A New Seismic Phase with Ray Parameter = 0: GOOOOOOOOOOOOOOOOOAOAOAOAOAOAOAOAAAAAAAALLLLLLLLLLL!!!

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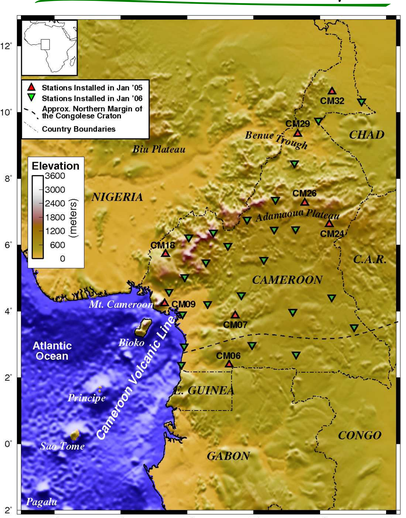
Abstract

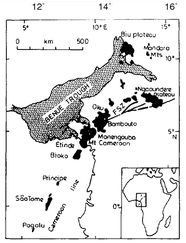
Simultaneous, high-frequency arrivals seemingly unassociated with earthquake activity were recorded on seismometers of the Cameroon Seismic Array (CSA) from January to February, 2006. The CSA is a temporary deployment, initially installed in January of 2005 with 8 stations and expanded to 32 stations after one year, that will continue to record until January 2007. The seismometer spacing is on average about 150 km and locations are confined to the Republic of Cameroon. The array is primarily intended to aid in resolving upper mantle and crustal features associated with the Cameroon Volcanic Line.

The phase in question exhibits a ray parameter of near zero, onsetting nearly simultaneously at most stations of the array. However, no corresponding earthquake sources have been identified in teleseismic catalogs and no phases with non-zero ray parameter are recorded near the time of the arrivals. The associated arrivals are confined to periods shorter than 0.5s, have both horizontal and vertical motion, show no waveform coherency except in duration, and have considerable variation in amplitude across the array. Among groups of arrivals, variation is observed in average amplitude, coda duration, temporal spacing, and the number of recording stations. Extensive temporal analysis indicates two levels of clustering: dense clustering within a span of a few hours and clustering of all noted arrivals within a period of roughly 2 weeks. Inspection of an atmospheric or solar relationship showed no significant correlation. However, investigation of anthropogenic activity led to a perfect correlation: the timing of the phases is confined to the period of televised Cameroonian soccer matches during the 2006 African Cup of Nations and the onset of the signals coincide with the kicking of a Cameroonian football into the opponent's goal.

The Cameroon Seismic Array

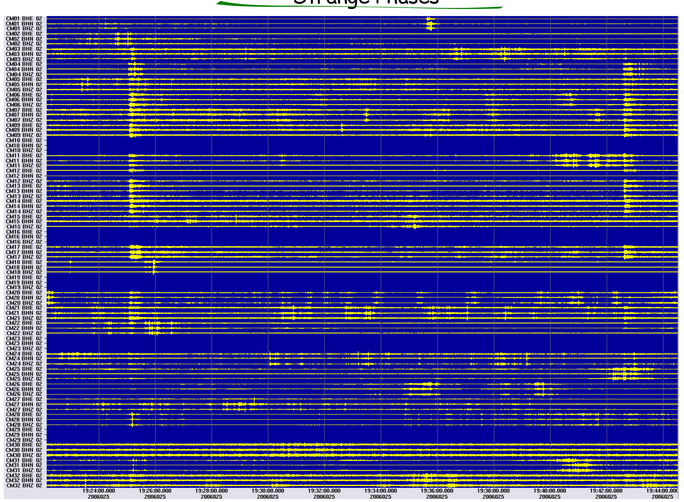


The Cameroon Volcanic Line (CVL) is a 1500 km long line of volcanic constructs extending from the island of Pagalu to the Adamawa Plateau and the Biu Plateau (right figure from Ateba and Ntepe, 1997). The CVL does not exhibit age progression and is relatively active (holocene volcanism extends across most of the line). The goal of the CSA (pictured above) is to critically evaluate models for the origin of volcanic lines without age progression by imaging seismic structure of the upper mantle beneath the CVL.



Array Deployment

Strange Phases

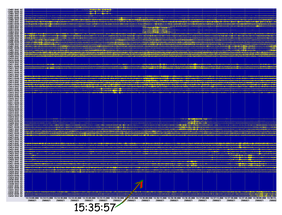


The figure above shows the initial two seismic phases found. The signals' spectra is confined to periods shorter than 1s - typical for local earthquakes - but there is no observed moveout associated with the phases as anticipated. The unidentified phases occurred within 17 minutes of one another, with no other arrivals noted to occur for more than an hour after this time. Global seismic records do not show similar arrivals nor were any earthquakes found to occur within an hour of the arrival times. The phases therefore betray most aspects of typical seismic interpretation.

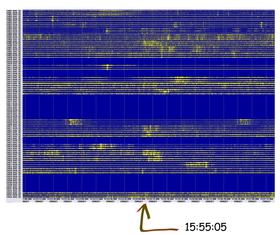
Correlation of Televised Cameroonian Football Matches to Unidentified Seismic Phases

Game 1: Cameroon vs. Angola (3-1)

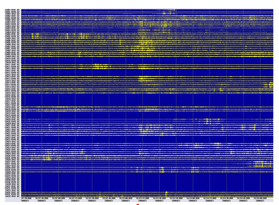
Goal 1



Goal 2



Goal 3



The first match for the Indomitable Cameroon Lions in the 2006 African Cup of Nations was against World Cup Qualifiers Angola. The Lions' top striker as well as the African Footballer of the Year, Samuel Eto'o, dominated the match with a hat trick of goals. The Angolans did strike back 30 minutes into the match to tie up at 1-1 but could not find the goal again afterwards. Our seismic records show strong motion across the array corresponding to the times of each of the goals by Eto'o but the signal to noise ratio is fairly weak (possibly a sign that not as many Cameroonians were watching the first game).

TIMES REPORTED BY THE BBC (in GMT):

15:15 - Game Begins
15:36 - Score for Cameroon by Samuel Eto'o
15:46 - Score for Angola
15:54 - Score for Cameroon by Samuel Eto'o
16:21 - 2nd Half Begins
16:53 - Score for Cameroon by Samuel Eto'o
17:11 - Match Ends

Team picture of the Lions from 2004.

Samuel Eto'o Fils

Samuel Eto'o works around the DR Congo defense

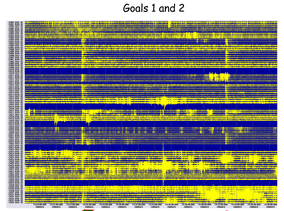
Albert Meyong Ze

Ivory Coast's Didier Drogba tries to break through the Cameroonian defense

Game 2: Cameroon vs. Togo (2-0)

Game two for Cameroon pitted them against another World Cup Qualifying team: Togo. The first half of the match went without a goal from either side - little notable motion on the array is seen at this time too. At 64 minutes into the match, Samuel Eto'o put in his 4th goal of the tournament to tie his best of 4 goals in 2000 when Cameroon went on to win the tournament. A mere 17 minutes later, with the tension on both sides rising as the end of the match was drawing near, Albert Ze Meyong snuck in another to bring the score to 2-0. Both goals for this match temporally align well with the timing of the two distinct phases originally noticed. The amplitudes are remarkably stronger than in the first match and the phase can be readily identified at several more stations. The figure on the right shows the records scaled to a fixed amplitude so that strong incoherent noise does not hide the signal at several of the stations. Note that the signals onset nearly simultaneously at CM06 and CM32, which are separated by a distance of 1200 km.

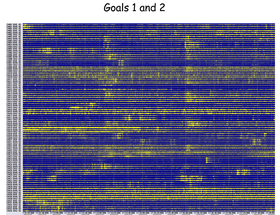
Goals 1 and 2



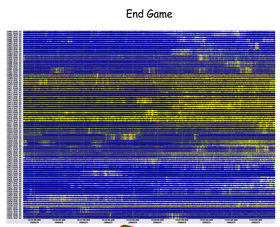
18:00 - Match Starts
19:02 - Halftime Over
19:25 - Goal for Cameroon by Samuel Eto'o
19:42 - Goal for Cameroon by Albert Ze Meyong
19:50 - Match End

Game 3: Cameroon vs. DR Congo (2-0)

Goals 1 and 2



End Game



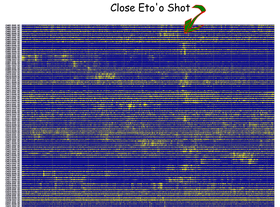
With two strong wins under their belt, the Cameroon Lions were the favored team in their tournament group. Their third adversary, the Democratic Republic of Congo's Simbas, was the second most favored team in the group with a win and a draw for their first two outings. Unlike Cameroon's second match though, which was scoreless for the first two-thirds of the game, this match saw two early goals separated by 2 minutes and a scoreless last two-thirds of the match. Cameroon's first goal of the match came from Geremi Njitap off of a free kick 33 minutes into the match. A second goal was quickly found for the Lions 2 minutes later when Njitap passed to the wide open Eto'o who smashed the ball in for his 5th goal of the tournament, putting Cameroon up 2-0. The Cameroon Array shows two notable arrivals also two minutes apart at the times mentioned by the BBC. As with the first match, the arrivals are not as pronounced as during the second match - possibly because the goals came early on in the game. Another significant feature that can be noticed is the rise in background noise that coincides with the time that the match ends - probably a result of the celebration of Cameroonians as well as the masses going home after watching the game at the bar (few Cameroonians own a TV much less can afford to have electricity).

17:01 - Game begins
17:34 - Goal for Cameroon by Geremi Njitap
17:36 - Goal for Cameroon by Samuel Eto'o
18:10 - 2nd Half begins
18:35 - DR Congo player (Gladys Bokese) ejected
18:58 - Game ends

2 minutes apart

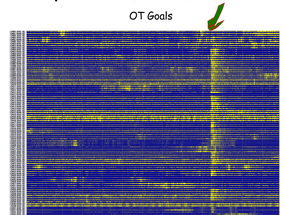
Game 4: Cameroon vs. Ivory Coast (11-12)

Close Eto'o Shot



OT Goals

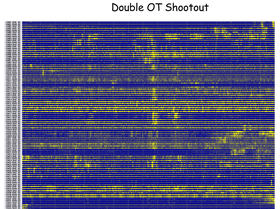
Cameroon

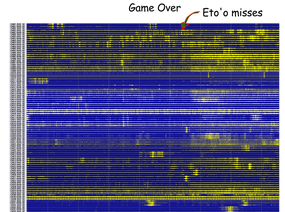


In what proved to be a historical football match, Cameroon ended their participation in the tournament with a spectacular and disappointing double-overtime match against World Cup Finalist Ivory Coast. The game was terribly tense as neither side could find the net for the entire match. The Cameroonian defense was having a difficult time blocking Ivory Coast's star player Didier Drogba who was all over the goal throughout the match. Cameroon's Samuel Eto'o was not without a good effort - but Ivory Coast's goalkeeper made a spectacular save in the first half to keep the match and Eto'o scoreless. The timing of the close shot by Eto'o matches well with a strong amount of motion all across Cameroon - the tremors from an anticipated goal. Strangly enough, only 1 minute into overtime Ivory Coast found the goal in a quick attack by Bakari Kone and Cameroon's Albert Meyong Ze quickly answered 4 minutes later. The Cameroonian goal is easily discerned in the upper-right figure but the Ivory Coast goal is not. With the score tied at 1-1, the match went into a double overtime shootout. Every player ended up making their shot - although one Cameroonian player missed the first shot but got a second chance as the goalie jumped too soon (associated seismic motion shown in lower-left). The end of the game came as a result of a missed shot by Eto'o in the second round of the double overtime shootout which resulted in fans going home and a large amount of seismic noise.

17:01 - Match starts
17:40 - Close shot by Eto'o (saved by Jean-Jacque Tizie
18:06 - Second Half begins
18:56 - Official end of match
19:01 - Overtime begins
19:02 - Goal for Ivory Coast by Bakari Kone (0-1)
19:06 - Goal for Cameroon by Albert Meyong Ze (1-1)
19:40 - Double OT Shootout Begins
20:06 - Missed shot by Samuel Eto'o
20:08 - Didier Drogba makes the shot to win (11-12)

Double OT Shootout



Game Over

Eto'o misses