EARTH SCIENCES

San Andreas Watch

from a Correspondent

EARTHQUAKE prediction, present seismicity and strain accumulation, and past motions along the San Andreas fault as inferred from geological and geochemical evidence were the topics discussed at a meeting at Stanford University from June 20–23.

Great progress has been made by Dr J. C. Crowell (University of California, Santa Barbara) and others in unravelling fault motions in southern California. The San Gabriel fault is now believed to have been the main strand of the San Andreas system throughout the mid-Tertiary. It moved vigorously 10 to 20 million years ago and continued to slip up to 3 or 4 million years ago when the San Andreas fault became active. Early Miocene displacement along the San Gabriel may have amounted to 40–60 km, which would bring the total displacement for that period of 350 km or so into agreement with that observed in central California. North of the Transverse Ranges, however, offset of earlier strata suggests an additional 300 km of right lateral slip which has not yet been documented in southern California.

Dr C. Scholz (Lamont) made an interesting comparison between the Alpine fault in New Zealand and the great bend region of the San Andreas. In New Zealand the Warran fault has the most offset across it but, in response to changing regional stress patterns, the Hope fault is now the active branch. Most of the recent seismicity in southern California is associated with the San Jacinto fault, which supplanted the Banning-Mission Creek trace 3 or 4 million years ago. Uplift occurs in the central portion of the Alpine fault where it is cocked with respect to the regional slip vector; in California, a similar misalignment is manifested by thrust faulting in the Transverse Ranges. As the San Andreas is the most heavily instrumented fault in the world, it is encouraging to think that the knowledge gained from it may have applicability elsewhere.

On the subject of earthquake prediction, more questions were raised than answered. Such fundamentals as whether seismic activity should increase or decrease prior to a large event are unresolved. On the one hand, Drs W. Ellsworth and R. Wesson (NCER) have predicted a magnitude 4.5 event in the Bear Valley region based upon a seismic gap approach. Dr T. Hanks (Cal. Tech.), on the other hand, suggests that large earthquakes will occur in zones of above average seismicity, such as the southern half of the San Jacinto fault zone.

Dr R. Nason (USGS), noticing accelerations in surface creep rates in the fault zone near San Juan Bautista, has predicted a magnitude 6 event on the 50 km section of the San Andreas immediately south of that town. But Dr R. Burford and Dr R. Lamson (NCER) have found that surface creep tends to follow seismic slip, occurring in response to deep motion rather than preceding it. Certainly, earthquakes cluster in areas where the rate of creep changes most rapidly with position along the fault or is abnormally low. The prediction by Dr A. Johnson (Stanford) of a magnitude 5.8 event near Hollister is based on this. Such behaviour indicates that creep is being retarded for one reason or other, possibly due to "sticky spots" on the fault plane at depth. The position of the creep meter with respect to these obstructions will determine the kind of creep behaviour recorded. Unfortunately, almost nothing is known about the location, extent or persistence of sticky spots, so that for any particular area whether accelerations or decelerations might signal an earthquake can only be determined empirically.

Then, inevitably, there were discussions of travel time ratios and variations on that theme. Reports of normal travel times prior to large events outnumbered reports of anomalous behaviour by four to two, but certain patterns emerge. Systematic t_s/t_p variations have only been observed in association with thrust faults and not necessarily even then. Since Whitcomb *et al*. showed that most of the variation in t_s/t_p is due to changes in t_p, Dr C. Allen (Cal. Tech.) has looked for changes in compressional wave velocity prior to the San Fernando earthquake using records of mining explosions. His group failed to see any systematic change, contrary to Whitcomb's observations. Differences in seismic source and receiver station geometry with respect to the focal zone probably account for the disparate results. The ray paths of the pulses examined by Allen's group would have passed under the epicentral region at a depth of about 25 km. As virtually all of the seismic activity in California is confined to the upper 15 km of the Earth's crust, it is perhaps not surprising that no effect was observed. Whitcomb and coworkers also used remote stations, but because the sources were foreshocks, the ray paths through the focal zone were quite a bit shallower.

Dr I. Gupta (Mackay School of Mines, Reno) reported the use of variations in $t_{SH}-t_{SV}$ to predict the time of occurrence of earthquakes in central Nevada. This scheme is promising in that, if the gross features of the regional stress pattern are known, only one seismic station is required to monitor an area. Moreover, variations in $t_{SH}-t_{SV}$ are expected in regions of strike-slip and normal faulting.

If earthquake prediction using seismic methods is in its infancy, two other methods in the foetal stage received attention. One, relying on the magnetoseismic effect, does not appear promis-

Past Climate of Tunisia

IN next Monday's *Nature Physical Science* a climatic history of southern Tunisia for the past 80,000 years is revealed from cores obtained from the Sebkha el Melah by Fontes and Perthuisot. The Sebkha el Melah is a coastal basin filled with recent post-Neotyrrhenian deposits and the sediments reveal in order first a thin layer of saline mud with dolomite, magnesite and sometimes polyhalite. Below this layer is found a thin layer of mixed halite and gypsum with secondary polyhalite towards the inland. Underneath this is found a carbonate complex containing sands and clays with their upper parts rich in magnesite and/or huntite. Then there is a layer of clays and silts with gypsum.

The principal sedimentation events which occurred at Sebkha el Melah are shown in the diagram. The chief features of the climatic record which Fontes and Perthuisot deduce is that two high sea levels occurred at about 35,000 and 6,000 years ago. The first of these high seas is, of course, well known, and the existence of the second is often discussed. The present work is another piece of evidence in favour of this second high sea level.