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GPR INVESTIGATIONS ON ACTIVE FAULTS IN URBAN AREAS : THE GEORISC-NZ PROJECT.

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Georisc-NZ is a joint French-New Zealand programme studying active deformation in New Zealand, mainly based on Ground-Penetrating Radar (GPR) imagery. Data was collected in New Zealand in March 1998 within or close to urban areas to accurately locate (within 0.5 m) buried active faults. Locations were selected to test the GPR imagery in a variety of tectonic and sedimentary environments; several radar frequencies were also tested. The preliminary results of Georisc-NZ will be presented in a poster at this conference.

Known and previously unknown strands of faults have been identified in the selected sites. In Thorndon, Wellington, GPR images suggest that the Wellington Fault comprises two or more strands that may merge at depth, illustrating the potential value of GPR in urban surveys. Northeastward, from Petone to Upper Hutt, the GPR profiles indicated persistence of the branching geometry observed on the fault within Wellington City. Several sites were also chosen to examine the Wairau, Awatere and Vernon faults in Marlborough. Active strands have been imaged near Blenheim (Wairau Fault) and Seddon (Awatere Fault) which illustrates a complex sub-surface geometry for these faults (several strands, step-overs). The last leg of Georisc-NZ was devoted to a reconnaissance of the active Poukawa Fault Zone from Waipukurau to Hastings. Reverse and normal faults have been imaged, corresponding reasonably well with trench observations.

Technical limitations of GPR, imposed by sediment and fault characteristics, have been identified during the survey. In Blenheim, Lower Hutt and southeast of Hastings, penetration depths and GPR resolution were strongly affected by sediments types (worst in clayey gravels, swamp/marine deposits, volcanoclastics), by the groundwater level (Blenheim) and by the gentle dip of fault planes (Hastings). However, alluvial and colluvial sediments in conjunction with steeply dipping faults in the Wellington area proved suitable for imaging.

GEOLOGICAL SOCIETY OF NEW ZEALAND and NEW ZEALAND GEOPHYSICAL SOCIETY Joint Annual Conference, CHRISTCHURCH, 30 November - 3 December 1998.

J.G. BEGG : presenter.

GROUND PENETRATING RADAR INVESTIGATIONS ON ACTIVE FAULTS IN URBAN AREAS : THE GEORISC-NZ PROJECT

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ABSTRACT

Georisc-NZ is a joint French/New Zealand programme studying active faults in New Zealand towns, mainly based on Ground Penetrating Radar (GPR) imagery. Data was collected in New Zealand in March 1998 within or close to urban areas. Locations were selected in both North and South Islands to test the GPR imagery in a variety of tectonic and sedimentary environments; several radar frequencies were also tested. The preliminary results of GeoriscNZ are presented in this poster.

Known and previously unknown strands of faults have been identified in the selected sites. In Thorndon, Wellington, GPR images suggest that the Wellington fault comprises two or more strands that may merge at depth, illustrating the potential value of GPR in urban surveys. Northeastward, from Pelone to Upper Hutt, GPR profiles indicated persistence of a branching geometry similar to that observed on the fault in Wellington City.

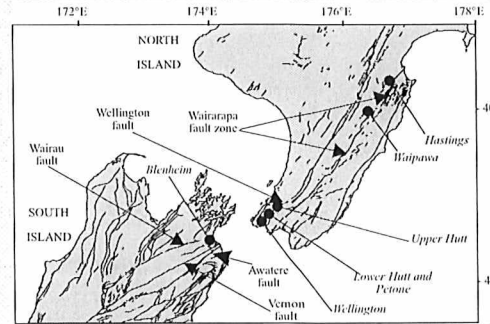
Another leg of Georisc-NZ was devoted to a reconnaissance of the active Poukawa fault-zone from Waipukurau to Hastings. Reverse and normal faults have been imaged, corresponding reasonably well with nearby trench observations.

Several sites were also chosen to examine the Wairau, Awatere and Vernon faults in Marlborough. Active strands have been imaged near Blenheim (Wairau fault) and Seddon (Vernon fault) which illustrate a complex sub-surface geometry for these faults (several strands, stepovers).

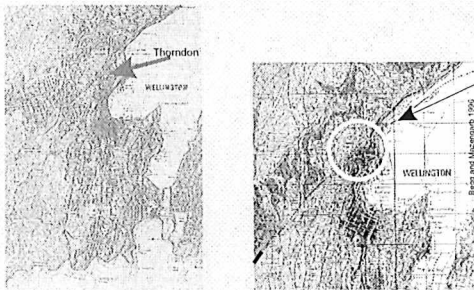
Technical limitations of GPR, imposed by sediment and fault characteristics, have been identified during the survey. In Blenheim, Lower Hutt and southeast of Hastings, penetration depths and GPR resolution were strongly affected by sediment types (worst in clayey gravels, swamp/marine deposits, volcanoclastics), by the groundwater level (Blenheim) and by the gentle dip of fault planes (Hastings). However, alluvial and colluvial sediments in conjunction with steeply dipping faults in the Wellington area proved suitable for imaging.

LOCATION OF SURVEY SITES

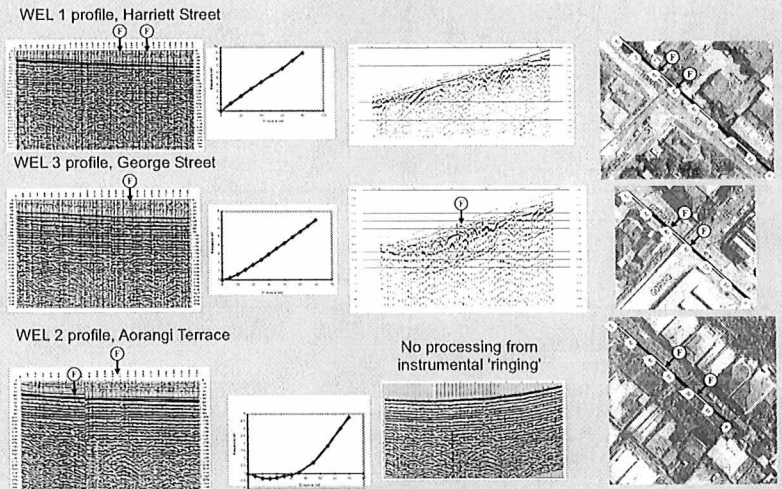
The active faults surveyed within central New Zealand towns were: 1- the Wellington fault in Wellington, Petone, Lower Hutt and Upper Hutt, 2- the Poukawa fault-zone and associated faults from Waipawa to Hastings and 3- the Wairau, Awatere and Vernon faults in the Blenheim region.



MAPS OF WELLINGTON SHOWING LOCATIONS OF GPR PROFILES

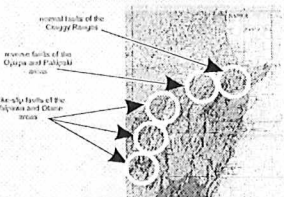


WELLINGTON PROFILES



Several GPR profiles were done across the Wellington fault along streets of Thorndon, Wellington. The plots on the left are plots from raw field data, while that on the right are adjusted for topography and/or processed to eliminate extensive instrumental "ringing". Information on soil stratigraphy and structure is hidden in the raw data plot by "ringing", but indication of the presence of the fault is restricted to zones of hyperbolae and diffractions. In the right hand plots, processing and topographic adjustment help to reveal the soil stratigraphy and structure, which better define the location of fault splays. The pencil-lines on the airphotos represents the location of the Wellington fault prior to Georisc determinations.

MAP OF THE HAWKE'S BAY AREA SHOWING LOCATIONS OF GPR PROFILES

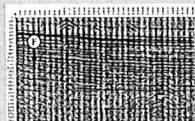


HAWKE'S BAY PROFILES

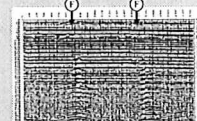
The WAK 1 profile was done within Waipukurau to test GPR capability to image active reverse/thrust faults and to assist the District Council's understanding of fault hazard. The soil here consists of alluvial gravel overlain by loess and colluvium. The radar image indicates that the base of the scarp is associated with a fault-plane, dipping gently to the west between trace 20 and 90. The HAU 1 profile was run near Te Mata to test the GPR on normal faults, across a c. 10 m high double scarp. The HAU1 profile shows two diffractions associated to the two discrete scarps at traces 68 and 157. These may represent the two normal fault strands associated with the two scarp. The soil consists of alluvial gravel overlain by loess and colluvium.

The POU 11 profile was run across a strike-slip fault running from eastern Waipawa to eastern Olone. At Pouterere Road, within Waipawa, thin topsoil and overbank silt deposits overlie alluvial gravels and Whangai Shale bedrock. In a trench beside the profile, the main fault was located at the base of the scarp. A lenuous diffraction zone appears around trace 60, at the base of the scarp, and may represent the fault signature. The wider scattering is due to the proximity of the cart carrying the GPR equipment.

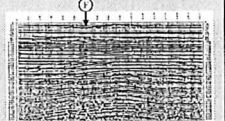
WAK 1 profile, Holt Pce, Waipukurau



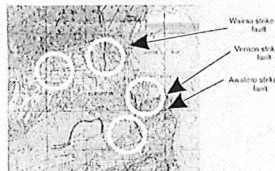
HAU 1 profile, Craggy Range Rd, Te Mata



POU 11 profile, Pouterere Rd, Waipawa



MAP OF THE MARLBOROUGH AREA SHOWING LOCATIONS OF GPR PROFILES

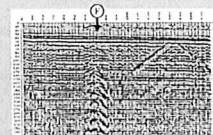


MARLBOROUGH PROFILES

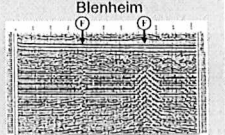
East of Blenheim, the Vernon fault is located between the Wairau and Awatere strike-slip faults. In this area, freshwater conglomerates of late Miocene age underlie fan gravel of probable Last Glacial age. Topographically the fault consists of two discrete scarps (suggestive of reactivation of an older scarp) and right-stepping en-echelon dry ponds. The VER1 profile shows a probable deformed (scattering) zone at the base of the scarp at trace 71; complementary profiles confirm the right-stepping en-echelon geometry.

At Delta, west of Blenheim, sediments consist of aggradational gravel and local fan gravel and silts of late Last Glacial age (Speargrass Formation; Brown, 1981). These are cut by the Wairau strike-slip fault. Here, the WAI 2 profile shows some dispersion related to two strands of the fault at traces 38 and 73, both identifiable in topography. Penetration is shallow due to the groundwater table which is observed at a 6-8 m depth in a nearby drillhole and the thick unconsolidated gravels inferred to lie on each side of the fault may contribute to poor resolution.

VER 1 profile, Vernon



WAI 2 profile, Delta, Blenheim



CONCLUSIONS

- GPR profiles were run across active faults (or considered active) in a variety of soil conditions and tectonic environments in central New Zealand.
- The resulting initial images are of variable quality and resolution. Raw GPR profiles proved to be of limited use until a previously unappreciated distortion or "ringing" inherent in the hardware was identified. Careful processing minimised the "ringing" effect and provided clearer images of subsurface structures (Wellington).
- At this stage, most of the images are available only in an initial form; further processing and analysis is required to confidently locate active faults and related structures and to check whether low angle faults have been accurately imaged in the data.
- Overall, the method has proved successful in locating faults in favourable soil conditions and where fault planes are steeply dipping (Wellington), but less successful in locating gently dipping faults in marginal soil conditions: these include clays or clayey loess (Seddon), sediments with high organic or iron content (Otago), and water saturated sediments (Blenheim), particularly where groundwater has appreciable salinity levels (Vernon). However, the Georisc-NZ survey coincided with unusually dry meteorological and groundwater conditions, thus providing higher resolution.
- The technique has proved useful for accurately locating fault strands with no surface expression. Features in GPR images that are interpreted as fault traces can be located easily to within a metre, when ends points of survey lines are also satisfactorily located (in towns).
- Location of potential fault rupture is useful in quantifying the associated hazards. The principal advantages in using GPR to locate fault strands are that the method is quick, non-destructive and cheap (excluding the cost of the equipment). The equipment is highly portable minimising access difficulties and the main limitation of the method is that in most cases, subsurface fault strands cannot be defined as active or inactive on the only basis of the GPR images. Identification of fault activity is an important step in hazard mitigation, and where required, GPR may be used as a tool to locate a suitable site for conventional paleoseismic techniques such as trenching.
- Processing work on extensive topographic levelling data collected during the survey has yet to be completed, and may provide an independent method of estimating the earthquake history of surficial scarps and earthquake-related terrace sequences.

ACKNOWLEDGMENTS

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