Historical investigation of the 1716 Algiers earthquake effect, damages and vulnerability.

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ABSTRACT

This work presents the consequences of the 1716 Algiers earthquake after the ottoman files, consular mails, scientist and travellers of the XVIIIth century.
The 1716 Algiers earthquake is one of the most significant historical events having affected the city (*I= 9 MSK*). Indeed several sources describe it and give an idea of its event and the importance of the damage, which it caused. The historical sources are numerous.
The first sources used in this work are the Arab files dating from the Ottoman time and which have been consigned in the various acts (domanial and of succession) and in manuscripts.
During Ottoman regency, Algiers maintained the diplomatic relations with the Mediterranean countries and with the other countries such as the United Kingdom, the United States, Hollande and well of others.
The fact the consular files belong to the sources, which gave information concerning this earthquake.
In the XVIIIth century, much of religious men, scientists and travellers visited Algiers and some evoked the catastrophe either because they were there or because they went there during the first years, which followed the event.
All these sources and in particular those of Ottoman regency were studied and allowed us to supplement information on this earthquake.
This work makes it possible to have a meaning vision as well on the damage as on the vulnerabity of old constructions of XVIIIth century because the obtained information can constitute a damage data, which will make it possible to work out the future seismic scenarios to protect the cultural heritage, built from Algiers.

Key Words: historical earthquake, ottoman files, 1716 earthquake, Algiers, Algeria.

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Qualified Architect in historical construction. Has conducted many research from 2000 until today in the field of Historical seismicity of the Maghreb, preventive constructive techniques used after the great earthquake in the Maghreb, reducing risk to cultural heritage in Algeria. Is a membership of the NASG, GADR and DRH,
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Post-Neogene faulting along the West Coast of South Africa

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ABSTRACT

This paper reflects the findings and interpretation of field data collected during about three months of fieldwork between the Cape Town and Alexander Bay. Investigations were aided by an extensive database containing geological, topographical (20 m DEM) and seismicity datasets. Aerial photography studies preceded fieldwork and satellite imagery was employed on an ongoing basis. The research included a full review of possible correlations between seismicity and geological structure, including some new geophysical data provided by the results of the Inkaba yeAfrica project on the crustal composition.

Field evidence was reviewed as objectively as possible using internationally accepted procedures for classifying non-tectonic features from tectonically induced ones. The investigation started in the south along major fault lines in the Swartland and progressed towards the diamond mining areas of Namaqualand. The availability of numerous mining excavations north of the Olifants River proved very helpful and led to a first discovery of possible Quaternary fault reactivation along the West Coast of South Africa. Evidence of strong ground motion proved to be present but very rare in the Neogene marine successions of the West Coast. An appreciable amount of knowledge was added to the investigation by a review of hundreds of archived exploration trench logs at the Alexkor diamond mine. A brief investigation of Neogene gravels along the Orange River west of Vioolsdrif did not reveal neotectonic faulting. However, evidence is provided of some recently discovered thrust and normal faulting along the Middle Orange River and these are then interpreted in terms of crustal stress and epeirogenetic axes. Investigations along the West Coast south of the Olifants River are severely compromised by a lack of Cenozoic exposures caused by extensive Pleistocene cover sands.

Exposures in mining pits between Hondeklip Bay and Koingnaas along the Namaqualand coast revealed the presence of a palaeo-seismogenic Quaternary fault, the Langklip fault. The southern limit of the fault is currently defined by observation of a 1 m normal faulting displacement in a mining pit SE of Hondeklip Bay, and the northern limit by reliable evidence from De Beers geologists that similar faulting was observed at Wolfkop west of Koingnaas. In addition, features indicative of fluidisation were observed in a pit north of Wolfkop and secondary faulting accompanied by liquefaction in another exploration pit. This evidence suggests that the Langklip fault is at least 19 km long and comprise one of a number of NNW striking faults within a regional zone of brittle fractures that was reactivated in the Quaternary. Such a length would agree well with the width of the damage zone of the fault in bedrock exposures. The minimum inferred length of the fault between Hondeklip Bay and Koingnaas and displacement in the mining pit suggest one post-Pliocene event with moment magnitude of between 6 and 7. However, because the sediments affected by the faulting covers the period from 5 to 3 Ma, this evidence implies a minimum recurrence of such events on this fault segment of about 2 Ma. Another possible Cenozoic fault striking parallel to the Langklip fault, here termed the "dune lineament", was identified between Hondeklip Bay and Koingnaas. It is currently interpreted as an accumulation of Latest Pleistocene aeolian sand against a SW facing fault scarp. No evidence of Cenozoic faulting was found in the available diamond mining pits at Alexander Bay, but a few indications of possible post-Pliocene faulting and strong ground motions were observed in the exploration trench logs.

Gravels along the Orange River at Hopetown show thrusting that ties in with a SE directed direction of SHmax in that area.

The chances of finding evidence of Cenozoic deformation declines rapidly south of the mining areas due to the absence of fresh exposure, with investigations that focused on aeolianites and local exposures in quarries. Faults were observed in Late Neogene clay deposits in a pit SW of Malmesbury and in Late Pleistocene aeolianites at Saldanha. Neogene silcrete overlying one of the major NW striking faults in the SW Cape has been fractured parallel to the fault, confirming relatively recent activity.

Key words: West Coast, Cenozoic faulting, palaeoseismicity

PRESENTER'S BIOGRAPHY

Coenie de Beer was born and grew up in the SW Cape Province, where he graduated at Stellenbosch University in 1978. He has been with the Council for Geoscience for 30 years, working mostly on mapping rocks of Mesoproterozoic to Palaeozoic age. He completed an M.Sc. on the structural geology of the syntaxis of the Cape Fold Belt in the Ceres area in 1989. He has been working with staff in the seismology section of the CGS for the past 8 years on the input of geological data into models of seismic hazard.

On the possible origins of seismicity in the SW Cape Province, South Africa

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ABSTRACT

The paper reports on a comparison of locations of historic and instrumentally recorded seismicity with geology, in particular structural geology. This comparison was made as part of a process of characterization of seismic sources performed during a regional palaeoseismic-neotectonic project for input into a seismic hazard assessment. It used the seismic catalogue of the CGS and existing 1:250,000 scale geological maps contained in the GIS database at the Western Cape Unit in Bellville, near Cape Town. This paper preferentially makes use of historical seismic data. The main aim of this paper is to present ideas about the possible origin of the two M>6 events and associated seismic clusters that occurred in the SW Cape in historic times. One is the "Cape Town cluster" (including the "Milnerton event" that struck Cape Town on 4/12/1809) and the other is the "Ceres cluster" (including the 29/9/1969 "Ceres-Tulbagh event").

The Cape Town cluster is one of the most controversial sources of historical seismicity in South Africa; this state of affairs is partly caused by uncertainty as to the influence of anthropogenic factors. Events associated with this source were broadly within range of those reported for the Ceres cluster. Our idea of the size of the biggest event that this cluster is capable of is based upon the 1809 and 1811 events described by Burchell (1822) and Von Buchenröder (1830). The secondary effects of the largest of these earthquakes that took place on 4 December 1809 are interpreted to suggest a size of M_L 6.3 and intensity of VIII (Brandt et al., 2005), because of the presence of extensive liquefaction and surface cracks. The earthquakes were all, to a greater and lesser extent, very noisy, and many buildings were cracked, but apparently none in Cape Town needed to be rebuilt. Liquefaction occurred in unconsolidated sediments at Jan Biesjes Kraal (a locality near the present Milnerton) and Blauweberg's Valley, about 11 km north of Milnerton. The largest of the three events of 1811 (Burchell, 1822) probably had an intensity of VII and M_L 5.7 (Brandt et al., 2005). All of these historic events, including the very first event reported by General Augustin de Beaulieu in 1620, occurred very close to Cape Town. Past hypotheses for their origin postulated reactivation along a major NW striking fault of Pan-African age, which possibly was reactivated during Mesozoic breakup of Gondwana. Although it had never been seen, this fault was called the Milnerton fault, or if extended across the Cape Flats, the Milnerton-Hangklip fault. Evidence is presented that the events at Cape Town could have been caused by a combination of fault and dyke intersections, gravitationally induced instabilities and possibly hydrogeological aspects.

Although there are reports of earlier seismicity in that area, the earliest events contained in the CGS historical catalogue for the Ceres cluster were two events at the beginning of the 1920's: an M_L 5.0 in 1921 and an M_L 3.7 event in 1922. The record then contains no events for this area until the 1950's, and the 1960's started off with an M_L 4.8 in 1960, followed by four events between 4.8 and 5 occurring before the 1969 event. The events on 29 September 1969 started with M_L 3.5 and 3.7 events during the day, and the M_L 6.3 that same night, followed by a series of aftershocks varying between M_L 3.3 and 5.1. Subsequent relatively large events were the M_L 5.7 event on 14 April 1970, and M_L 5.9, 5.6, 5.1, 4.4 events in 1977, 1983, 1991 and 2003. The main shock was located approximately 1 km to the north of the zone of aftershocks, which approximately correlates with the WNW-striking Groenhof fault. However, most aftershocks occurred above 10 km depth in a 20 km long subvertical zone. Importantly, this activity occurred at the western termination of the 800 km long, E-W striking, Ceres-Kango-Baviaanskloof-Coega fault zone. Evidence is presented that explain the origin of the Ceres cluster in terms of intersecting faults, structural kinks and fold axis intersections, reactivation of Mesozoic rift faults and hydroseismicity.

Key words: Historical seismicity, SW Cape Province, structure, hydroseismicity

PRESENTER'S BIOGRAPHY

Coenie de Beer was born and grew up in the SW Cape Province, where he graduated at Stellenbosch University in 1978. He has been with the Council for Geoscience for 30 years, working mostly on mapping rocks of Mesoproterozoic to Palaeozoic age. He completed an M.Sc. on the structural geology of the syntaxis of the Cape Fold Belt in the Ceres area in 1989. He has been working with staff in the seismology section of the CGS for the past 8 years on the input of geological data into models of seismic hazard.

PRESENTERS BIOGRAPHY

M. L. Goedhart, M.Sc., has mapped the stratigraphy, structure and geomorphology of various parts of the south-eastern Cape Fold Belt for several years. His work is used mainly for mining and quarrying activities, groundwater targeting, environmental assessments, and infrastructure developments, including preparing the base geological maps for the new Ngqura habour at Coega. Overseas, he has done exploration mapping across the Oman ophiolite sequence, and has determined several new groundwater and oil/gas targets for the Emirate of Fujairah, based on results from multi-disciplinary exploration ventures. Since 2004 he has been involved in the energy field, and enjoys the multi-disciplinary aspect of palaeoseismic investigations for the siting of new nuclear power stations. His latest interest is the use of groundwater in faults as a potential early-warning system.

Review of seismicity and fault reactivation in the south-eastern Cape Fold Belt, South Africa, and proposals to improve the seismic catalogue for use by non-seismologists

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ABSTRACT

The South African National Seismic Network (SANSN) database underpins several similar regional seismo-tectonic models for southern Africa. These depict the southern to south-eastern Cape Fold Belt (CFB) as a stable intraplate-type domain where seismicity is sporadic in space and time. While small seismic clusters do occur in places, it is questionable if the dataset can be used at lower scale, i.e. to recognize capable faults within the domain. Associating seismicity with known faults is hampered by limited accuracy of epicentral location and absence of easily-accessible 'metadata' for individual events, in particular for the historical data and for most events up to the late 1990s. In contrast, post-2000 data has far better epicentral resolution and events <3M have been able to be verified in the field, suggesting the Kouga and Baviaanskloof faults are micro-seismically active.

Addition of palaeoseismic data to the seismic catalogue, ranked according to the Environmental Seismic Intensity scale (ESI 2007), can augment PSHA of several new critical facilities by providing quantitative pre-historical data from faults with very low slip rates or from areas that are currently inactive. The procedures and results of a palaeoseismic investigation of the Kango fault, a crustal-scale structure, will be presented. The data reported will include the location and extent of the surface rupture, the local stress direction, the date and magnitude of the most recent event, the minimum recurrence interval, and maximum slip rate. Epicentral intensity was devastating (ESI I_o = XI). The tectonic driver is likely slow isostatic rebound along an east-west trending gravity trough extending from Port Elizabeth towards Willowmore. This geophysical anomaly suggests long-term crustal instability can be expected in the eastern CFB, precisely where the regional seismo-tectonic model, based on sparse SANSN data, suggests maximum stability. Large low-recurrence earthquakes could therefore occur along similar crustal structures that currently appear inactive. It is therefore essential to determine if the large faults in the region are capable, and if any of the existing data can be linked directly with these faults.

The review indicated that the seismic catalogue should include a quality statement per event, and metadata, particularly if localities were moved, e.g. why, by who, and when. Or why a magnitude was changed from an original source, or why different intensity values are reported. Ranking the data quality would be a step towards reducing uncertainty about location accuracy and improve understanding of an otherwise rather faceless epicentral/magnitude symbol on a map. This could refine apparent hazard to infrastructure developments threatened by an event that may have been innocently 'stuck on a fault' several decades ago.

It is concluded that the density of the SANSN needs to be increased to meet the more localized demands being made on the data. The pre-2000 data could be made more useful by adding a quality statement per event, and hot-links to metadata, where available. This should extend down to historic and palaeoseismic data sets. This would reduce uncertainty in linking at least some of the recorded seismic events to known faults.

Key words: Cape Fold Belt, SANSN, palaeoseismic, Kango, Kouga, Baviaanskloof faults, ESI scale.

The 4th December 1809 Cape Town (South Africa) earthquake and attendant phenomena- a bicentennial perspective

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ABSTRACT

The Cape Town (South Africa) earthquake of 4th December 1809 (MMI VI) was the first to be properly documented in South Africa, and is one of the earliest earthquakes for which there are fairly reliable records concerning the timing and relative intensities of the main shocks and numerous aftershocks, as well as on attendant phenomena such as sound effects, behaviour of animals during the earthquake, atmospheric conditions, wind velocities and directions, barometric pressures, temperatures, structural damage to buildings, geological effects such as soil liquefaction and boils, rents opening in the ground, and boulders being dislodged on mountainsides; and numerous first-hand accounts of the shocks and the panic that ensued, and the psychological effects on the population. It also appears to be the first well-described earthquake during which luminous electromagnetic phenomena in the form of "fireballs", "flames" and "shooting stars" were observed. Other curious phenomena attributed to the earthquake include the first appearance in Cape Town waters of the fish kingklip (*Genypterus capensis*), the alleged sinking of Robben Island, and a colder climate which affected the wine harvest in subsequent years. In this paper the various accounts of this earthquake are assembled for the first time, and some of the phenomena observed during and after the earthquake are re-assessed, in terms of our modern understanding of related processes.

The seismicity around Cape Town is associated with the large NW-SE Milnerton Fault. The 1809 earthquake had its epicentre at Jan Biesje's Kraal, which is today an area occupied by the Ascot Racecourse in the Table Bay area. The best descriptions of this earthquake and aftershocks were given by Wilhelm von Buchenroder, who meticulously recorded the events which he published only in 1830. Other detailed eyewitness accounts were those of two anonymous observers, and diary entries of the surgeon Dr William Mackrill, and of Mrs Thom née Meyer. Based on these eye-witness accounts, the following events are reconstructed:-

Shortly after 10 PM on 4th December 1809, a strong shock was felt for a minute or two, accompanied by a sound like distant thunder, but very much louder. This was followed after a minute, by a second, more powerful shock, accompanied by a tremendously loud noise. Two observers felt a third shock, weaker than the first two, between 1 and 5 minutes after the second. Following these first three shocks, there were two more aftershocks within half an hour, and a total of 10 aftershocks were perceived until 2:45 AM the next morning, the last four of which were heard rather than felt. At 6 to 7 AM, and at 2:30 PM on 5th December 1809, more aftershocks were felt, accompanied by loud noises. Further sporadic aftershocks were recorded on 6th (~5:30 AM) and 7th December (~7:30 PM, ~10:55 PM, 11:57 PM), and rumblings were felt from 12th to 15th December, and from 19th to 28th December, 1809. Further strong earthquakes occurred in the Cape Town area on the 2nd and 19th June 1811, as recorded by William Burchell.

Keywords: Cape Town, 1809, earthquake, luminous phenomena

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Unique double-casts of mudcracks: a new type of palaeoseismite?

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ABSTRACT

In 1969, Dr Roy Miller discovered, in the Bethanie District of south central Namibia, a slab of sandstone from the Mesoproterozoic Auborus Formation which contains a unique variety of a common sedimentary structure - a set of mudcracks which had formed on a thin layer of mudstone interbedded with the sandstone. The mudcracks were filled with sandstone from the overlying layer. However, unlike in all other known examples of mudcracks, in this example the polygonal network of mudcracks was doubled. Each polygon was repeated, with a deep sharp original impression of the mudcrack in positive relief, and a second less sharply defined impression slightly offset from the original, in *negative* relief.

In 1975, Miller published an account of this slab in the Journal of Sedimentary Petrology, and claimed an unspecified tectonic origin for the structure. Recently, in 2008, the renowned German palaeontologist, Professor Dolf Seilacher, published illustrations of this same slab (incorrectly identified as coming from the Nama Group) in his book "Fossil Art". According to Seilacher, the sandstone infilling of the mudcracks was less compressed during compaction than the mudstone in which the cracks had formed; hence they were bulbous and penetrated in the over- and underlying beds. He assumed that during tectonic deformation, the beds had undergone flexural slip folding. The tops of the sand infills remained attached to the overlying bed, which was displaced and then made a second impression of the mudcrack network on the still-soft mudstone.

The ~1m by 0.4m rock slab containing the doubled mudcracks is housed in the Geological Survey of Namibia in Windhoek, where it was studied by the present author. Analysis of photographs of the slab reveals information that is incompatible with a tectonic origin of the double-cast structure. By placing an overlay on a photograph of the slab, and drawing arrows linking every identifiable point where two or more positive-relief mudcracks intersect, with the corresponding offset point on the doubled impression of the same cracks, a set of arrows that define vectors of movement of the overlying bed with respect to the mudcracked bed is generated. The arrows do not define a linear vector field of uniform distance, as required if the movement of the overlying bed was by flexural slip during folding. Instead, the offset increases from <0.5 cm at one end of the slab to >2 cm at the other end, and the movement vectors are not parallel, but curved. Such a motion of the overlying bed could only have been produced if it was close to surface, detached, lifted and *rotated* anticlockwise before settling back onto the unlithified mudcracked bed. The most likely proposed mechanism for this to happen is through the passage of a seismic surface or Love wave, which has a component of rotational motion. Seismic shaking may also have induced momentary liquefaction in non-Newtonian thixotropic mudstone, allowing the doubled impressions to be made. The unique double-cast mudcracks are thus regarded as a new type of palaeoseismite, and imply syn-depositional seismicity in the Auborus Formation.

Keywords: Double-casts, mudcracks, Auborus Formation, Namibia, palaeoseismite

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Paleoseismic investigation along the Kango Fault, South Africa: Determination of associated uncertainty

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ABSTRACT

The logic-tree formalism is used to systematically treat uncertainties associated with a paleoseismological investigation along the Kango fault, South Africa. It provides some rationale into the uncertainty allocated to the investigation results in the seismic hazard analysis logic tree. Uncertainties in six stages (i.e. tectonic setting and strain rate, site selection, extrapolation of the conclusions drawn from the detailed site analysis to the entire fault, identification of individual paleo-earthquakes, dating of paleo-earthquakes, paleo-earthquake size estimates) typically considered in a paleoseismic investigation are considered. A quality weight factor that illustrates the associated uncertainty is determined for each stage. The logic tree formalism was then applied to calculate a paleoseismic quality factor value of 0.28, which reflects the six main sources of uncertainties associated with the paleoseismic trench investigation.

Keywords: Logic Tree, Uncertainty, Kango Fault, Paleoseismic

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Dr V. Midzi is employed as a Scientific Officer in the Seismology Unit of the Council for Geoscience in Pretoria, South Africa. His qualifications include an MSc and PhD in Seismology from Bergen University, Norway. Dr Midzi is a well rounded seismologist with experience in seismic monitoring and seismic hazard analysis, which is his main field of work. He has worked on projects in seismic monitoring sponsored by IPPS under the East and Southern Africa Seismological Working Group of which he is an active member, as well as on other research and commercial seismic hazard studies on the African continent. His experience also includes work as an academic at the National University of Science and Technology, Zimbabwe. He has presented his research work at several conferences and workshops, and is well published in reputable journals.

Seismicity of St Helena

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ABSTRACT

St. Helena is an island in the middle of the South Atlantic Ocean, approximately 800 km east of the mid-Atlantic ridge. The nearest continental land masses is Africa, 1930 km away. Despite its remote location and small population, it does in fact have a record of historical seismicity going back to the mid 18th century. None of the known events is reported to have caused any damage, and seem to have been (so far as can be judged) small local earthquakes associated with a volcanic seamount. We have no records of earthquakes felt on the island since 1864, and modern instrumental seismicity in the area has not been close to St Helena. The best-described event is that of 21 September 1817, which occurred during the period of Napoleon Bonaparte's exile on the island.

Key words: intraplate seismicity, St Helena, South Atlantic Ocean

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