Preliminary paleoseismological results from Kaparelli Fault (Central Greece): evidence of seismic events for the past 10.000 years*

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ABSTRACT: We present preliminary paleoseismological trenching results of the active Kaparelli Fault (KF), which ruptured the surface during the 1981 Gulf of Corinth earthquake sequence. The aim of this study is to better understand the past earthquake behavior and to resolve long term slip and slip per event of the Kaparelli Fault. The identification of paleoseismic events is based on fault-scarp colluvial deposits, formation of soil and displacements of key horizons. The analyzed trenches expose evidence of at least three events, for the past 10,000 years, with the 1981 event included. Preliminary radiocarbon dating results from two of the trenches shows that the age ranges for colluvial sedimentation are 7540-7300 BC, 3760-3620 BC, 560-690 AD, and 680-890 AD. Displacements on analyzed fault strands within the trenches vary between 0.7 and 1 m. The total vertical displacements associated with interpreted paleoearthquakes at the trench site are in the order of 2.7 m. Average slip rates derived from the trenches is in the order of c. 0.3 mm/yr.
Key-words: *Paleoseismology, Seismotectonics, Kaparelli active fault, fault slip rate, Culf of Korinth, Greece.*

ΠΕΡΙΛΗΨΗ: Στην εργασία αυτή χρησιμοποιούνται τεχνικές της παλαιοσεισμολογίας, κύρια η τεκτονοστρωματογραφία ολοκαινικών κολουβιακών ιζημάτων σε τεχνικές εσκαφές και παρουσιάζονται αποτελέσματα άγνωστων σεισμών για το ενεργό ρήγμα του Καπαρελλίου κατά την περίοδο των τελευταίων 10.000 ετών. Η γεωτεκτονική θέση του ρήγματος αυτού βρίσκεται στο ανατολικό άκρο της δομής του Κορινθιακού Κόλπου, ο οποίος διαστέλλεται με ρυθμό 6-15 χιλιοστά/ έτος. Το ρήγμα του Καπαρελλίου, ένα μεσαίου μεγέθους παρουσιάζει πολύπλοκη γεωμετρική δομή, έχει γενικά Α-Δ διεύθυνση, κλίνει προς νότο και χωρίζεται σε τρία τμήματα. Το ρήγμα συνδέεται με τους σεισμούς της 4[ης] Μαρτίου του 1981. Κατά την διάρκεια των σεισμών του 1981 χαρτογραφήθηκαν, επί του ίχνους του ρήγματος, συν-σεισμικές διαρρήξεις της τάξης των 10-12 χιλιομέτρων. Τα δεδομένα της παλαιοσεισμολογίας χρησιμοποιήθηκαν για να εκτιμηθεί η σεισμοτεκτονική συμπεριφορά του ρήγματος. Επιπλέον γίνεται εκτίμηση του ρυθμού ολίσθησης του ρήγματος, της ολίσθησης σε κάθε σεισμό καθώς και του χρόνου επανάληψης μεταξύ δύο διαδοχικών ισχυρών σεισμών. Για τις ανάγκες της μελέτης έγιναν τρεις παλαιοσεισμολογικές τομές δύο εκ των οποίων αναλύονται στην παρούσα εργασία. Η εξεύρεση παλαιοσεισμικών γεγονότων έγινε με βάση την χαρτογράφηση κολουβιακών αποθέσεων, μετατόπιση χαρακτηριστικών οριζόντων και τη μελέτη παλαιοεδαφών. Ο προσδιορισμός των σεισμών και η περίοδος που μεσολάβει ανάμεσα σε δυό διαδοχικού σεισμούς έγινε έμμεσα με χρονολόγηση χαρακτηριστικών στρωματογραφικών οριζόντων, που οφείλονται σε τεκτονικές αλλαγές. Οι αποθέσεις αυτές μεταχρονολογούν τους σεισμούς. Τα προκαταρκτικά δεδομένα με βάση τις ραδιογεωχρονολογήσεις με ^{14}C έδειξαν ότι κατά τις περιόδους 7540-7300 π.Χ., 3760-3620 π.Χ., 560-960 μ.Χ. και 680-890 μ.Χ. έγινε απόθεση κολουβιακών αποθέσεων. Αναγνωρίσθηκαν με βάση τις χρονολογήσεις και την ανάλυση των τομών τρεις πιθανοί σεισμοί κατά τη διάρκεια των τελευταίων 10.000 ετών του σεισμού του 1981 περιλαμβανομένου. Οι μετατοπίσεις ανά σεισμό εκτιμώνται σε 0,7 έως 1 μέτρο. Η κατακόρυφη μετάπτωση στη διάρκεια των τελευταίων 10.000 ετών εκτιμάται σε 2,7 μέτρα και ο μέσος ρυθμός ολίσθησης επί του ρήγματος σε 0,3 χιλιοστά / έτος.
Λέξεις-κλειδιά: *Παλαιοσεισμολογία, Σεισμοτεκτονική, Ενεργό ρήγμα Καπαρελλίου, ρυθμός ολίσθισης ρήγματος, Κορινθιακός Κόλπος, Ελλάδα.*

INTRODUCTION

The Gulf of Corinth is recognized as one of the most rapidly developing rifts in the Mediterranean region, with the geodetically estimated extension as high as 1 cm/yr (BILLIRIS *et al.,* 1991). Extension has a roughly N-S direction (SEBRIER, 1977; CLARKE *et al*., 1997; DAVIES *et al*., 1997; DOUTSOS & KOKKALAS, 2001). Most of this extension is accommodated by spectacularly exposed normal faults on the southern side of the Gulf of Corinth. Their length is in the order of tens of km (ROBERTS & KOUKOUVELAS, 1996; DOUTSOS & KOKKALAS, 2001; MICARELLI *et al*., 2003; XYPOLIAS & KOUKOUVELAS, 2005). Although the majority of these faults are north dipping some less well developed antithetic faults have significant role in the architecture of the Gulf that is

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traditionally suggested as a complex asymmetric half graben (Doutsos & Kokkalas, 2001). This study concentrates on a south dipping fault that is called Kaparelli Fault.

During February & March 1981, two devastating earthquakes affected the easternmost end of the Gulf of Corinth, an area known for hosting strong events (Koukouvelas & Doutsos, 1996). The epicentral area of these earthquakes that is called, Alkyonides Bay, is characterized by large onshore and offshore faults that form steep slope and deep basins respectively of a half-graben separating the Perachora peninsula from the rest of Central Greece (Leeder *et al*., 2002). The February earthquakes (Ms: 6.7-6.4) are very possibly related with ruptures all along the southern edge of the Alkyonides Bay, while the Ms: 6.4 March earthquakes created south-dipping surface faulting along the northern side of the Gulf in the area of Kaparelli and Plataies (Fig.1; Papazachos *et al*., 1981; Jackson *et al*., 1982). These earthquakes ruptured the boundary between Triassic limestones and alluvial deposits and the colluvium at the base of the existing E-W trending scarps along the Kaparelli fault.

Palaeoseismology is a geological method applied to the study of prehistoric earthquakes (Solonenko, 1973; Sieh, 1978; Wallace, 1981; Mc Calpin, 1996) especially their location, timing and size. This method tries to interpret geological evidence created during individual paleoearthquakes and correlate moderate to large earthquakes with specific faults. Thus palaeoseismological studies based on trenches excavated along or across faults are commonly used in order to extend historical seismological data. In addition since the palaeoseismology is primarily based on the analysis of colluvial tectonostratigraphy, it can provide data regarding the occurrence of destructive prehistoric earthquakes (Mc Calpin, 1996; Pavlides *et al*., 1999; Pavlides & Caputo, 2004).

Although Greece is a rapidly extending continental region palaeoseismology is applied mainly over the last fifteen years. The first paleoseismological studies in Greece were conducted in Mygdonia basin in Macedonia and the Souli Fault in Hepirus (Pavlides *et al*., 1992; Chatzipetros & Pavlides, 1994; Pavlides, 1996). Recently palaeoseismology is applied at almost all tectonic settings in Greece like the Gulf of Corinth or Thessaly basin (Pavlides, 1996; Pantosti *et al*., 1996; Collier *et al*., 1998; Koukouvelas *et al*., 2001; Pavlides *et al*, 2004; Caputo *et al*., 2004; Koukouvelas *et al*., 2005; Chatzipetros *et al*., 2005).

This study applies paleoseismologic trenching investigation in order to give new evidence on the seismic history of the Kaparelli normal fault that ruptured during the March 1981 Gulf of Corinth earthquakes. Parts of the data of this study are summarized also in the Chatzipetros *et al*. (2005). In detail this study presents tectonostratigraphy of fault colluvial sequences and dating of paleoevents by using ^{14}C dating. Finally we draw conclusions on the events recognized within the trenches and their recurrence interval.

THE KAPARELLI FAULT

The Kaparelli fault (KF) is south facing roughly E-W striking fault, segmented along its strike into three prominent segments showing clear evidence from the 1981 ruptures (Figs 1 and 2). These segments are clearly expressed at the surface by nearly continuous scarps (Kokkalas & Koukouvelas, 2005). The footwall of the northwest strand of the KF reaches c. 600 m height and is composed primarily of pre-rift Triassic-Jurassic limestones of the Pelagonian zone (see geological map of IGME, 1984). Livadostras river flows along the fault strike. A sedimentary basin called hereinafter as Livadostras basin in the hangingwall of the KF accumulates from bottom to top 230 m of syn-rift fluvio-terrestrial deposits of probable Pleistocene age, Holocene alluvial deposits and recent scree (Fig. 1).

Although all three segments of the fault on the basis of their geomorphologic expression are apparently active only two of them was reactivated during the March 1981 earthquakes. Its co-seismic rupture was characterized by a vertical throw in the order of 70 cm, but, in specific cases this throw was more than 1 m. Slip vectors as determined by matching homologous points at the opposite sites of the coseismic ruptures suggest that the slip on the surface ranges N200°E/60-70° and resembles approximately movements at depth similar to that determined by the seismological data (Jackson *et al*., 1982; Roberts & Koukouvelas, 1996; Morewood & Roberts, 2001).

The ruptured fault segments attained a maximum length of about 10-12 km during March 1981 and formed a left-stepping en echelon geometry that crossed Livadostras River (Jackson *et al*., 1982) (Fig. 1). One of them was mapped immediately south of Kaparelli village forming a continuous limestone scarp for about 5 km (Fig. 2d) (Jackson *et al*., 1982; Pavlides, 1993). This fault scarp is characterized also by a 3 m high zone with different color along its base. Recently Benedetti *et al*. (2003) dated this 3 m high scarp by ^{36}Cl to suggest that this is a cumulative effect of past earthquakes. The eastern end of the surface rupture turns abruptly south in ESE-WNW direction (Pavlides, 1993) suggesting that the end of the surface expression of this fault is probably related with the end of the fault itself (Tsodoulos & Koukouvelas, 2004). Its western end was a diffused zone within the Livadostros River. The second ruptured fault segment was south dipping and lies along the northwestern slope of Kithaironas Mt. to the south of Livadostros river with its westernmost termination located probably at the coast of the Livadostros Bay (Fig. 1).

METHODOLOGY

The KF is a typical target for palaeoseismic research because to that the March 4th 1981 Gulf of Corinth earthquake event ruptured the fault and these surface ruptures are easily recognized even 25 years after the earthquake (Fig. 2a-c). Thus using these data three trenches were excavated during May 2002 across the Kaparelli fault scarp, sampling the ruptured fault segment for 3 km (Fig. 1). In addition, as to that fault arrays in the study area as well as within the Central Greece are of almost pure dip slip (Doutsos & Kokkalas, 2001) trenches were excavated perpendicular to the fault trace. They are designated from west to east as Kap1 to Kap3. Trenches are located mainly in Holocene deformed sediments (colluvium, Kap2, Kap3) or fluvial (Kap1), in contact with bedrock limestone or fluvial sediments, respectively (Fig. 2). Trenches are 15 to 20 m in length and 2-4 m in depth and their walls were logged in detail, at a scale of 1:20. Trenches start from the last reactivated fault scarp and extend southward, with the Kap1 as the only exception as it crosses the 1981 fault rupture (Figs 3, 4, 5). Walls of the trenches were gridded with grid cell dimensions at 1m x 1m. Faults and contacts were etched into wall and marked with painted nails to enhance their visibility in the photographs. The walls of all trenches were photographed, cell-by-cell, while they were locally cleaned in order to provide a complete unobstructed view of the entire trench wall. The wall that was mapped in each trench was chosen as to preserve the best stratigraphy, and exhibiting faulting events with clear marker horizon displacements. Kap2 and Kap3 trenches constitute mainly of typical colluvium (unconsolidated angular limestone fragments and soil), which includes occasionally tile fragments, rare charcoal and some pottery fragments. In this study we will present data from trenches Kap1 and Kap2 due to that we have no age control on the colluvial deposits within trench Kap3.

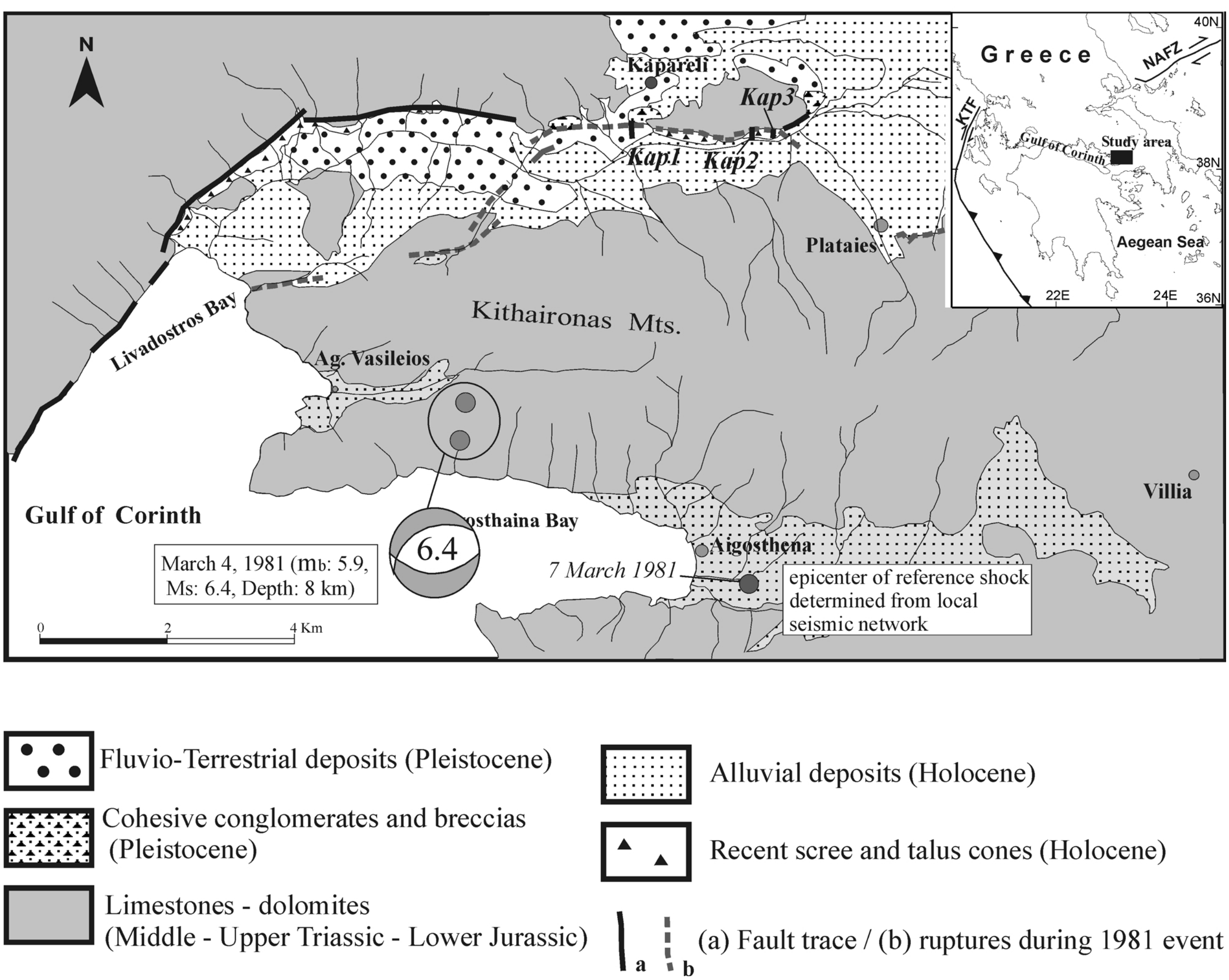


Fig. 1. Simplified map of the eastern Gulf of Corinth highlighting major faults and the position and magnitudes of the mainshocks of the 1981 earthquake. (Relocated epicenters and hypocentral parameters from Jackson et al. 1982). Faults with white colored teeth correspond to fault segments activated during 1981 earthquake. Location of the paleoseismological trenches are also shown as Kap1 to Kap3.

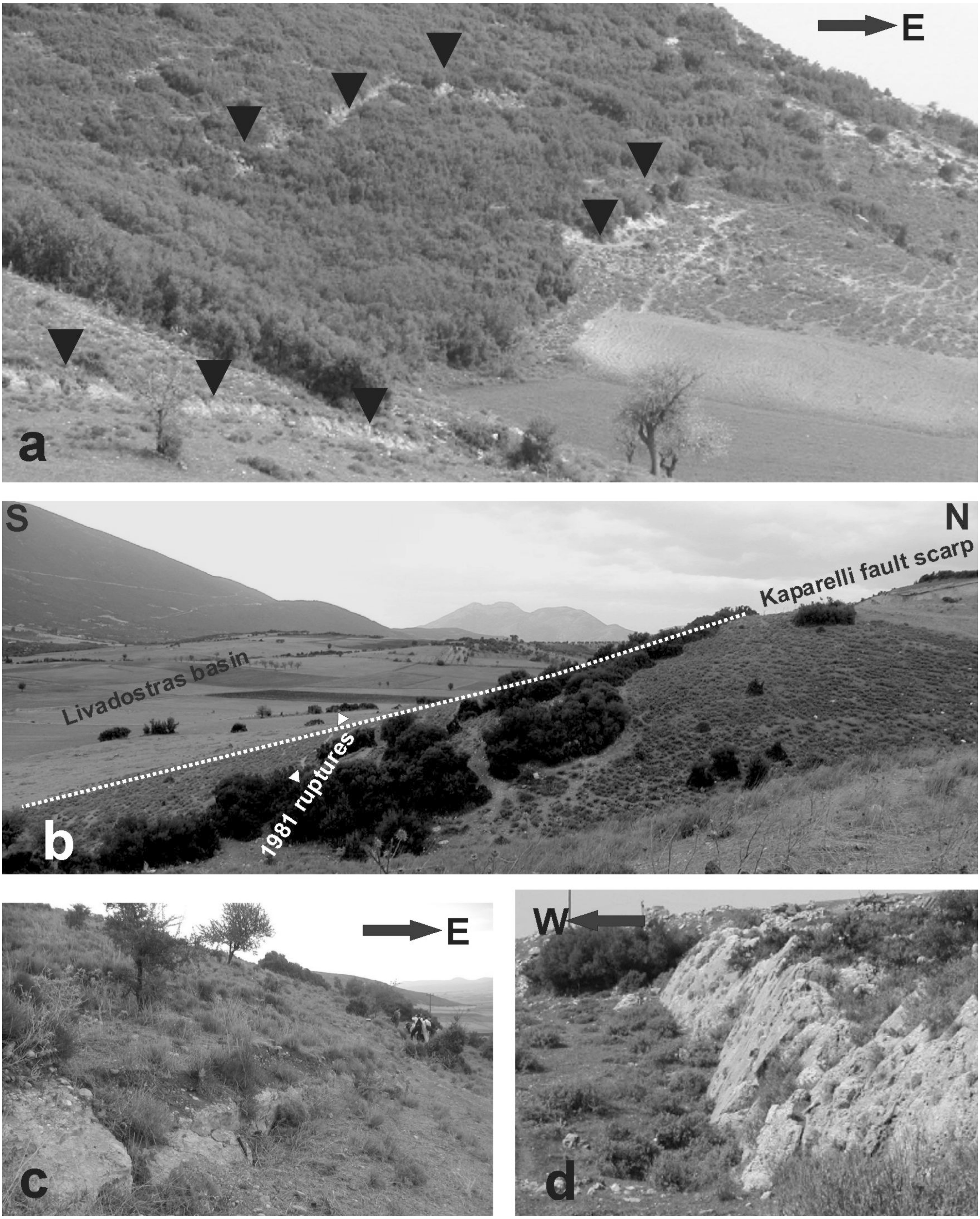


Fig. 2. Key structural observations showing a series of ruptures related with the 1981-earthquakes. (a) Arrowheads show the two strands of the faults west of the Kap1 trench. (b) A west looking view of the Kaparelli fault scarp. On the figures are also shown the Livadostras basin than formed on the hangingwall of the fault as well as the 1981-earthquake related ruptures. (c) A close-up view of the surface rupture just east of the Kap1 trench, photo is taken looking east. (d) Photo looking west of a fresh limestone fault scarp near the Kaparelli village.

RECOGNIZING FAULTING EVENTS WITHIN PALAEOSEISMOLOGICAL TRENCHES

The ground surface at the time of a paleoearthquakes is termed as an "event horizon" (Pantosti *et al.*, 1993). An event horizon is stratigraphically defined by either scarp-derived colluvium that buries the pre-faulting surface and/or by unconformities that develop as a result of warping and subsequent deposition. Therefore, the number of event horizons should equal the number of paleoearthquakes or similar the number of discrete colluvial wedges represents deposition following a surface-rupturing event.

Commonly used indicators of event horizons include liquefaction, upward terminations of faulting and abrupt changes in deformation between units separated by an event horizon. All these, taken alone, might also be explained by off-fault seismic sources or fault creep. Lines of palaeoseismic evidence that may be unique to coseismic rupture and not creep include fissure fills and colluvial-wedge deposits (Stenner & Ueta, 2000; Kelson & Baldwin, 2001). For this reason the colluvial wedge model is applied for the palaeoseismic investigation of the two trenches in Kaparelli region assisted also by other characteristic observations such as, upper terminations of secondary faults, fissure fills or striking difference between deformed and less deformed units.

TECTONOSTRATIGRAPHY

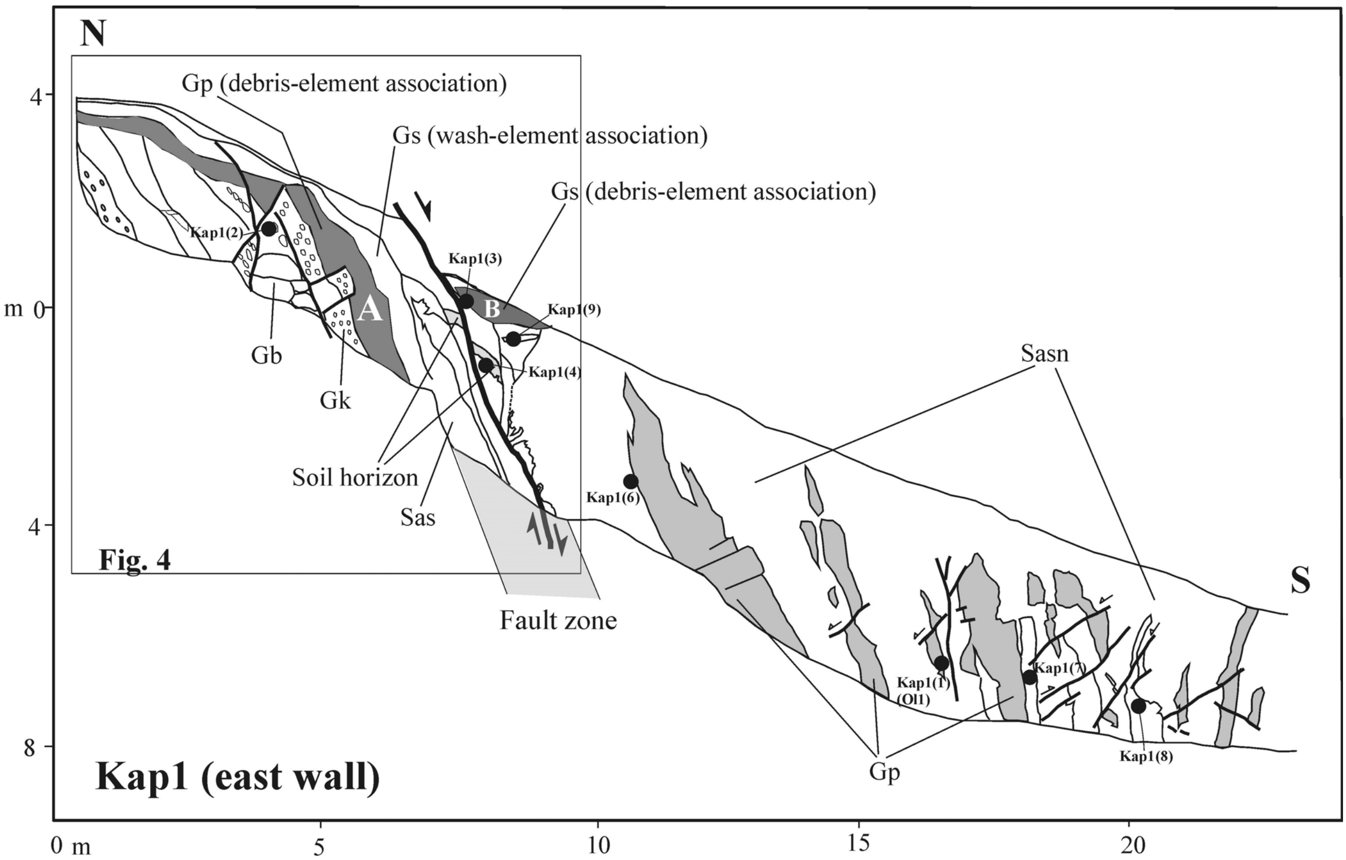
Trench Kap1

The first excavated trench exposed a ca. 4 m deep section. This section exposed a coarse-grained sequence within the footwall block and unconsolidated well-stratified silty-sand unit with conglomerate intercalations in the hangingwall block (Figs 3 and 4). The northern part of the trench comprises a moderate to high dipping wedge-shaped colluvial association which is subdivided, based mainly on its lithology (grain size), matrix and proximity to the fault scarp, into two subunits: (1) a lower part corresponding to a debris element association deposited over angular basement blocks (Fig. 3, unit A) and (2) an upper part, poorly developed, classified as a wash element association. The debris element can be characterized as a pebbly-cobbly gravel bed, containing clasts up to 15 cm in length. Clasts include primarily ophiolites (≈70%) with the rest of pebbles are Triassic- Jurassic limestones. Above this, lithofacies are getting much thinner consisting mainly of silty sand with sparse pebbles. This wash element association is not well-developed and is lying on the slope surface of the debris element. Below this sequence a complex assemblage of weathered basement blocks, up to 50 cm in length, as well as poorly sorted conglomerate beds of probable fluvial origin is lying, restricted mainly in the base of the colluvium. Based on these lithofacies assemblage we interpret the thickness of the sediments above the basement, as thin and the scarp location is controlled by a basement shallow. High angle normal synthetic and antithetic fault strands displace this assemblage, as well as the debris element of the overlying colluvium, showing a complex geometry.

The main structural feature in this trench is a 3 m wide high angle normal fault zone, which was reactivated during the 1981 seismic event (Fig. 3). This zone shows the following characteristics: a chaotic assemblage of sheared "in situ" deposits, material that has fallen into fissures in intact blocks, plus circulation of meteoric water and precipitation of $CaCO_3$, partly disaggregated blocks and material washed into depressions by running water, during the development of the wash element. Based on all these characteristics and that during the last earthquake fault reactivation occured in this zone we interpret this fault zone as a long-lived fault zone. Many pebbles have been dragged along the fault plane and some layers appear to be warped. A small soil key-bed horizon is displaced along the fault surface, showing a vertical offset of c. 50 cm. (Fig. 3) The lower limit of this key-bed horizon (sample Kap1,4) has been dated to 3760-3620 BC (calibrated age) (Fig. 6).

The hangingwall block of the reactivated fault strand comprises a strongly rotated (>60^0) sedimentary seque-nce, which consists of silty-sand with pebbly gravel bed intercalations. This rotation may have been achieved with fault interaction and formation of a restraining overlap zone (see also Rykkelid & Fossen, 2002) during cumulative fault deformation. Soil samples taken from this sequence showed an age range from 5500 BC to 5200 BC (Samples Kap1,1 and Kap1,8) (Fig. 6). However, this age can't explain the rotation of the sequence, implying either strong earthquake events at low recurrence interval of high aseismic creep of the fault. Both hypotheses are ill constrained by the ^{14}C age data or the geodetically derived data over the Central Greece (Clarke *et al.*, 1997). The most recent history is disrupted by human activity, like ploughing and a more detailed and careful soil dating is needed in order to study the recent faulting process in detail and to draw conclusions on the rate of deformation, the recurrence interval of moderate to strong earthquakes etc.

However, the age range covered by the sediments within the trench is 5500-5200 BC (for the fluvial sediments) to 680-890 AD (Fig. 3, unit B; base of the younger colluvial wedge). This small-scale colluvial wedge adjacent to the surface rupture trace of the 1981 event corresponds to a strong event prior the 1981 earthquake, with a lower age limit of 3760-3620 BC and an upper limit of 680-890 AD, bracketing by the underlying soil bed horizon (Fig. 3, sample Kap1,4) and the small colluvial wedge (Fig. 3, sample Kap1,3).



Lithofacies Codes

Main lithology	Lithologic unit modifier	Internal structure	Interpretive modifier
G gravel	**b** bouldery	**t** clast supported	**(w)** highly weathered
S sand	**k** cobbly	**x** matrix supported	
F fines	**p** pebbly	**n** contains lenses of sandy or gravelly sediment	
R bedrock	**a** sandy		
	s silty		
	d coarse		

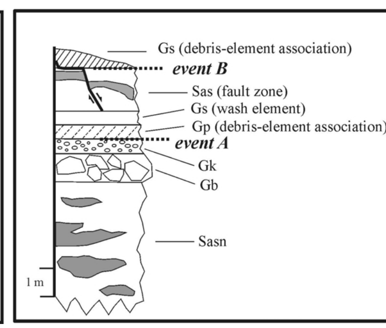


Fig. 3. East wall of trench Kap1 with a schematic tectonostratigraphic column. Capital letters within colluvial units show which units were deposited following the first (A) or second (B) faulting event. Lithofacies codes after Nelson 1992. Rectangle shows the location of the Fig. 4.

Trench Kap2

The Kap2 trench is c. 16 m long, 3 m deep and 2 m wide (Fig. 5). This trench constitutes a typical colluvium succession. It is composed mainly by sub-angular limestone fragments and soil, which include occasionally tile, pottery fragments, and some charcoal.

The lower and upper debris-element facies associations of the lower colluvium (unit A) are distinguished primarily by their position in the wedge next to the scarp and their lithology, and by the proportion of basement blocks, coarse clasts and fine-grained sediment, which are relative to their source lithologies. The upper debris-element facies consists of lithofacies that are thinner, more laterally extensive and contain smaller and more dispersed blocks and clasts than lithofacies of the lower debris element.

Above this association lies a subunit, which comprises a less wedge-shaped assemblage of lithofacies deposited on the sloping surface of the debris element. It is finer grained than the upper debris element and the internal bed contacts are more nearly parallel. The percentage of matrix increases upwards from 10% in the lower beds to 40% in the upper beds, while the clast size decreases significantly. This fact, as well as its position relative to the underlying debris element, enabled us the interpretation of the unit as a wash element association.

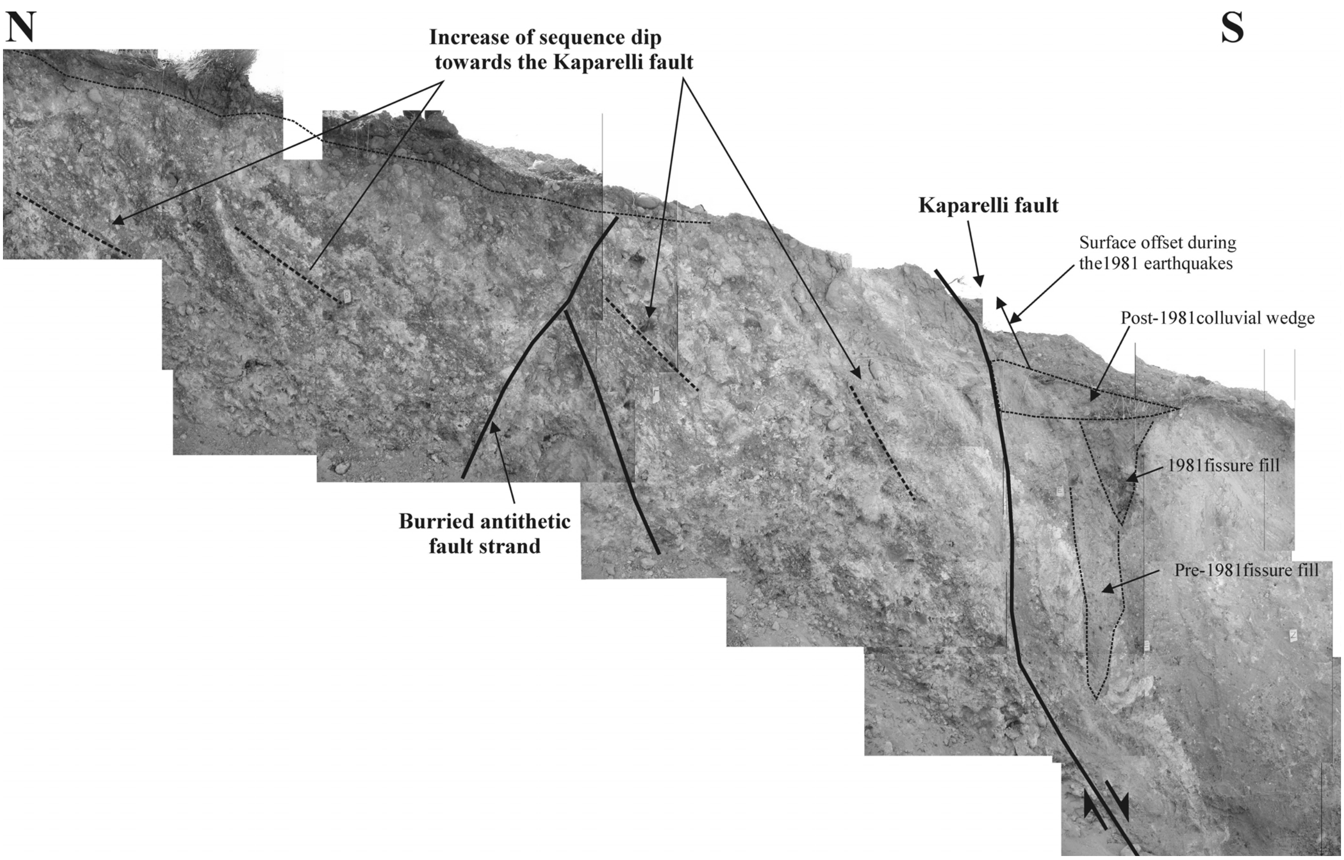


Fig. 4. Photo-mosaic of the east wall of trench Kap1, for location of photo see fig. 3. The photo-mosaic shows increase of sediments dip towards the faults, the fault zone and a seires of fissure fills. For details see also the text.

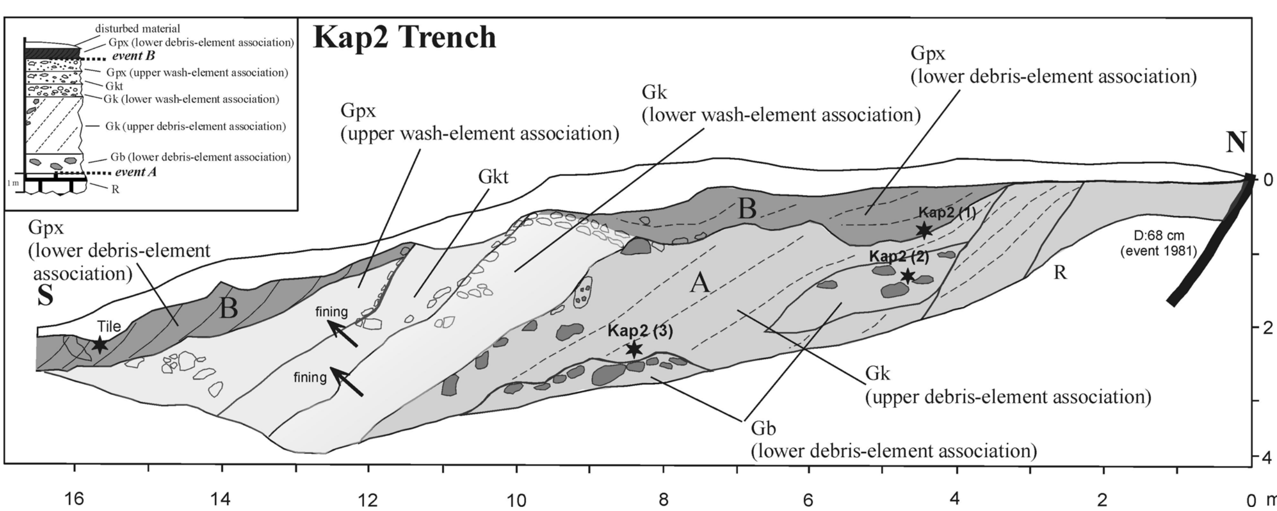


Fig. 5. West wall of trench Kap2 with a schematic tectonostartigraphic column. Lithofacies codes as explained in Fig. 3 for details see also text.

Above the wash element and an erosional surface lies a second colluvial wedge (unit B) that is finer grained than the first and more laterally extended. The results from a soil sample taken at the base of this colluvium indicate that, at 2σ, the age ranges from 560-690 AD. Additionally, samples from the base of the older debris element indicate that, at 2σ, age ranges from 7540-7300 BC (Fig. 6).

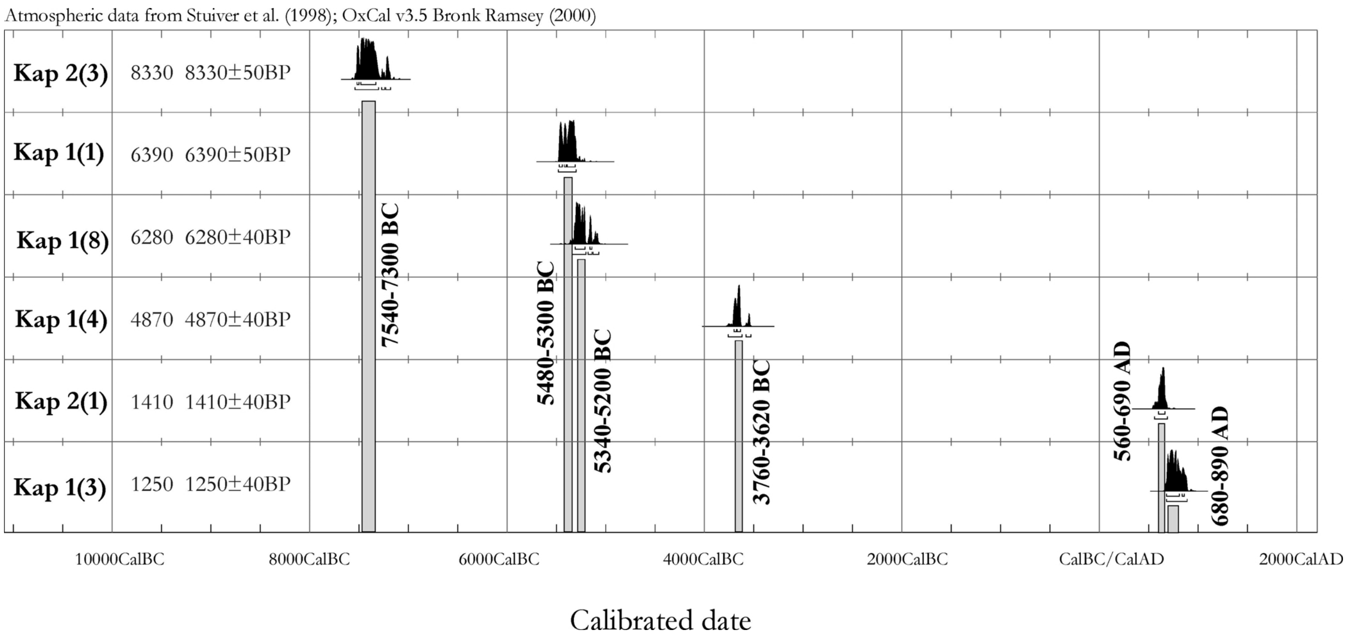


Fig. 6. Outlines show probability distributions of calibrated radiocarbon ages of samples. Lines below each distribution show limits of the 95.4 and 68.2 percentile confidence ranges for these samples (using OxCal, ver. 3.5, Ramsey 2000). The likelihood of different possible ages of the sample shown as the solid black distribution. For more details about samples see also Table 1.

TABLE 1

Dates of Radiocarbon samples from Kaparelli trenches.

Sample	Laboratory	Description	$\delta^{13}C$	^{14}C Age	Calibrated Age (at 2σ)
No	*No*		*(‰)*	*Years BP*	*Calendar Years*
Kap1,4	11002	soil	-10,88	4,870±40	***3760-3620 BC (85,8%)***
					3580-3530 BC (9,6%)
Kap1,8	11003	soil	-23,47	6,280±40	***5340-5200 BC (75,8%)***
					5180-5140 BC (11,7%)
					5130-5070 BC (7,9%)
Kap1,3	11004	soil	-21,55	1,250±40	***680-890 AD (95,4%)***
Kap1,1	11005	soil	-14,28	6,390±50	***5480-5300 BC (95,4%)***
Kap2,3	11006	soil	-21,88	8,330±50	***7540-7300 BC (86,8%)***
					7270-7240 BC (1,5%)
					7230-7180 BC (7,1%)
Kap2,1	11007	soil	-23,39	1,410±40	***560-690 AD (95,4%)***

RADIOCARBON DATING

Table 1 shows the results for 6 samples of soil that were dated by radiocarbon method. Radiocarbon ages were calibrated to calendar ages using the program OxCal ver. 3.5 (Ramsey 1995, 2000) that uses the atmospheric data of Stuiver *et al*. (1998). These samples were chosen from locations that are in the vicinity of the debris associations. Date samples from the uppermost part of the sections were excluded because they might be too young in age and thus their dating would have been unreasonable due to uncertainties in calibration.

Measurements of radiocarbon concentration are usually expressed in terms of a notional age, in numbers of years before 1950. This notional age is calculated on the simplistic assumption that the amount of radiocarbon in the atmosphere has always been the same, which is not quite the case, and so for anything other than a very rough indication of age the measurement must be calibrated. Calibration is performed by comparing the radiocarbon measurements on the sample to those made on material (usually tree rings) of known age. This comparison allows one to determine the possible calendar age of the sample. Figure 6 shows calibration of six samples on the Kaparelli trenches. The range of possible ages is shown only for the best level of confidence (2σ: 95%)

DISCUSSION

In view of the increased vulnerability of modern society to hazards it is worthwhile to continue palaeoseismic research, applied to active faults in a high seismicity area such as the Gulf of Corinth, for large earthquakes that occur on a longer timescale. On the other hand ancient earthquakes can also warn scientists about a presently tectonically quiet region in a broader area, and a potential return of activity in the future. Although the stratigraphic complexity of sediments near faults can be intimidating, lithofacies analysis of colluvial sequences in fault exposures helps significantly to interpret the history of faulting. In order to get more complete picture, more trenches are needed enabling a correlation of events over the rupture front of a postulated paleoearthquake. Among the most important results of a paleoseismological study are definitions of surface offset per event, number of events on a fault or a fault zone, recurrence interval of past events and corresponding magnitude per event.

Along KF, thicknesses of the units in the colluvial wedges of offset of discrete marker horizons are in the order of 0.7 m. As resent co-seismic displacement on this segment average 60-70 cm, and strips of different color are recognized at the base of fresh bedrock exposed at the base of the scarp suggest that offset of past events is probably in the same order of magnitude.

Based mainly on colluvium tectonostratigraphy, depositions of sedimentary layers, formation of soil, and small displacement of some key horizons, three at least faulting seismic events (paleoearthquakes) were identified during Holocene. We consider the strongest evidence for paleoearthquakes to be the existence of successive colluvium wedges (trench Kap2) and fissure fill facies (trench Kap1) deposited adjacent to the main fault trace, as material must be shed off a newly exposed fault scarp relatively quickly.

Our preliminary results from the two trenches show that age range for colluvial sedimentation is 7540-7300 BC, 3760-3620 BC, 560-690 AD, and 680-890 AD, (Fig. 6; Calibrated radiocarbon analysis results) and they are probably associated earthquake wedges. In the first trench (Kap1) the last event (1981) is clearly shown within a greater fault zone of ~3 m width, where tilted (50^o-70^o) sediments (clay, sand, colluvial wedges and soil) are strongly rotated by previous tectonic events. Based on these data the Kaparelli fault appears to be reactivated at a recurrence interval in the order of 2500 years. Corresponding magnitude during the three recognized events are in the order of 6.4 following equations of PAVLIDES & CAPUTO (2004). Finally an estimation of the slip rate of the fault can be suggested by dividing the total thickness of the accumulated sediments with the age determined for the older sediment deposited within the trench Kap2.

CONCLUDING REMARKS

1) Stratigraphic record within the trenches shows that at least three events are hosted on various strands of the Kaparelli fault. The age range recognized within the trenches covers the entire Holocene with the 1981 event included.
2) Colluvial tectonostratigraphy and analysis of displacements on key bed horizons suggest surface rupturing events in the order of 0,7-1 m.
3) Preliminary results regarding the age range of sedimentation suggests that the recurrence interval ranges between 2500- 5000 years. This interval may suggest a non-systematic medium to short recurrence for strong earthquake hosted on the Kaparelli Fault.
4) Colluvial thickness in Kap2 trench is about 2,7 m and the calibrated age of its lower limit is 7550-7220 BC (86,8%, at 2σ) suggesting an average slip rate of the Kaparelli Fault along this sampled portion in the order of c. 0,3 mm/yr.

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