play a pivotal role in the existence of the ancient myth of the Loch Ness Monster. Previous studies at other ancient sanctuaries have concluded that relationships exist between myths, cult-sites and local seismic faults, deriving from peculiar natural phenomena on faults' trace (e.g., Delphi, Ephesus, Cnidus, Monte Sant'Angelo, and others). Direct correspondence of myth, cult-site and active fault exists also in the case of the Monster of Loch Ness, whose liar sits directly on the most seismic sector of the GGF.

KEY WORDS: Active faults, Earthquakes, Glacio-seismotectonis, Great Glen Fault, Loch Ness monster

RIASSUNTO - L'articolo, descrive evidenze geologiche di movimento post-glaciale lungo la Great Glen Fault (GGF), la struttura tettonica più marcata della Scozia, ricavate da rilievi sul terreno, analisi di telerilevamento e studi di modelli digitali del terreno.
Il lavoro mette in luce evidenze di attivazione recente della faglia visibili non in un solo punto, ma su tutta la lunghezza della struttura. Morfologie glaciali del terreno relative all'ultimo massimo glaciale (ca. 28-18 ka BP) risultano troncate dalla faglia. Morene e depositi fluviali correlati al riavanzamento dei ghiacciai Ardesier e Loch Lomond (ca. 13 e 10 ka BP, rispettivamente), così come conoidi attivi, sono dislocati dal movimento della faglia. La faglia risulta essere la probabile sorgente di eventi sismici di moderata entità quali quelli del 1901 (M=5) o 1816 (M=5.1).
Antiche leggende locali possono essere interpretate come indicazione della attività sismica recente di questa faglia. In particolare, memorie di un terremoto sulla GGF, con epicentro fra il Loch Ness e Inverness, sembrano essere presenti nelle leggende del VI sec. riguardanti il viaggio di San Colombano in Scozia. Questo evento è qui indicato come il terremoto di "San Colombano".
L'attività di questa faglia ha inoltre giocato un ruolo importante nella nascita dell'antico mito del mostro di Loch Ness. Studi precedenti hanno infatti messo in luce la corrispondenza e le relazioni esistenti fra miti, luoghi di culto e faglie sismiche locali, derivanti dai particolari fenomeni goelogici che si verificano lungo le tracce delle faglie attive (es. Delfi, Efeso, Cnido, Monte Sant'Angelo e altri). La corrispondenza diretta tra mito, luogo di culto e faglia attiva esiste anche nel caso del mostro di Loch Ness, il cui sito è ubicato direttamente nel settore a più elevata sismicità del GGF.

PAROLE CHIAVE: faglie attive, terremoti, glacio-sismotettonica, Great Glen Fault, Mostro di Loch Ness

(*) C.N.R. – Istituto di Geoscienze e Georisorse, Via G. La Pira 4, 50121 Firenze, Italy. piccardi@geo.unifi.it

1. - INTRODUCTION

In most sanctuaries of antiquity sacredness was not limited to temples and altars. Every natural feature was part of a sacred geography. A special reverence was due to seismic faults, peculiar geologic elements apparently endued with proper life, because of their association with earthquakes and related phenomena (e.g. underground sounds and rumblings, ground ruptures, lightning phenomena, sudden variations in the activity of springs, hydrothermal manifestations, etc.). These awesome and fearful aspects impressed past cultures and attracted mythological explanations, and became the kernel around which many myths nucleated. Therefore, several sanctuaries of antiquity were deliberately positioned directly above active fault traces (PICCARDI, 2001). Knowledge of earthquake geology allows us to recognize how these faults became the kernel around which a main myth nucleated during centuries. Most common attribution of these ruptures was to be gates to Hades, "*Ditis spiracula"*, Hell's mouth or Heavens' doors: in any case a passageway from the upper- to the lower-world, the fertile womb of Mother Earth (PICCARDI, 2000 a). Also, the occurrence of such unusual telluric manifestations has often induced the belief in subterranean beings, monster or divinities, and these places were indicated as dragon's lairs (PICCARDI, 2000 b).

To investigate how geological phenomena may have influenced similar legendary attribution is not easy. One can study such a remote and uncertain process only by comparative analysis of similar cases, to highlight possible analogies.

This work has a twofold aim. On the one hand, it documents for the first time clear geological evidence for post-glacial slip on the Great Glen Fault, a still much debated question. Our observations imply that the fault is capable of seismic slip, although small. On the other hand, it analyses if local legends may contain useful information on historical seismicity of the area. We finally also investigate the belief in the Loch Ness monster, and conclude that it may be similar in origin to other ancient geo-myths related to seismic faults and earthquakes (PICCARDI, 2001).

1.1. - EARTH DRAGONS AND EARTHQUAKES

The dragon of the Earth, the chthonic monster so frequently indicated as the shaker of earth, is a very ancient and complex image, common to almost all cultures in the world. This archetypal figure is the product of a long and complex cultural evolution, the slaying of these dragons reflecting a cultural/religious evolution. In fact, mayor myths show a marked religious stratification, in which new elements are over-imposed on an older structure, reworking religious traditions, symbols and rituals of a sacred place, from the pre-existing cult into the new religion. In our society this implied the conversion from pagan cults to Christianity, while in pre-historic times a similar passage occurred from the cult of chthonic Earth divinities, often related to unexplained telluric forces (Cyclops, Tytans, dragons, and so on) to a more heavenly religion (the Olympians in the Mediterranean area). The telluric creatures were subjugated by the new divinity. The underworld, once their kingdom, becomes their prison. Their sudden roars and powerful shakings continue to make the earth tremble. So we have Apep overthrown by Ra in ancient Egypt, Python slain by Apollo in Greece, Typhon overcast by Zeus in Sicily, Ravana pinned down by Shiva in India (fig. 1 A), Namazu crushed by Kashima in Japan (fig. 1 B), Michael defeating the Dragon in Italy (fig. 1 C), the Whale overcome by Thunderbird in North America, and many others.

The "sanctuaries" of these telluric monsters, guardians of the gates to Hades, were therefore necessarily related to the presence of openings on the underworld. These sacred creatures of the underworld were associated to special places, Hades' doors", indicated as their lair, their grave or the way through which they came to the surface. An interdisciplinary survey on these ancient sacred sites, performed here in particular in the East Mediterranean region, reveals that the close correspondences between the cult-sites and the local active faults, so frequently observed, appears to be intentional and significantly motivated (PICCARDI, 2001).

Myths often associate the earth-shaking dragons with a specific place, and in some case the geographical reference may become accurate, linking the myth to a specific spot. For instance, the flaming tongue of the Chimaera, indestructible fire-breathing dragon killed by Greek hero Bellerofron, remained after her death in the form of an inextinguishable flame burning methane, which exhales out of the ground along a major active fault south of Antalya (Turkey). Similarly, the Hydra of Lerna (offspring of Typhon and Echidna and sibling of Chimaera and Cerberus) had his liar in the small Alcyonian Lake, in the east coast of Peloponnesus, a famous entrance to Hades, positioned above a seismic fault (PICCARDI, 2005 a).

In many cases, sanctuaries have been built to preserve the venerated spot, so that the geologic fulcrum of the cult remains incorporated into the sacred architecture. Monte Sant'Angelo, in southern Italy, provides a brilliant example of such a kind of cult-site. Here the sanctuary was said to have been built expressly to preserve unusual "traces", not better specified in the legend, found impressed in the rock after an earthquake and interpreted as the "footprints" of Archangel Michael. The connections of the sacred place with earthquakes, clearly highlighted in the myth, find striking correspondences in local geology and arrangement of the sanctuary. The sacred "footprints" result to be small seismic fractures, interpreted as supernatural by local people, opened at the entrance of what was already a sacred cave (PICCARDI, 2005 b).

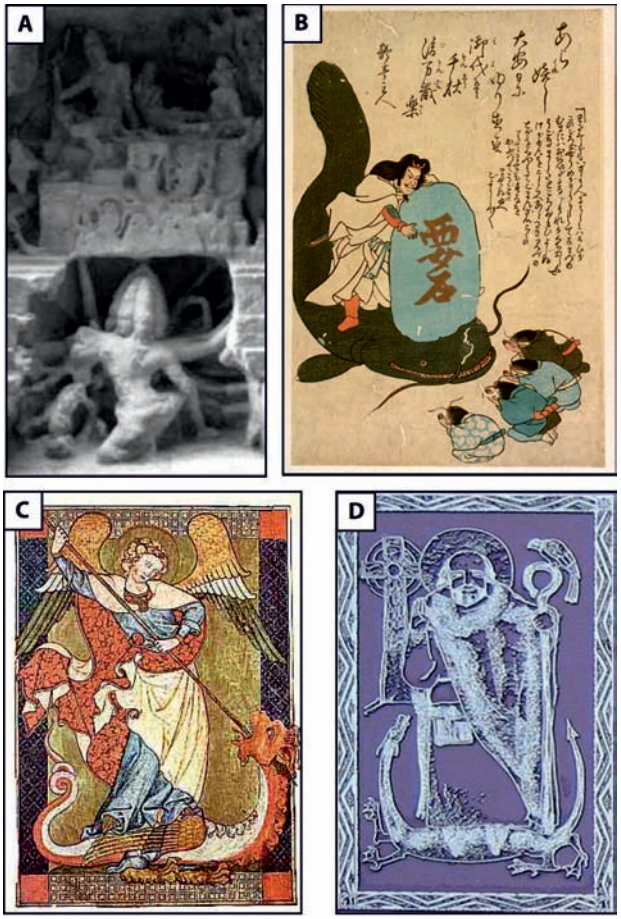

Fig. 1 - Comparative iconographies showing the defeat and subjugation of the dragon. A) Ravana shaking Mount Kailash from below (India, Ellora cave n. 16). B) The Namazu pinned down by god Kashima (Japan). C) The Dragon crushed by Archangel Michael (Italy). D) St. Columba triumphing over the Loch Ness monster (Scotland).

- Iconografie comparate che mostrano la sconfitta e la sottomissione del drago. A) Ravana che scuote da sotto il Monte Kailash (India, Ellora, grotta n. 16). B) Il Namazu schiacciato dal dio Kashima (Giappone). C) Il drago schiacciato sotto all'Arcangelo Michele (Italia). D) San Colombano trionfante sul mostro di Loch Ness (Scozia).

Apollo's Oracle at Delphi (Greece), provides the clearest, direct and explicit mention of a seismic chasm, originally sacred to Ge and the "Earth-shaker" Poseidon, as fulcrum of this most important sanctuary of antiquity. The oracle was in fact located directly on the local active fault, and the geological correspondences between the myth and local geology has been discussed in earlier works (PICCARDI, 2000 c; PICCARDI *et alii*, 2008 and references therein). The myth configures an earthquake scenario at Delphi, with the giant snake Pythone being hit by Apollo's arrow and in his agony shaking the earth. Some authors say that Python, the semi-divine dragon guardian of the oracle, lived inside the sacred chasm, others say that he was left to rot there inside, after being killed by Apollo. It was the exhalations rising from its corpse through the chasm that gave inspiration to the prophetess.

One can find the same elements of the Delphi legend (dragon-snake, earthquake, opening of the earth), although arranged with a different order within the narration, also in a palaeo-Christian legend. The Apocrypha 'Acts of Philip', which accounts for the martyrdom of the Apostle in AD 80 at Hierapolis of Phrygia (Aegean Turkey), relates a somehow similar story. The arrival of Philip is highlighted first by the apparition of a dragon, with strong earthquake and lightning, and later by the opening of a deep abyss in the earth, which swallowed 7000 men, in the middle of the city. The infernal snake-goddess, the Viper or Echidna in Hierapolis, had the chasm as the grave, just like the snake-dragon Python in Delphi. Hierapolis was then known also as Ophioryme: "Snake street" (or "street of the snake"). The city is laid directly on an active fault, which crosses the town from side to side. Just along the trace of the fault is built the main street. Both the Sanctuary of Cybele, the Plutonium, one of the most famous Hades' mouth of antiquity, and the Temple of Apollo where build bridging the trace of the seismic fault (PICCARDI, 2007).

2. - LOCH NESS AND ITS MONSTER

Among ancient dragons, one gained so much credibility to obtain the recognition of a proper biological name, *Nessiteras rhombopteryx* (SCOTT & RINES, 1976): that is the Monster of Loch Ness (Scotland), affectionately called *Nessie* (figs. 2 A, 3). Those authors published on *Nature* underwater photographs of what it was assumed to be an animal, but the photos resulted to have been manipulated with the computer.

The dragons described in the chapter above are basically earthly monsters, but they were also associated to water, lakes, and sea. Especially in Irish folk-tales, water was the domain of the other-world, and lakes were frequently regarded as passageways between the two worlds.

Loch Ness, 39 km-long, less than 2 km-large and with a surface area of more than 56 km² (figs. 2 A, 3 B), is the second largest lake in Britain, after Loch Lomond. Its surface elevation is about 16 m a.s.l. Due to its great depth it is the largest reservoir by volume (7.4 km^3). Its deepest point is 230 m.

Apart from the modern apparitions of Nessie, the Loch Ness was famous in the past for another unusual feature that made it to be regarded as 'peculiar' among the other lakes. This is the fact that it does not freeze over in winter. It may be due to relevant processes of thermal convection, which are possible here because of the great amount of water in this extremely deep lake. This fact was so peculiar and relevant, that it was specifically reported on most maps of Scotland between 17th and 19th century, with the quotation: "*The Loch Ness and the river Ness never frozen in winter*" (fig. 3 C) (ORTELIUS, 1573; MERCATORE, 1595; SPEED, 1610;

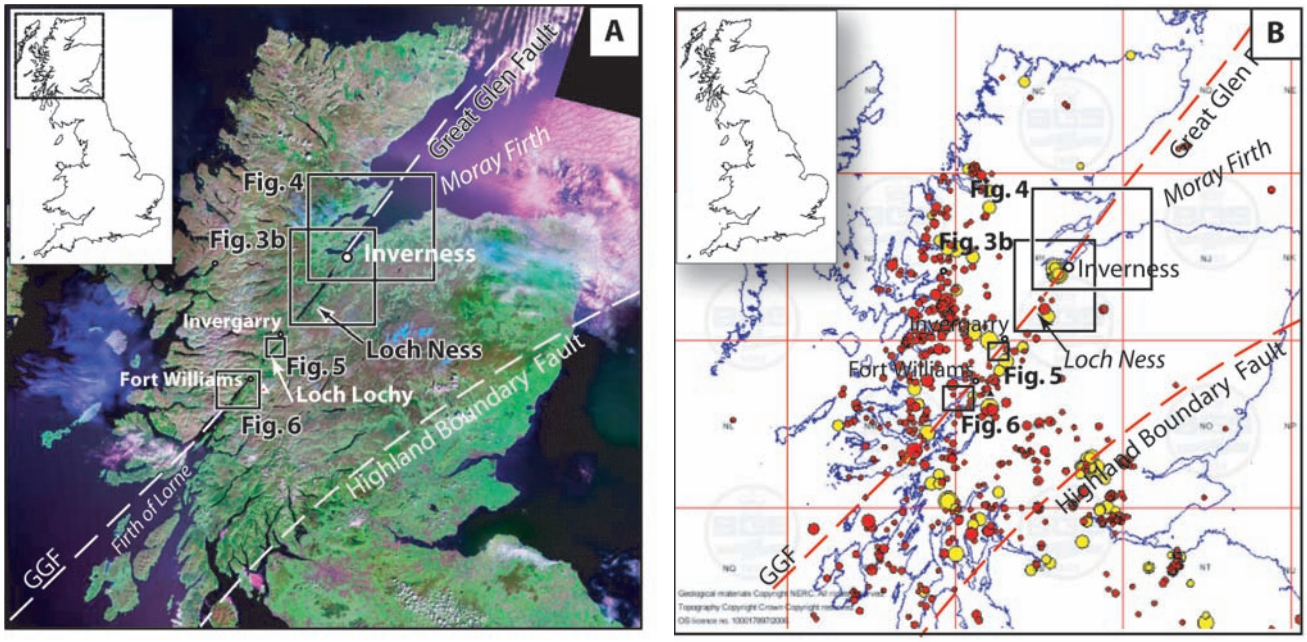

Fig. 2 - A) Landsat image of Scottish Highlands, showing the Great Glen Fault, the most prominent tectonic structure of Scotland. B) Seismicity of Scottish Highlands, data from British Geological Survey "Interactive UK earthquake map" (www.earthquakes.bgs.ac.uk). Many instrumentally recorded seismic events, al least until 1994, could be reliably located to only within 30 to of their epicentres (MUSSON, 1994).

- A) Immagine Landsat delle Highlands scozzesi, con evidenziata la Great Glen Fault, la struttura tettonica più marcata in Scozia. B) Sismicità delle Highlands scozzesi, dati da "Interactive UK earthquake map" del British Geological Survey (www.earthquakes.bgs.ac.uk). Molti eventi sismici registrati strumentalmente potevano essere ubicati, almeno fino al 1994, solo con una approssimazione del loro epicentro da 15 a 30 km (MUSSON, 1994).

HONDIUS 1636; CORONELLI, 1696; available on www.maps.nls.uk/scotland).

2.1. - NESSIE SIGHTINGS

The modern belief in Nessie mostly spread out in 1933, after the road A82 was opened to traffic allowing travel along the coast of the lake. Famous sightings, such as the so-called "surgeon's photo" in 1934, consolidated its iconography as the long necked plesiosaurus familiar to most of us. Since then, there have been a large number of alleged sightings of the monster, but none has produced convincing evidence of a beast. The photographs taken above water are all quite different, showing a variety of creatures of different size and shape. Differing from what one could expect, the number of sightings seems to go down the more the Loch is visited, so that we have now less pictures documenting Nessie than in the early years of the phenomenon.

MACKAL (1976) studied a collection of ca. 10,000 reported sightings, the strongest evidence being by a long the eyewitness reports. Out of these, after critical examination, he reduced the number of valid observations, meaning that could not be accounted for by any other simple explanation, to less than 250. Excluding from these deliberate hoaxes, misinterpreted spotting of animals or objects, and mirages due to air refraction (e.g. LEHN, 1979), the predominance of sightings resulted related to anomalous wave-wakes.

2.2. - LOCH NESS AND THE GREAT GLEN FAULT (GGF)

Loch Ness is positioned directly on top of the Great Glen Fault (figs. 2, 3B). One could more properly say that the lake is positioned directly within the fault zone itself.

The Great Glen Fault is a major crustal subvertical, SW-NE oriented strike slip fault, deriving from Caledonian orogeny, which extends for a distance of about 500 km. It goes from the Inner Hebrides to the Shetland offshore in the north. The fault separates, the Northern Highlands, to the northwest, from the Grampian Highlands, in the southeast. It divides the predominantly Moine rocks of the Northern Highland Terrane from the Dalradian rocks of the Central Highland Terrane to the south. The present architecture of the fault zone might represent a positive flower structure formed during regional sinistral transpression (STEWART *et alii*, 1999). The history of strike slip of the GGF system has been complex, with multiple reactivations. Predominant displacement seems to have been a sinistral shear in its earlier Caledonian stages (between ca. 430 and 390 Ma), and dextral offset after deposition of the Old Red Sandstone in Devonian (KENNEDY, 1946; ROGERS *et alii*, 1989; STEWART *et alii*, 1999).

The GGF represents, together with the Highland Boundary Fault (HBF), one of the major geological features of Scotland.

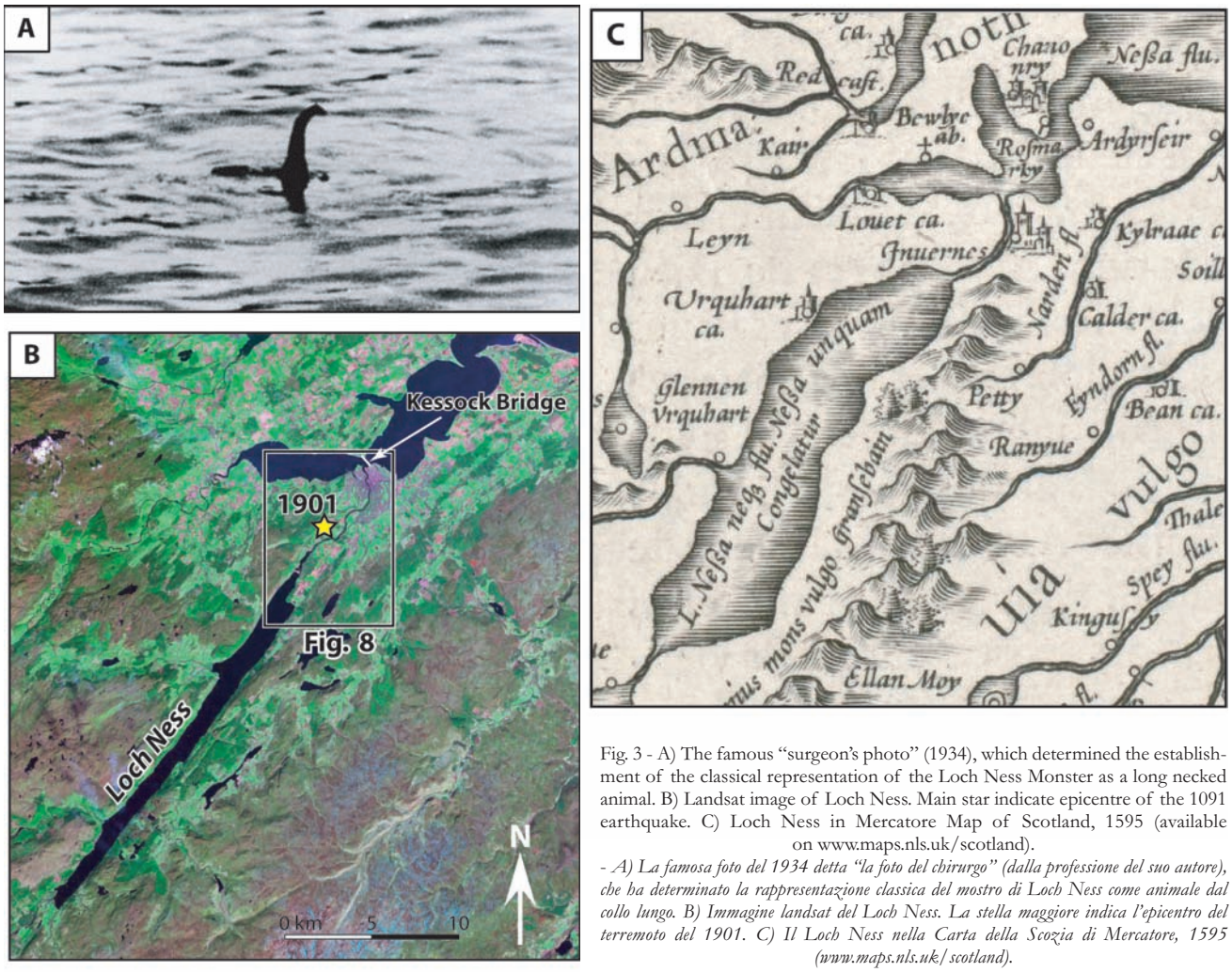

Fig. 3 - A) The famous "surgeon's photo" (1934), which determined the establishment of the classical representation of the Loch Ness Monster as a long necked animal. B) Landsat image of Loch Ness. Main star indicate epicentre of the 1091 earthquake. C) Loch Ness in Mercatore Map of Scotland, 1595 (available on www.maps.nls.uk/scotland).

- A) La famosa foto del 1934 detta "la foto del chirurgo" (dalla professione del suo autore), che ha determinato la rappresentazione classica del mostro di Loch Ness come animale dal collo lungo. B) Immagine landsat del Loch Ness. La stella maggiore indica l'epicentro del terremoto del 1901. C) Il Loch Ness nella Carta della Scozia di Mercatore, 1595 (www.maps.nls.uk/scotland).

3. - IS THE GREAT GLEN FAULT ACTIVE?

Historical and instrumental seismicity in northern Britain presents a complex pattern. Seismicity is known to be strongly influenced by glacio-isostatic readjustment following deglaciation (Musson, 1996; Stewart *et alii*, 2000; Firth & Stewart, 2000). Musson (1996) infers that a number of minor ancient faults reactivated by these changes would have remained active where favourably oriented with respect to the present crustal stress regime. Postglacial rebound also affects the current stress regime deriving from the Mid-Atlantic ridge-push force, which results rotated from the expected NW-SE directed one (Stewart *et alii*, 2000; Ottermöller & Thomas, 2007). Extensive postglacial reactivation of short segments (1–14 km) of major basement faults is also documented (Davenport & Ringrose, 1987; Ringrose *et alii*, 1991). Although being only short fault segments, slip rates can be relevant.

Geological analysis of suspected active faults in Scotland has often produced ambiguous results, such as in the case of the Kinloch Hourn fault, where researchers have reached different opinions (Ringrose, 1989; Stewart *et alii*, 2001). Nevertheless, there is a general consensus that a phase of enhanced seismic activity occurred immediately following deglaciation, about 13000 years BP, and there is evidence that postglacial rebound, in certain areas, has been accomodated by block uplift along pre-existing faults rather than only by regional tilting (Davenport & Ringrose, 1987; Stewart *et alii*, 2000; Firth & Stewart, 2000; Stewart *et alii*, 2001; Stoker & Bradwell, 2009). Davenport & Ringrose (1987) argued that micro-earthquake activity in Scotland cluster along major NE-SW trending Caledonian basement faults, like the Ben Nevis seismic zone close to the Great Glen Fault and parallel to it.

Occurrence of seismic slip on the Great Glen Fault is still a matter of debate. Some authors maintain that UK geology bears no relation to the observed seismicity of the last 300 years, and that it is impossible to identify any demonstrably active faults (Browitt *et alii*, 1985; Musson, 1994, 1996 and 1997). They argue that the two roughly parallel major faults, the GGF and the Highland Boundary Fault (HBF in figure 2), do not

show sign of present activity (MUSSON 1996, 1997, 2001). They attribute, for instance, the 1901 earthquake to a N-S oriented fault, supposed but apparently not otherwise documented, splaying from the GGF in the vicinity of Inverness (MUSSON, 1996, 1997; MUSSON, 2001). Most authors consider instead the GGF to be active and capable of seismic slip, as for instance in the 1901 event (DAVISON, 1906, 1924; KENNEDY, 1946; LILWALL, 1976; WILLMORE *et alii*, 1977; PRENCE, 1995; COOPER & O'SULLIVAN, 1998; STEWART *et alii*, 1999; OTTERMÖLLER & THOMAS, 2007). STEWART *et alii* (1999), describe earthquake-related slump structures in unconsolidated glacial deposits adjacent to the shear zone, as evidence of present activity of the GGF. A chaotic layer ca. 35 cm thick, located at ca. 1.2 m depth, found in two drillings in the sediments at the bottom of Loch Ness, has been attributed to a slumping event from the steep lake shores about 4000 yr BP (COOPER & O'SULLIVAN, 1998). Also other studies have indicated that these two major faults, the GGF and the HBF, are active structures. In particular, OTTERMÖLLER & THOMAS (2007), studying the Aberfoyle earthquake sequence of June-September 2003, concluded that the WSW–ENE striking causative fault was associated with the HBF zone.

Although many earthquakes initially located in the Great Glen, like the 1934 event (August 16, M=4.1), have been later relocated (MUSSON, 1994), the area between Loch Ness and Inverness remains one of the most seismically active ones in Great Britain. In the last two centuries, at least three earthquakes hit this area (www.earthquakes.bgs.ac.uk): in 1816 (August 13, M = 5.1, the strongest shock in Scotland), in 1890 (November 16, M = 3.5) and in 1901 (September 18, I=VIII, M = 5).

The September 18, 1901 Inverness earthquake (Mk=5) deserves particular attention because it is the second strongest event in Scotland, and a large amount of first-hand macroseismic data is available (figs. 3B and 8). The area was the object of a careful post-seismic survey, and the seismic sequence and its effects were monitored by contemporaneous witness and described in detail (e.g. DAVISON, 1906). There was about ten foreshocks and a very large number of aftershocks (more than 50), whose sequence continued until 12 November 1901 (MUSSON *et alii*, 1987). According to the macro-seismic observations, the earthquake was due to slip on the Great Glen Fault, and the fault had a vertical slip, albeit minimal, with downthrown of its southern block (DAVISON, 1905, 1906, 1915). The epicentre was determined about 2.5 km ENE of Dochgarroch (figs. 3 B and 8). The focus of the tremor extended for about 8 km, from Loch Ness to Inverness. A break in the ground, a few cm wide and about 500 m long, was described along the northern bank of the Canal (v. fig. 8). Although surface faulting was excluded as origin of this crack, it indicates the maximum intensity area.

Because of the uncertainties of epicentre locations ranging between 15 to 30 km until 1994 (MUSSON, 1994), it has often been difficult to assign single shocks to a determined fault. The recent earthquake of October 4, 2013, with a ML = 2.4, has instead been precisely located (www.earthquakes.bgs.ac.uk/earthquakes/recent_events/20131004204901.html#page=additional). It occurred on the west bank of Loch Ness, at the very shallow depth of 2 km, at the head of Urquhart Bay, which associate it with the Great Glen Fault. The shock was felt up to 25 km from the epicentre all along the Loch Ness and Inverness area. Associated to ground shaking, many people described a sound like "*a big rumbling bang*", "*an explosion*" or "*a loud rumble*".
(www.earthquakes.bgs.ac.uk/earthquakes/recent_events/.

Despite the great interest for assessing active slip on the GGF, discussion has generally been based on speculations about epicentre locations (e.g. MUSSON, 1997), and little field investigation has been devoted to this specific aim. Much of the debate also focused in trying to distinguish between seismotectonic and glacio-seismotectonic activity, that is movement on faults due to regional tectonics or due to post-glacial isostatic rebound. Defining the triggering cause of the movement remains beyond the scope of the present work. The area is subject to tectonic stress due both to expansion of Atlantic Ocean and to glacial rebound, and most quakes are likely to be the result of the interplay between these forces. The aim of the paper is only to assess whether post-glacial movement may have occurred on the GGF, i.e. if the fault is active and may therefore originate earthquakes, although moderate. Our observations are consistent with the fact that at least some slip may still presently occurs along the GGF, either due to tectonic stress or/and to postglacial rebound.

3.1. - EVIDENCE FOR POST-GLACIAL MOVEMENT ON THE GREAT GLEN FAULT

The Great Glen, the most prominent valley in Scotland, is a rectilinear deep valley that runs for over 100 km between Fort Williams and Inverness along the GGF zone. Much of the fault zone is submerged beneath a series of elongated lakes. It is a fact that most of present-day morphology of the Great Glen results from enhancement due to glacial erosion along the shattered rock of the fault zone, but this process alone cannot explain all of the present-day morphologies visible along the fault.

This paper presents geologic and geomorphic data to show that slip, although at a slow rate, occurs along the GGF. Although movement may take place by independent reactivation of blocks, evidence of slip is to be seen all along the fault. Examples from key sites are described here below.

In the northeast sector the effects of ice-sheet flow and single glaciers are well preserved and constrained (fig. 4). The two sides of the GGF are visibly asymmetric, with a sharp rectilinear cliff on the north but not on the south. Ice stream flow during the Last Glacial Maximum (LGM) is documented by the diffused and consistent glacial streamlined landforms, such as flutings and drumlins (e.g. CLARK *et alii*, 2004; FINLAYSON &

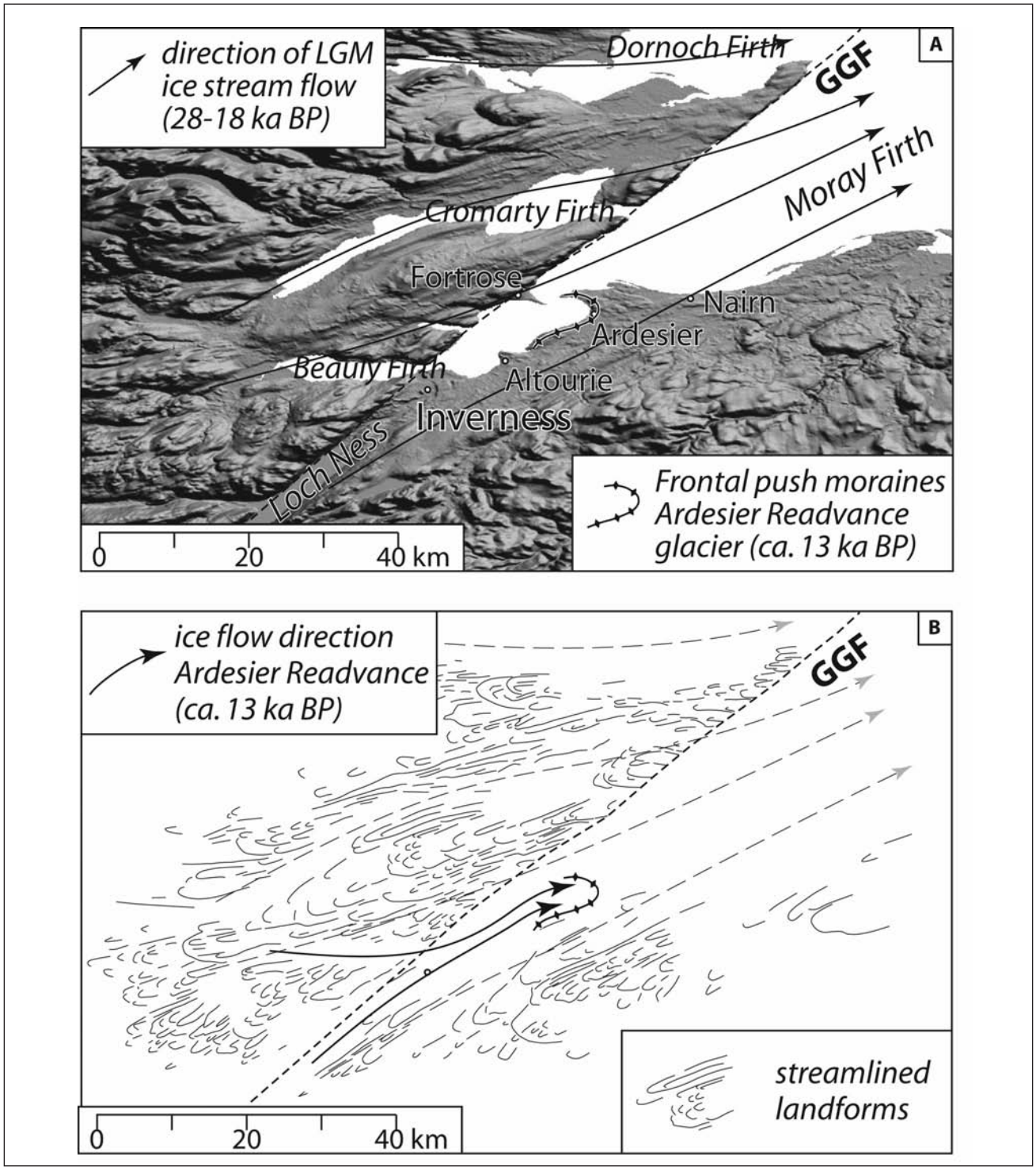

Fig. 4 - A) Digital elevation model of the Loch Ness-Moray Firth area, derived from the USGS/NASA SRTM data (JARVIS *et alii*, 2008), elaborated with Global Mapper v8.01. Flutings and drumlins fields document the flow direction of the Moray Firth Ice Stream. B) Schematic representation of streamlined landforms truncated by the Great Glen Fault, and flow direction of the Ardesier glacier.

*- A) Modello digitale del terreno dell'area Loch Ness-Moray Firth, dati USGS/NASA SRTM (JARVIS et alii, 2008) elaborati con Global Mapper v8.01. morfologie glaciali (*flutings and drumlins*) documentano la direzione di flusso della corrente glaciale di Moray Firth. B) Rappresentazione schematica delle morfologie glaciali troncate dalla Great Glen Fault, e la direzione di flusso del ghiacciaio di Ardesier.*

BRADWELL, 2008). Fluted morphologies make an angle with the fault, resulting truncated in correspondence of it. This demonstrates the independence of this escarpment from ice flow pattern and relative scouring, constraining activity of the GGF to be at least post-Last Glacial Maximum (LGM, from about 28 to 18 ka BP, e.g. EVANS *et alii*, 2005). Such linear cliff cannot be due to sea erosion. Nor it can be due to action of the readvancing Ardesier glacier shortly after 13000 years BP. Decay of the main Late Devensian ice sheet was interrupted by a series of readvances and stillstands. During the Ardesier Readvance (ca. 13 ka BP), ice flowed via the Beauly Firth and Great Glen to create the ice-pushed front moraines forming the curved Ardesier Peninsula (e.g. PEACOCK & HARKNESS, 1990; MERRIT *et alii*, 1995). The GGF escarpment results uninfluenced by extent of that glacier. Moreover, NE of Inverness at Fortrose, and SW of it between Dochgarroch and Torvean, the fault trace is marked by a scarp at the contact between the substratum and the glacial deposits, consistent with post-13 ka BP activity of the GGF. Also the bottlenecks of the Beauly and Cromarty Firths glacial valleys at crossing the fault, provide further indication of post-glacial uplift of the GGF.

In the central sector of the Great Glen, the clearest example of faulted active alluvial fan is at Kilfinnan (Loch Lochy, figure 5). A fault scarp marks its contact with the bedrock, offsetting the concave slope profile of the glacial valley. The fan is also dissected by faults farther to the south. In particular, in the middle of the

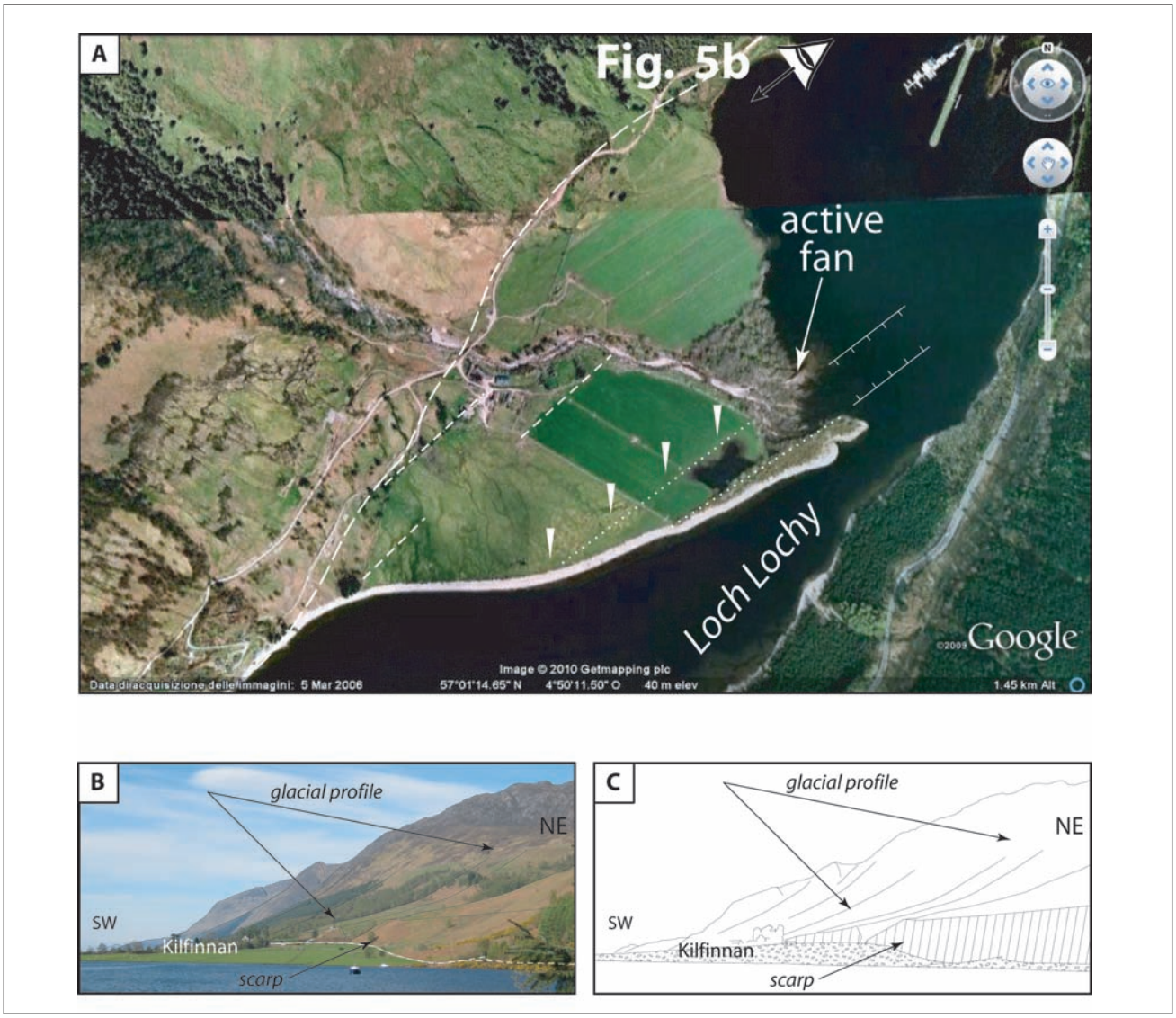

Fig. 5 - Faulted active alluvial deposits at Kilfinnan, Loch Lochy. This area is close to the epicentres of 1597 (July 23, M = 4.6), 1839 (March 20, M = 3.2) and 1946 (December 25, M = 4.1). A) The alluvial fan, the largest cone in the Great Glen, covers the valley floor from side to side, resting in less than 10 m deep water. Loch Lochaidh, the gaelic version of Loch Lochy, means "Lake of the Black Goddess". B) and C) View of the mountain front and Kilfinnan debris fan from the north-east. - *Conoide attiva fagliata a Kilfinnan, Loch Lochy. Questa area è vicina agli epicentri del 1597(23 luglio, M=4.6), 1839 (20 marzo, M=3.2) e 1946 (25 dicembre, M=4.1). A) La conoide alluvionale, la più grande nella Great Glen, copre il fondovalle da parte a parte, con una profondità dell'acqua di meno di 10 m. Loch Lochaidh, la versione gaelica di Loch Lochy, significa "lago della Dea Nera". B) e C) Vista da nord-est del versante e della conoide di Kilfinnan.*

valley, a small graben structure, making an angle with the main direction of GGF, controls on-going deposition. This attests the present-day activity of these faults.

Also in the southwest sector there is a marked asymmetry, with a well developed rectilinear and faceted mountain front on the north side of GGF but not to the south (fig. 6). Evidence for Holocene movement on the fault is visible at Corran Narrow (Loch Linnhe).

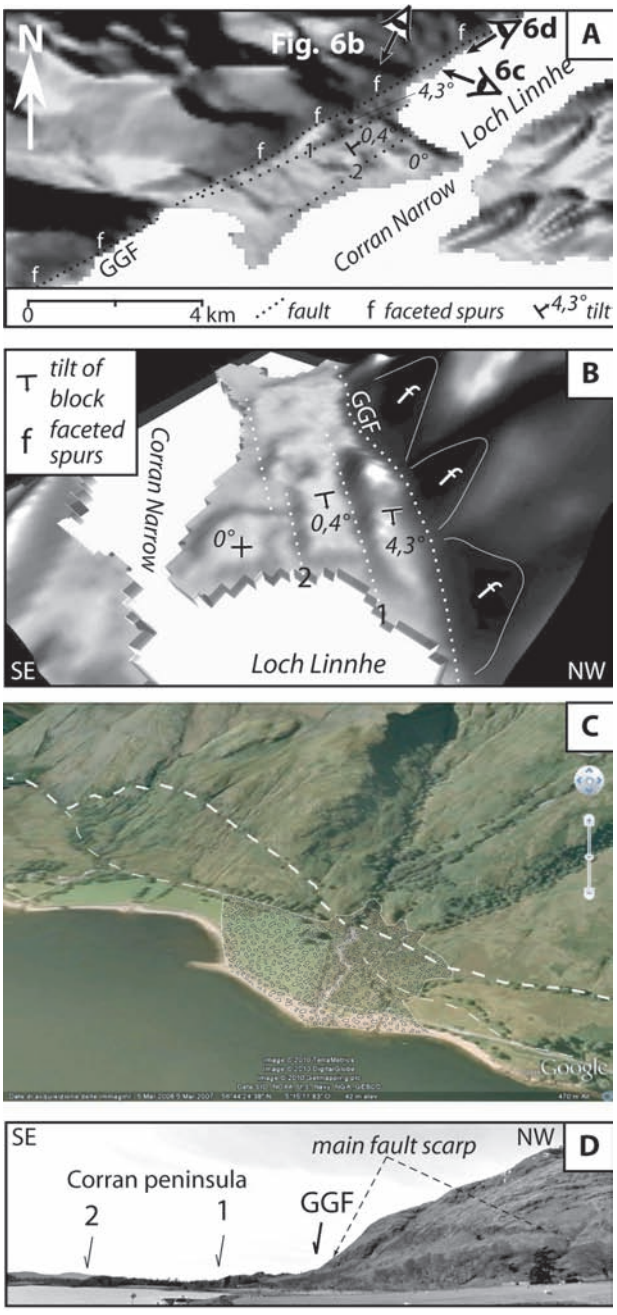

Fig. 6 - A) and B) DEM of Loch Linnhe area, with detail on Corran Narrow showing the faulted fluvio-glacial deposits (dip of blocks surface derived from profiles on DEM). C) Active debris cone is faulted. D) Panorama on the fault zone looking to the SW.

- A) e B) modello digitale del terreno dell'area del Loch Linnhe, con dettaglio sullo Stretto di Corran con evidenziati i depositi fluvio-glaciali fagliati (l'inclinazione dei blocchi è calcolata su profili ricavati dal modello digitale del terreno). C) Cono di detriti attivo fagliato. D) Panorama sulla zona di faglia verso sud-ovest.

The curved belt of gravel deposit forming the peninsula of Corran are a fluvio-glacial outwash fan, deposited during a standstill in the retreat of the Loch Lomond readvance glacier (ca. 10 ka BP; e.g. McCann, 1961; Sisson, 1974; Ballantyne, 2002). The Corran peninsula has a stepped morphology, created by faults. The tectonic origin of this morphology is also confirmed by the different tilting of blocks individuated by these faults, with tilt progressively decreasing toward the middle of the valley. Also here active alluvial fans appear faulted by the GGF.

4. - NESSIE AND THE "ST. COLUMBA EARTHQUAKE"

The Loch Ness myth derives from the pre-Christian culture of the Picts. Folk belief associated monstrous beings with rivers and lakes. Christianization was accompanied by number of Saints who conquered dragons in lakes or chained them to the bottom of the water. Hence the common place-name of "*Loch na piast*", "Lake of the monster" (MacCulloch, 1991). The pagan Picts (meaning the "Painted People"), made extensive use of animal symbols, both for their body tattooing and in stone carving. These were sacred symbols with totemistic tribal significance (McCulloch, 1991). All pictish symbol creatures represent actual animals, except for the kelpie, who alone makes up about 40% of all animal symbols found. Its large diffusion attests for its great importance, so that it may have represented the office of kingship (Sutherland, 1994).

Nessie appears to be the reflection of the primitive belief in the *kelpie,* or *eich uisge* ("water horse") (figs. 7 A, B), which dominated Scottish folklore and was believed to inhabit many Scottish and Irish lakes (Sutherland, 1994). The belief in the mythological sea-horses, or hippocampus, was also diffused all over the Mediterranean. In Greek Roman mythology they were Poseidon's horses, and Poseidon was the god of earthquakes (e.g. Nur, 2000) (fig. 7 C).

The Inverness area, between Loch Ness and Moray Firth, is also the area where the main original myth of the Loch Ness developed (figs. 3 B and 8). The first mention of the Loch Ness monster is reported in Adamnan's biography of St. Columba, written about 696 AD, which describes events which took place more than one century before (e.g. Sharpe, 1995). Adamnan principally retells stories which were handed down within his own community of monks, but also deriving from a wider oral tradition about the Saint, which reworked more popular folk-tales. These popular traditions are known to have been used in particular in the accounts of the visit of St. Columba to the king of the Picts, while approaching his castle, when he had to engage conflict with the pagan wizards of the king (e.g. Sharpe, 1995).

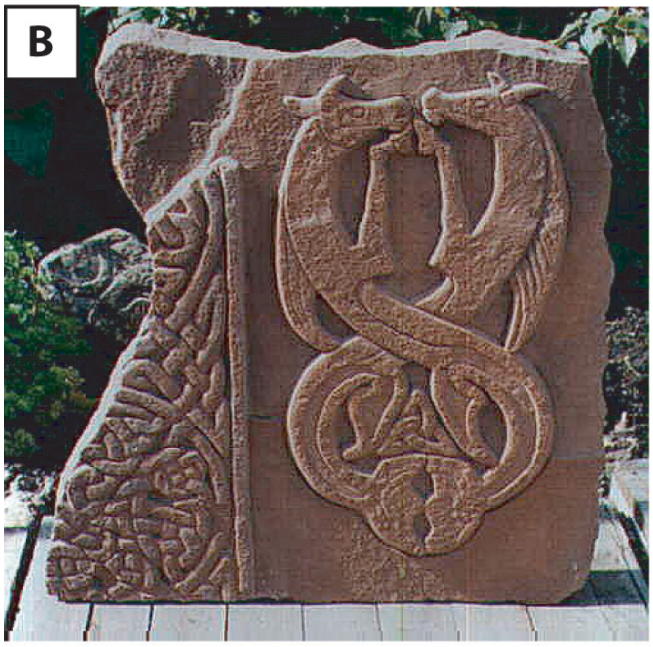

Fig. 7 - A) and B). The *kelpie*, or water horse, the sacred beast of the Picts who inhabited lakes, from whom derives the modern Loch Ness monster (e.g. SHARPE, 1995). C). The "water-horses", or hippocampus (hippos – horse, and kampos - sea monster), in greek-roman mythology drew the chariot of Poseidon, god of earthquakes. The triumph the St. Columba over the kelpie is a metaphor for the conversion of pagan cults.

- A) e B) Il "kelpie", o "cavallo d'acqua", la bestia sacra dei Picti che ritenevano abitasse i laghi e dalla quale deriva il moderno mostro di Loch Ness (e.g. SHARPE, 1995). C) Il "cavallo d'acqua", o "hippocampus" ("hippos"-cavallo, e "kampos"-mostro marino), nella mitologia greco-romana trainava il carro di Poseidone, dio dei terremoti. Il trionfo di San Colombano sul kelpie è una metafora della conversion dei culti pagani.

According to tradition, St Columba (ca. 521–597 AD) set out from Ireland to spread Christianity across pagan Scotland in about 567 AD. During this time the saint is said to have paid visit to King Bridei (or Brude) who ruled Pictland about from 550 to 580. The King had his fortress just above River Ness. Some scholars suggest this castle to have been sited in the centre of Inverness, or at Torvean south of it, but most authors identify this fort with Craig Phadrig, built in 4th century BC and still occupied in 6th century AD (SUTHERLAND, 1994; SHARPE, 1995) (fig. 8).

Three episodes of this visit are of particular relevance to understand the myth and its geologic origins. In these episodes, all of them occurred in the nearby of King Bridei's castle, the area between the Loch Ness and Inverness is associated with earth tremors and related phenomaena, in particular seismic sounds. The first episode (a in figure 8) is the account of the encounter of St. Columba with the monster. This encounter took place not in Loch Ness, as commonly maintained, but indeed in River Ness. The legend says that, on his way to King Bridei's fortress, Columba encountered some locals burying one of their own people, killed by a creature in the River Ness (*Life*, 2-28; Appendix A). The dead man's boat lay on the other side of the water, so Columba ordered one of his followers to swim over and retrieve the boat. As the man was then attacked by the monster, Columba, in the name of God, commanded the beast to return to whence it came and it vanished beneath the water leaving the swimming man unharmed. In the original Latin version of the legend, the monster is described to appear "*cum ingenti fremitu*" (with an "*awful roar*"), and to disappear "*tremefacta*" (shaking herself).

The second episode (b in figure 8) occurred near the castle as a contest with the pagan wizards, just before the arrival of the saint to the fort. It is said that suddenly the voice of the saint "*was miraculously lifted up in the air like some terrible thunder, so that the king and his people were filled with unbearable fear*" (*Life*, 1-35; Appendix B).

The third event (c in figure 8) occurred at the castle's gate, that the king wanted to keep close to the saint, but the saint made a sign of the cross "*At once the bars were thrust back and the doors opened of themselves with all speed*" (*Life*, 2-38; Appendix C).

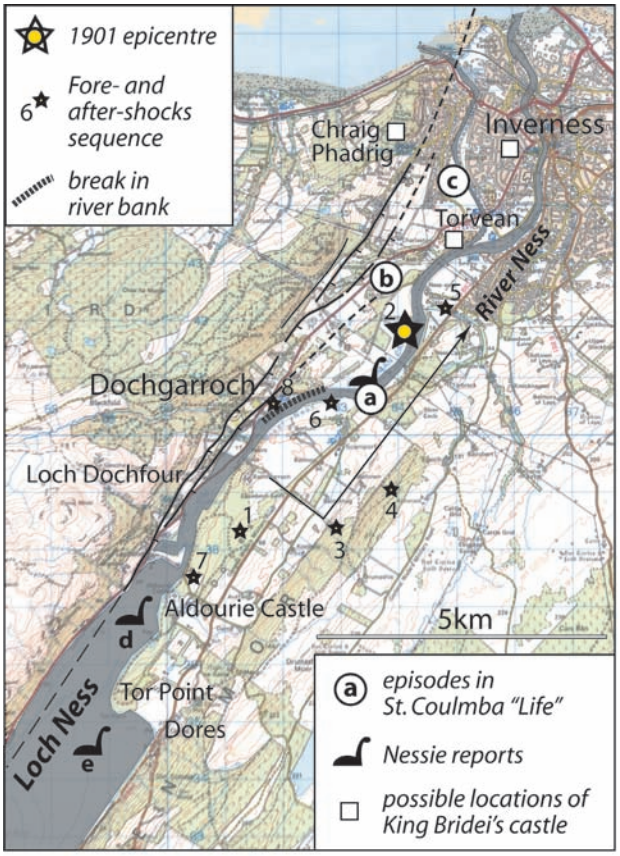

Fig. 8 - Epicentre area of the September 18, 1901 earthquake (M=5). The seismic sequence continued until November 12, (e.g. DAVISON, 1906). The focus of the tremor extended for about 8 km. A few cm wide and about 500 m long break in the ground, along the northern bank of the Canal.
- Area epicentrale del terremoto del 18 settembre 1901 (M=5). La sequenza sismica è continuata fino al 12 novembre (e.g. DAVISON, 1906). Fu stimata una estensione di circa 8 km per la sorgente del terremoto. Lungo la banchina settentrionale del canale si aprì una rottura nel terreno larga alcuni centimetri e lunga circa 500 m.

The first episode makes direct reference to loud roar and shakings. The occurrence of loud sounds (first and second episodes) in connection with earthquakes (first episode) is a common phenomenon in this area, just as everywhere else. These sounds are sometimes associated also to shocks sometimes too small to be perceived by men. Seismic rumours were particularly strong during the 1901 earthquake, and the sounds were compared to "*thunder, explosions, passing wagons or loads of stone falling*" (DAVISON, 1905, 1906, 1938). It was "*like a distant thunder*" during the 1816 earthquake (PRENCE, 1995). A similar noise was reported recently during the Forth Williams earthquake of 10 December 2005, "*sounding like a heavy clap of thunder, a gust of wind or even a quarry blast*" (www.earthquakes.bgs.ac.uk/earthquakes/reports). Also the third account finds correspondence in modern moderate earthquakes: for example, during the event of March 23, 1839 (M = 3.2) "*felt from Glen Garry to Kingussie. The shock was apparently strong enough to unlatch doors at Invergarry*" (www.earthquakes.bgs.ac.uk/earthquakes/historical).

5. - DISCUSSION AND CONCLUSIVE REMARKS

Comparative analysis of similar sacred landscapes demonstrates that active faults, due to the extraordinary phenomena which might be experienced at the surface, especially along the fault trace, may have been regarded as sacred places, and the phenomena observed there often induced the belief in chthonic monsters, worshiped in prehistorical times (PICCARDI, 2000a, 2000b, and 2001).

Both due to glacio-seismotectonics or direct crustal stress, nonetheless it appears that moderate earthquakes may originate on the GGF. Earthquakes hit more frequently the area between Inverness and Loch Ness. One can infer that activity of the GGF played a pivotal role in the ancient myth of the monster in the lake, same as in other similar cases (e.g. PICCARDI, 2001). Some of modern spottings of Nessie may as well have been due to disturbances observed at the otherwise extremely calm water surface of the Loch Ness. This can be due directly to the seismic fault or to seismicity in the nearby region.

The beginning of the modern belief in Loch Ness monster (March 1933) occurred in a period not far from one of the main seismic periods in the Highlands, culminated in the earthquake of August 16, 1934. It is therefore possible that some solicitation may have affected the lake surface. The Inverness Courier, for instance, shows the concomitance between earthquakes activity and monster spotting during the 1934 earthquake. At page. 5 of the issue of August 17, 1934, one can find the description of the earthquake in Inverness, and on the facing page 4 the report of a monster spotting.

In the more credited reports, in fact, the witnesses only saw a violent commotion of the water and anomalous wave-wakes, without a clear vision of the alleged beast supposed to have originated it. Two examples will help to clarify this fact. The first one is the report from north of Tor Point (location d in figure 8, text in Appendix D), which sparked off the modern popularity of belief in Nessie, which describes a "*a violent commotion in the mirror-like surface*" of the water. The second one south of Tor Point (site e in figure 8, text in Appendix E) is even more significant because although the water disturbance came in contact to fishermen, hitting their boat, they could not see any beast below it, because "*the wash hid the 'creature' from view*".

Peculiar phenomena at the Loch Ness are known to occur in connection with earthquake, even with very distant ones. For instance, the lake experienced a notable *seiche* as a consequence of the 1755 Lisbon earthquake (e.g. PRENCE, 1995). In another case, during the 1890 earthquake, the ferryman of the Kessock Ferry (from Inverness to the Black Isle) reported that they found their boat suddenly driven along toward the shore (PRENCE, 1995).

The story of St Columba's triumph over the most important Pictish sacred-beast, symbol of kingship, although being a metaphor for the subjugation of the old

religion, nevertheless contains information on an ancient sacred belief, based on telluric manifestations and localized at River Ness, the dragon's lair. It cannot be ignored that this place is the sector of the Great Glen Fault more frequently hit by the strongest earthquake in the past (fig. 3B). The localization of the victory of the Saint over the *kelpie* at this site, points to this place as particularly important in the ancient cult at that time, indicating that this area was already experienced at that time as a seismic one.

The GGF shows geologic and geomorphic evidence of active slip, although at a slow rate, and may generate moderate earthquakes. In the NE sector of GGF, the fault post-date both the streamlined landforms of Last Glacial Maximum (28-18 ka BP), as well as the Ardesier readvance moraines and the glacial deposits SW of Inverness (ca. 13 ka BP). Dissected glacio-fluvial deposits at Corran Narrow indicate slip on the fault to post-date the Loch Lomond readvance phase (10 ka BP). Faulted active alluvial fans at Loch Lochy and Loch Linnhe, central and southwest sectors respectively, reveal that movement is still ongoing.

In fact, the Kessock Bridge (fig. 3B), opened in 1982 to carry the A9 road north from Inverness to the Black Isle across the Great Glen Fault, is the only bridge in Great Britain built with anti-earthquake buffers, installed in the north abutment, right above the fault. Similarly, a project for a sewage water seabed pipeline straddling the GGF line at Kessock has been designed, in September 2008, with a degree of flexibility to cope with earthquakes.

Major evidence of active slip occur on the northern side of the GGF, a south facing sub-vertical fault, which seems therefore to be the main active fault of the GGF system. The possible inference of a small component of dextral slip, as could be envisaged by arrangement of splay structures (figs. 5 and 8), remains speculative.

We cannot unambiguously discern if an earthquake actually occurred at the time of St. Columba, or if the story reworked instead folk-tales containing memories of a past earthquake. Both possibilities remain open. Nevertheless, this legend reveals that an earthquake may have occurred about that time, or little earlier, with epicentre in the area of River Ness, where the episodes are located. The phenomena reported in the legend correspond to facts historically observed here during earthquakes of magnitude 3 to 5, like codified images of real seismic phenomena. This event, that we may indicate as the "St. Columba earthquake", appears therefore to be somehow similar to the 1901 event, documenting an ancient (6th century?) seismic slip on the Great Glen Fault.

Some of modern spotting of the Nessie may as well have been due to disturbances observed at the otherwise extremely calm water surface of the Loch Ness. This can be due directly to the seismic fault or to seismicity in the nearby region (or even distant, as in the case of the local *seiche* consequent to the 1755, Lisbon earthquake (e.g. PRENCE, 1995).

5.1. - OTHER EXAMPLES OF TELLURIC FAMOUS LAKE MONSTERS

In concluding this examination, one can shortly indicate, between the many claimed lake monsters around the world, two of the most famous cases, which are somehow similar to the Loch Ness case. These cases help to understand how the relation between unexplained sightings in lakes may be related to geologic activity, and in particular how such a legendary indication at a certain place may be a sign of ongoing geologic activity and inform on related natural hazard.

One of the most cited lake monster is the one said to live in Van Lake, in the far east of Turkey (fig. 9). Van Lake is the largest lake in Turkey. It is 119 kilometres across at its widest point, averaging a depth of 171 metres with a maximum recorded depth of 451 metres. It is one of the largest endorheic lakes in the world, and active volcanoes (Nemrut and Süphan volcanoes, between the highest in Turkey) lie on its borders. It is a saline and soda lake, so that although Lake Van is situated at an altitude of 1640 m with harsh winters, it does not freeze due to its high salinity except occasionally the shallow northern section.

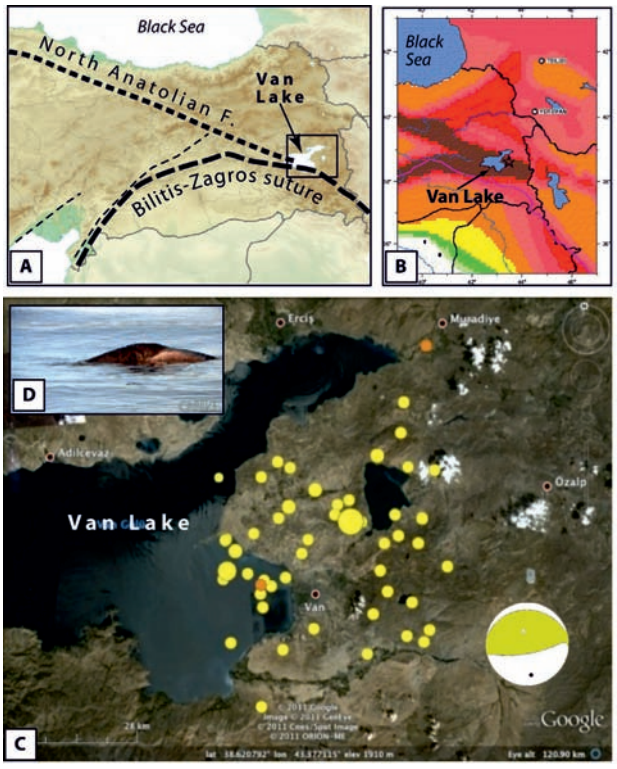

Fig. 9 - The Van Lake Monster (Turkey). A) Major seismotectonic structures of the area of Van Lake in the Arabia-Eurasian collision zone. B) Seismic Hazard Map of the region of Lake Van (www.earthquake.usgs.gov). C) Detail of the October 23, 2011, Van earthquake (M=7,2), with major aftershocks. D) Most famous photo depicting the Lake Van Monster.
- Il mostro del lago Van (Turchia). A) Principali strutture sismotettoniche dell'area del lago Van, nella zona di collisione Arabo-Eurasiatica. B) Mappa del rischio sismico della regione del lago Van (www.earthquake.usgs.gov). C) Dettaglio del terremoto di Van del 23 ottobre 2011 (M=7.2), con i principali aftershocks. D) La più famosa immagine del mostro del lago Van.

The Lake Van Monster was not reported until 1995, but there are now more than 1000 people claiming to have witnessed the beast, which is reported to measure around fifteen meters long, with spikes on its back, and appears similar to a Plesiosaur or Ichthyosaurus. Researches showed creature first mentioned on Saadet newspaper's (a newspaper published at Istanbul at the time) April, 29, 1889 issue, says that the creature dragged a man into lake. Following these reports the Turkish government sent an official scientific survey group to the lake who failed to spot the creature. In 1997 a teaching assistant at Van University, claimed to have captured the creature on video, which was sent for analysis, but his video is under constant criticism.

The Van Lake is situated in one of the most tectonically active region of the world, just on the collision zone between Arabian Plate, which converges in a northerly direction at a rate of about 24 mm/yr, and Eurasian Plate. It is situated due above the point where the North Anatolian Fault meets the Bilitis-Zagros Thrust Zone (figs. 9A, B). Lake Van was the seat of the recent destructive Van earthquake (October 23, 2011, M=7.1), whose epicentre was just a few km near the shore, with the aftershocks sequence affecting the lake. Another famous lake monster is the one said to inhabit the Tianchi Lake (Heaven Lake), a 213 m deep crater lake, which partially fills the summit caldera, about 5 km large, of Baitou (or Baekdu) Mountain (2744 m), an active volcano at the border between North Corea and China (fig. 10). Tianchi is the deepest mountain lake and the largest crater lake in China. This mountain is the highest peak in Korea, and it has been worshipped throughout history. Koreans consider it as the place of their ancestral origin, and one of the three "spirited" mountains. It was first recorded in the Chinese classic texts with the name Buxian Shan (the Mountain with God).

The first reported sighting of this monster was in 1903. It was claimed that a large buffalo-like creature attacked three people, and that the monster then retreated under the water after having been shot six times. More than a hundred people reported sightings since then, increasing in the last 20 years. A famous sighting was videotaped by a tourist in 2005. Similar to the case of Loch Ness, also in this case the beast was more supposed by commotion of the water than really observed, the witness in fact admit that "*We were more than 1,000 metres away so it's difficult … But I did notice that every time it was above water, there were huge ripples in the water, suggesting the rest of it was enormous*." Another famous sighting was showed in 2007 by a Chinese TV reporter, who said had shot a 20-minute video of six unidentified creatures in the volcanic lake on September 6. He claimed to have observed six seal-like, finned creatures in the lake for an hour and a half, before they disappeared around 7:00 a.m.

The caldera hosting Tianchi Lake formed with a large eruption in 969 AD, and eruptions occur in average once every 100 years (1413, 1597, 1668 and 1702). Is it surely interesting to notice that the last time the volcano erupted in 1903, same year as the first monster spotting. Moreover, since 2002, Mt. Baekdu is under constant monitoring because it is showing sings of a possible reprisal of volcanic activity. The newspaper article of *The Korea Times* (June 25, 2010) on this subject deserves to be quoted literally: "*Baekdu could erupt anytime soon," said geologist Yoon Sung-hyo at Pusan National University. "A variety of indicators are backing this scenario. … 'unusual signs,' including minor trembling among others, began to emerge in June 2002 and a 7.3-magnitude earthquake rattled areas in the vicinity of Baekdu. The frequency of the quakes has notably increased since then. The height of the mountain has grown nearly 10 centimetres since 2002, and in 2006 a Russian satellite found the surface temperature of the mountain notably higher than before. If the eruption is major in scale, it would bring about massive consequences to the two Koreas as well as the surrounding states, including China, Japan and Russia."*

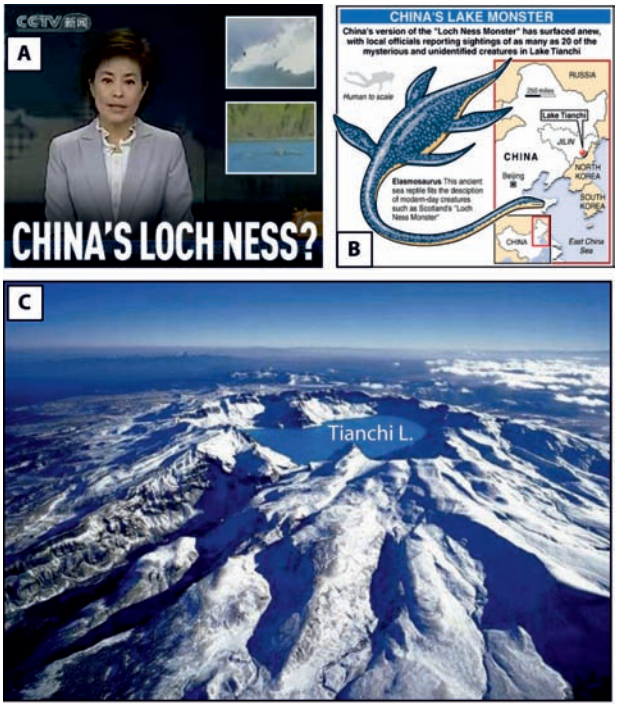

Fig. 10 - The Tianchi Lake Monster (northern China). A) Screenshot of TV news announcement of the spotting of the Tianchi Lake Monster in 2007. B) The beast is described as similar to the Loch Ness Monster. C) The Tiachi Lake occupies the volcanic crater of the main peak of Mount Baekdu, which marks the border between China and Korea.
- Il mostro del lago Tianchi (Cina del nord). A) Annuncio TV dell'avvistamento del mostro del lago Tianchi nel 2007. B) Il mostro è descritto in maniera simile al mostro di Loch Ness. C) Il lago Tianchi occupa il cratere vulcanico della vetta principale del Monte Baedkdu, che segna il confine fra Cina e Corea.

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APPENDIX

Appendix A

Biography of St. Columba (SHARPE, 1995)

Chapter 2-27
HOW AN AQUATIC MONSTER WAS DRIVEN OFF BY VIRTUE OF THE BLESSED MAN'S PRAYER

On another occasion also, when the blessed man was living for some days in the province of the Picts, he was obliged to cross the river Nesa (the Ness); and when he reached the bank of the river, he saw some of the inhabitants burying an unfortunate man, who, according to the account of those who were burying him, was a short time before seized, as he was swimming, and bitten most severely by a monster that lived in the water; his wretched body was, though too late, taken out with a hook, by those who came to his assistance in a boat. The blessed man, on hearing this, was so far from being dismayed, that he directed one of his companions to swim over and row across the coble that was moored at the farther bank. And Lugne Mocumin hearing the command of the excellent man, obeyed without the least delay, taking off all his clothes, except his tunic, and leaping into the water. But the monster, which, so far from being satiated, was only roused for more prey, was lying at the bottom of the stream, and when it felt the water disturbed above by the man swimming, suddenly rushed out, and, giving an awful roar, darted after him, with its mouth wide open, as the man swam in the middle of the stream. Then the blessed man observing this, raised his holy hand, while all the rest, brethren as well as strangers, were stupefied with terror, and, invoking the name of God, formed the saving sign of the cross in the air, and commanded the ferocious monster, saying, "Thou shalt go no further, nor touch the man; go back with all speed." Then at the voice of the saint, the monster was terrified, and fled more quickly than if it had been pulled back with ropes, though it had just got so near to Lugne, as he swam, that there was not more than the length of a spear-staff between the man and the beast. Then the brethren seeing that the monster had gone back, and that their comrade Lugne returned to them in the boat safe and sound, were struck with admiration, and gave glory to God in the blessed man. And even the barbarous heathens, who were present, were forced by the greatness of this miracle, which they themselves had seen, to magnify the God of the Christians.

DE CUJUSDAM AQUATILIS BESTIAE
VIRTUTE ORATIONIS BEATI VIRI REPULSIONE

ALIO quoque in tempore, cum vir beatus in Pictorum provincia per aliquot moraretur dies, necesse habuit fluvium transire Nesam: ad cujus cum accessisset ripam, alios ex accolis aspicit misellum humantes homunculum; quem, ut ipsi sepultores ferebant, quaedam paulo ante nantem aquatilis praeripiens bestia morsu momordit saevissimo: cujus miserum cadaver, sero licet, quidam in alno subvenientes porrectis praeripuere uncinis. Vir e contra beatus, haec audiens, praecipit ut aliquis ex comitibus enatans, caupallum, in altera stantem ripa, ad se navigando reducat. Quo sancti audito praedicabilis viri praecepto, Lugneus Mocumin, nihil moratus, obsecundans, depositis excepta vestimentis tunica, immittit se in aquas. Sed bellua, quae prius non tam satiata, quam in praedam accensa, in profundo fluminis latitabat, sentiens eo nante turbatam supra aquam, subito emergens, natatilis ad hominem in medio natantem alveo, cum ingenti fremitu, aperto cucurrit ore. Vir tum beauts videns, omnibus qui inerant, tam barbaris quam etiam fratribus, nimio terrore perculsis, cum salutare, sancta elevata manu, in vacuo aere crucis pinxisset signum, invocato Dei nomine, feroci imperavit bestiae dicens, Noles ultra progrdi, nec hominem tangas; retro citius revertere. Tum vero bestia, hac Sancti audita voce, retrorsum, ac si funibus retraheretur, velociori recursu fugit tremefacta: quae prius Lugneo nanti eo usque appropinquavit, ut hominem inter et bestiam non amplius esset quam unius contuli longitudo. Fratres tum, recessisse videntes bestiam, Lugneumque commilitonem ad eos intactum et incolumem in navicula reversum, cum ingenti admiratione glorificaverunt Deum in beto viro. Sed et gentiles barbari, qui ad praesens inerant, ejusdem miraculi magnitudine, quod et ipsi viderant, compulsi, Deum magnificaverunt Christianorum.

Appendix B

Biography of St. Columba (SHARPE, 1995)

Chapter 1-37
HOW THE HOLY MAN'S SPIRIT BROUGHT COMFORT TO WORKING MONKS ON THE ROAD

Again, I cannot remain silent about the occasion when his voice was uplifted in this extraordinary way, so we are told, near the fort of King Bridei. The saint was

saying vespers as usual with a few brethren, outside the king's fort, and some wizard came quite close to them, trying as best as they could to make them stop. For they were afraid that the heathen people would hear the sound of God's praise from the brethren's mouths. Knowing this, St Columba began to chant the forty-fourth psalm, and at that moment his voice was miraculously lifted up in the air like some terrible thunder, so that the king and his people were filled with unbearable fear.

Appendix C

Biography of St. Columba (SHARPE, 1995)

Chapter 2-35
HOW THE GATES OF THE ROYAL FORTRESS SUDDENLY OPENED ON THEIR OWN

Once, the first time St Columba climbed the steep path to King Bridei's fortress, the king, puffed up with royal pride, acted aloofly and would not have the gates of his fortress opened at the first arrival of the blessed man. The man of God, realizing this, approached the very doors with his companions. First he signed them with the sign of the Lord's cross and only then did he put his hand to the door to knock. At once the bars were thrust back and the doors opened of themselves with all speed. Whereupon St Columba and his companions entered.

Appendix D

"In March 1933 John Mackay and his wife, then tenants of the Drumnadrochit Hotel, were returning from Inverness, driving along the old narrow road near the seven-mile stone, opposite Aldourie Castle at the very northern tip of the lake, when Mrs Mackay shouted to her husband to stop and look at an enormous black body rolling up and down. By the time he had stopped the car all he could see were ripples, but he knew that something 'big' was out there, 'about a mile and a half [2,5 km] away'. According to Gould, Mrs Mackay caught sight of a violent commotion in the mirror-like surface about 100 m from the shore. The commotion subsided and a big wake became visible, apparently caused by something large moving along just below the surface. This wake went away across the water towards Aldourie Pier. Then, about halfway (some 450 m) the cause of the wake emerged, showing as two black humps moving in line, the rear one somewhat larger. They moved forward in a rolling motion like whales or porpoises, but no fins were visible. They rose and sank in an undulating manner. After some time the object turned sharply to port and, after describing a half circle, sank suddenly with considerable commotion" (CAMPBELL, 1996).

Appendix E

"At about 8.15 p.m. on 22 July 1930 three young anglers (one was Ian Milne who later kept a gunsmith's shop in Inverness) were fishing in a dead calm off Tor Point near Dores when they heard a great noise and saw much commotion in the water about 600 m away down the lake (southwards). This commotion, throwing spray up into the air, advanced to within 300 m of their boat and then seemed to turn aside into the bay above Dores. Their boat rocked violently as a 75 cm high wave passed. They claimed that although they detected a wriggling motion, the wash hid the 'creature' from view. Milne stated that the object travelled at a speed of 7 m/sec with an undulating motion; he compared it to an enormous conger eel, and was sure that it was neither a seal nor an otter" (CAMPBELL, 1996).