PALAEOSEISMICITY ALONG THE TSHIPISE FAULT, SOUTH AFRICA, AND ITS IMPLICATIONS FOR THE FEASIBILTY OF A MAJOR POWER FACILITY

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The facility forming the subject of this study is a pumped storage scheme, involving upper and lower dams and a subterranean power station; its purpose was to satisfy peak power demands and to stabilize the national transmission grid. Although based on hydro rather than nuclear power, in its size and sensitivity to seismically induced ground accelerations the scheme shares many similarities with conventional nuclear power plants.

Located in the Soutpansberg Mountains of the Northern Province (Fig.1) the scheme was to incorporate an upper dam 68 m high impounding 25 X 10^6 m^3, which would drain via a surge shaft 552 m deep and through a pressure tunnel to an underground power station. Discharge into a lower storage dam on the Mutale River would precede refilling of the upper dam through phases of reverse pumping. The estimated project cost was $350 million.

Preliminary investigations indicated that the area had been subject to large-scale slope instability in the past, including a major rock slide which impounded the upper Mutale River to form one of the few natural lakes in South Africa, Lake Fundudzi. Another takes the form of a large debris flow, indicative of liquefaction under seismic shock; in this feature coarse detritus has been rafted up to 1.3 km from the mountain front on slopes as low as 6%.

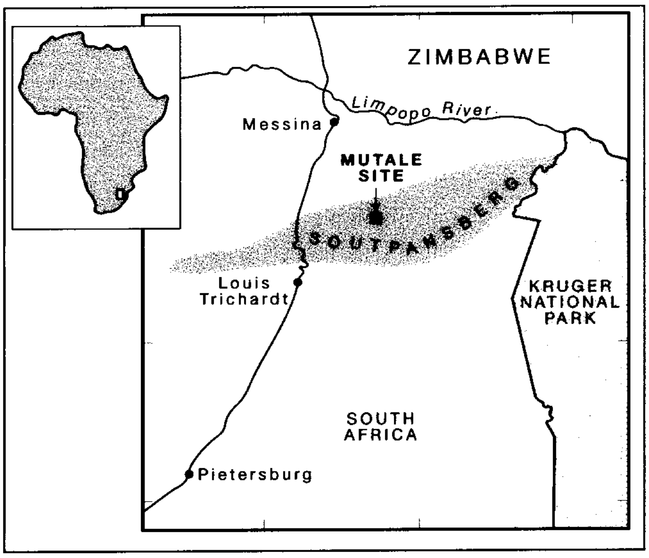

Fig 1. Locality map

While several strike faults are present within the Soutpansberg Mountains, none display manifestations of recent movements. These are evident, rather, in the scarps of the Tshipise and Bosbokspoort faults to the north of the mountains, which displace recent sediments (Fig.2).

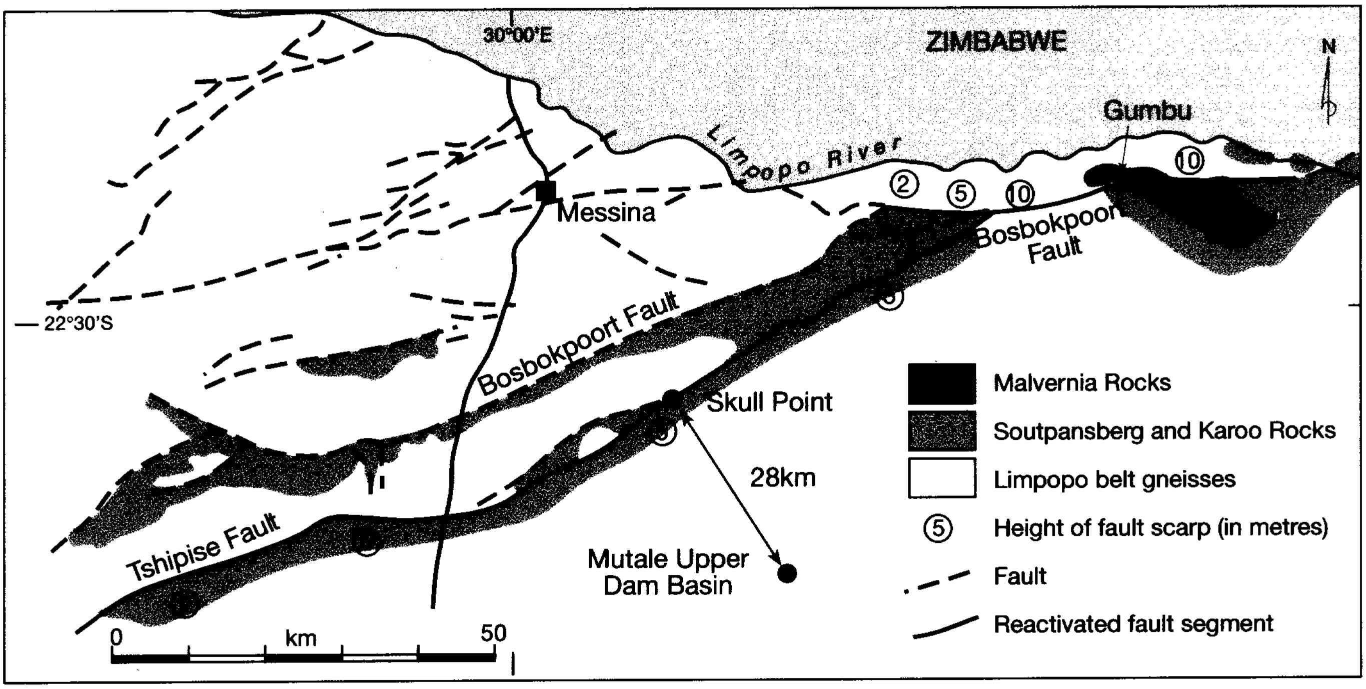

Fig 2 Simplified geological map.

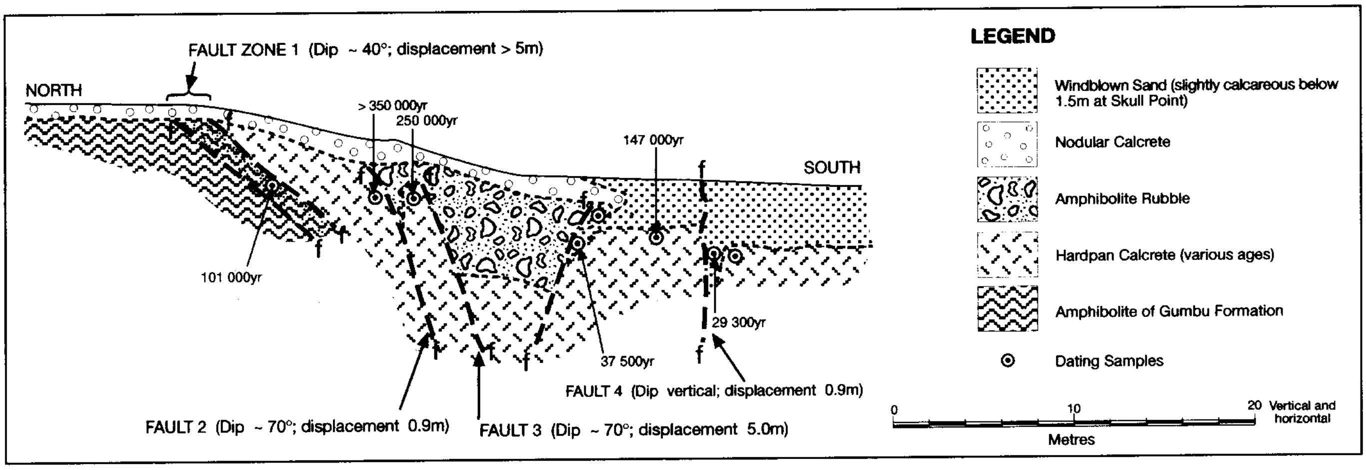

Fig 3. Section across Tshipise Fault at Skull Point.

Palaeoseismic analysis of the Tshipise Fault involved trenching across the recent, but nonetheless eroded, 5m fault scarp at Skull Point, situated 28km from the site of the upper dam. This scarp displaces calcified windblown sand, presently stabilized by vegetation, which was derived from the floodplain of the nearby Limpopo River. Regional evidence indicates that this and other aeolian deposits of the semi-arid interior of southern Africa were mobile during the Last Glacial and preceding cool, dry intervals. Multiple planes of movement were revealed, some displacing calcrete (caliche) which gave U-series ages ranging from >350 Ka to 147 Ka (Fig.3).

Three of the planes contained entrapped sand. Given the amplitudes of the associated displacements, it may be assumed that sufficiently high temperatures were generated to release any accumulated radiation doze; TL dates on these sands are therefore taken as indicative of the age of the respective movements. The associated seismic magnitudes were estimated using accepted empirical relationships established from field evidence (de Polo and Slemmons, 1991).

The TL dates enabled the magnitude/frequency relationships, established from recorded seismic events spanning the last century (SA Council for Geoscience, 1998), to be extended back to 101 Ka (Fig.4). The relationship in (a) was determined from all events within a 300km radius of the site, while that in (b) was based on those events with epicentres in close proximity to the fault system. The two regressions are reasonably similar and indicate that the 1:1000 year event is likely to have a magnitude of ~6.0, while that for the 1:10 000 year event would be ~7.0. The 1:10 000 year event was selected for risk analysis in view of the sensitive nature of the structures involved and the frequent, relatively rapid, drawdowns to which the upper dam would be subject under operating conditions. The moderately steep slopes of the basin of this dam are covered by deep, clayey residual soils whose properties were determined through the laboratory analysis of samples obtained by drilling and trenching. Conventional slope stability analysis, using deterministic and probabilistic methods, was applied under the conditions of residual pore water pressure which would prevail during both normal and emergency operating conditions. When the effects of attenuated ground accelerations, associated with seismic activity along the Tshipise Fault, were introduced into the slope stability model, a 100% probability of failure, involving more than $10^6 m^3$ of material, was found to exist, even under the accelerations produced by the 1:1000 year event. The collapse of this volume of material into the water retained in the reservoir would result in catastrophic overtopping of the embarkment into the populated area downstream.

The scheme was abandoned in the light of these findings.

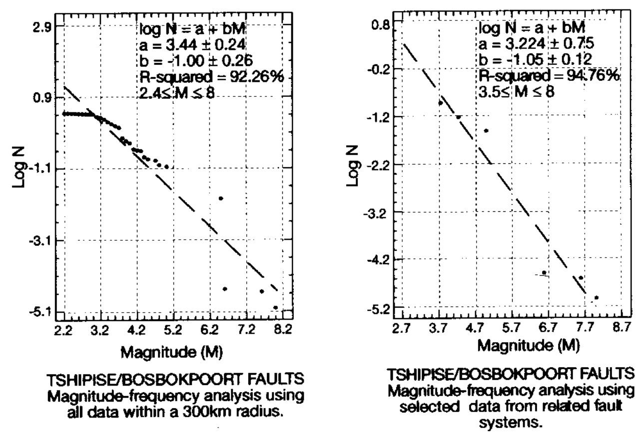

Fig 4. Tshipise/Bosbokpoort faults magnitude-frequency analysis

References

De Polo, C.M. and Slemmons, D.B. 1991. Estimation of earthquake size for seismic hazard. In: Krinitsky, E.L. and Slemmons, D.B. (Eds.) Neotectonics in Earthquake Evaluation. Geological Society of America, Reviews in Engineering Geology, 8.

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