ficantly larger (142,450 sq km) than that for the 1959 tremor (112,500 sq km). This suggests the events may be of about the same size, or perhaps that the 1912 event may be even larger. Both events had relatively shallow focal depths of 5 km or less, based on a study of reported maximum intensities. A comparative analysis of intensities for the two events using the same site locations shows higher intensities for the 1912 event. Also, a comparison of predicted and observed intensities at one site (Williams, Arizona) suggests that M_L5.70 is an appropriate magnitude for the 1959 event, whereas in order to match the observed intensities for the 1912 event, a larger magnitude than M_L5.5 is required.

Thus, based on isoseismal areas and a comparative study of intensities, the 1912 event appears to be the larger. Based on an acceptance of the 1959 M_L5.70 magnitude, this suggests the 1912 event may have been as large as M_L6.0. If one compares the 1912 and 1906 felt areas (142,450 vs. 233,100 sq km) then there is the likelihood that the 1906 event may have been at the upper end of the range suggested for it by other intensity studies (M_L5.7-6.4). This has important implications for seismic hazard studies in Arizona.

S31B-11 1053

A Test of Completeness for Earthquake Catalogs Using Noise Modulation

P A Rydelek and I S Sacks (Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington, D.C. 20015; 202-686-4385)

An understanding of the earthquake process involves the understanding of the frequency distribution of earthquake magnitudes. For example, self-similarity would imply an ever increasing number of small earthquakes. Therefore, we have to be confident of the reliability of the catalogs used. The linear relationship of the logarithm of the number of earthquakes N versus magnitude M is consistent with the idea of self-similarity of the earthquake process. Deviations from linearity in plots of $\log(N)$ versus M are believed to be either from statistical fluctuations because of the small number of events at large M, or from incompleteness because of a detection threshold at small M. Above some magnitude level, all local seismic events should be detected since they exceed the noise background on the seismogram. But as earthquake magnitude decreases some events will go undetected because the seismic signal approaches the threshold noise level at the seismograph. Thus we expect that a seismic network which records near the detection threshold should catalog more of the smallest detectable events during local night than local day; during the night the cultural and wind noise sources are diminished, resulting in less total noise background and presumably quieter seismograms. We exploit this modulation of the noise background to develop a completeness test for earthquake catalogs. A catalog is considered complete at (and above) any magnitude level when the day-night noise modulation is not significantly observed in the data. We use our test on three catalogs and show that this threshold magnitude can be lower or higher than the magnitude at which departures from linearity in the b-value plot are observed. In particular, catalogs that show a significant departure in the b-value plot at small M but are otherwise complete, are at odds with the hypothesis of self-similarity of the earthquake process.

S31B-12 1106

Microseismicity of the Salton Sea Geothermal Field*

L.J. Hutchings, Steve Jarpe, Paul Kasameyer, and Terri Hauk (Earth Sciences Division, University of California, Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, California 94550)

A microearthquake network was operated at the Salton Sea Geothermal Field from 15 September 1987 to 30 September 1988. Data from this study along with first motion recordings from two locally operated microearthquake networks are used to obtain source parameters of tectonic earthquakes and geothermally induced events. Accurate hypocentral locations allowed us to relate event locations to geologic features with dimensions as small as 100 m in this area that has been mapped in detail to several km depth. In addition, induced seismicity was observed along a portion of the Brawley fracture zone (BFZ) during the 23 and 24 November (M_L=6.2 and M_L=6.6) Superstition Hills earthquake sequence that is otherwise quiescent.

Microearthquakes are primarily confined to the BFZ and to depths of 3.0 to 7.0 km. Alignments of microearthquakes that have consistent focal mechanism solutions delineate a complex system of fractures with lengths up to 6 km and orientations from parallel to oblique to the NW strike of the BFZ. Very small seismic events, some with isotropic P-wave radiation patterns and very little S-wave energy, occur at shallower depths throughout the geothermal area.

The interpretation of the small scale structural dynamics is that microearthquakes occur mostly in the metamorphosed basement along the BFZ, where fractures allow intrusion of molten material. At shallower depths sedimentary material allows hot water to percolate laterally away from the BFZ throughout the geothermal field. Tectonic stresses are not stored at sufficient amounts to cause significant microearthquakes in the sedimentary material, and geothermally induced earthquakes can occur from fluid injection either from natural circulation or through drill holes.

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S31B-13 1119

Determination of Fault Planes at Coalinga, California by Analysis of Patterns in Aftershock Locations

M C Fehler and P A Johnson (Geological Engineering Group, Los Alamos National Laboratory, Los Alamos, NM 87545; 505-667-1925)

The May 2, 1983 magnitude 6.7 Coalinga, California earthquake was disturbing because it took place along a previously unrecognized fault in a region that had little historic seismic activity. The aftershocks from this event occurred in a large volume about the mainshock and did not fall along a single plane that can be identified by inspection of hypocentral locations. The mainshock focal mechanism, determined from both regional and teleseismic data, has a shallow SW dipping thrust plane and a steep NE dipping reverse plane. There have been arguments in favor of both nodal planes. In an attempt to determine which nodal plane was the mainshock slip plane, we applied a method, called the three point method, to look for planes along which the aftershocks clustered. Analyzing aftershock data from several months after the main event, we find planes that are subparallel to each nodal plane. Three of these planes intersect near the mainshock hypocenter making it difficult to determine which plane is the mainshock slip plane. However, two arguments in favor of the high angle reverse fault are: (1) the high angle NE dipping plane is the best delineated of the two nodal planes by aftershocks during the first 24 hours after the mainshock; (2) four events of magnitude greater than 4.2 occurred down-dip from the mainshock along the high angle NE dipping plane within 6 days of the mainshock. If the NE dipping plane is the slip plane, these events may represent rupture of a barrier along the plane following the mainshock.

S31B-14 1132

The Largest Magnitude Oceanic Earthquake Swarm: Off-Ridge Faulting Near the Atlantis II Fracture Zone

Douglas A. Wiens
David E. Petroy (both at: Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130)

The most prolific source of moderate and large earthquakes along the mid-ocean ridge system is located near the Southwest Indian Ridge in the region of the Atlantis II Fracture Zone. Most remarkable is a swarm of 49 events from 1925-1933, of which 30 are magnitude 6 or greater and 4 are magnitude 7.0. Relocated swarm events and an event in 1949 (M 6.75) cluster tightly around 33.8°S, 58.0°E, along an "inactive" section of the 58°E Fracture Zone approximately 100 kilometers east of the southern intersection of the Atlantis II Transform Fault and the spreading center. Location uncertainties for the larger swarm events derived from linearized joint confidence regions as well as from resampling techniques preclude locations along the active plate boundary, but a 1951 event (M 7.9) and associated aftershocks locate along the transform fault. Seven earthquakes of m_b 5.1-5.6 occurred at the location of the 1925-1933 swarm during 1977-1983. P and SH waveform inversion for the three largest recent events show normal faulting at depths of 12-16 km with a variable strike-slip component; neither the nodal planes nor the tensional axis shows consistency between the three mechanisms. Poor azimuthal coverage limits source parameter resolution for the historical events, but a grid search fit to the body waveforms from the 1949 event suggests normal faulting. As this unusual recurrent activity is located directly eastward of the southern ridge-transform intersection, it may result from heating and extension of the lithosphere due to the proximity of the southern ridge tip. Alternative explanations include stresses due to the earthquake cycle on the Atlantis II F.Z., or an incipient change in plate boundary configuration.

S31B-15 1145

A Re-examination of the May 7, 1964 Earthquake, a Deep Event in Northern Tanzania

D. R. Yarwood and D. I. Doser (Both at: Department of Geological Sciences, University of Texas at El Paso, El Paso, TX 79968-0555)

Previous analysis of P-waves and Rayleigh waves (Shudofsky, 1985) has suggested that the May 7, 1964 (m_b =6.2), located in northern Tanzania at the southern end of the Gregory Rift, occurred at a depth of 28 km, although other earthquakes of m_b of 5.0 to 5.2 within the region occurred at depths of 6 to 12 km. We have undertaken an exhaustive study of the P and S-waves of this event to determine if any source with a shallower depth would match the observed waveforms. Results of our waveform inversion study confirm that the earthquake was a deep event with a focal depth between 28 and 33 km, depending on the velocity model assumed for the lower crust and upper mantle. The focal mechanism we obtained (strike = 180°, dip = 55°, rake = -5°) is similar to Shudofsky's results, however our inversion results suggest the earthquake was a double event. Shudofsky et al. (1987) have proposed that the earthquake occurred in a lower crust of diabase composition. Rheological modeling, using reasonable ranges of heatflow, crustal thickness, and composition for the southern Gregory rift, will address the possibility that the earthquake occurred in the upper mantle.

Seismic Surveys of Crustal Properties and Structure (S32A)

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S32A-85 1330 POSTER

The THIRD DIMENSION of an ARCHAEAN GREENSTONE BELT: INITIAL RESULTS FROM THE ABITIBI LITHOPROBE EXPERIMENT in the NORANDA MINING CAMP.

J N Ludden and C Hubert (Dept de géologie, Université de Montréal, C.P. 6128, Succ A, Montréal, H3C 3J7.
A Green, L Mayrand and B Milkereit (Lithosphere and Canadian Shield Division, Geological Survey of Canada, 1, Observatory Crescent, Ottawa, Ontario, K1A 0Y3).

Many recent models for the evolution of Archaean greenstone belts invoke horizontal transport as a result of thrust and/or strike-slip motion. However, the deformation zones associated with such movements are poorly understood and are difficult to define due to lack of relief, glacial erosion, sedimentation and soil formation.

The LITHOPROBE project completed an experimental vibro-seismic survey across the Rouyn-Noranda base metal mining camp (RNL) and the Kirkland Lake Au district (KLL); two of the most important mining areas of the Abitibi greenstone belt in December '87/January '88. Both of these areas are characterised by extensive piles of mafic and felsic volcanic rocks of approximately 2700 m.y. (Mortensen, 1987), which probably represent the youngest phase of volcanic activity in the greenstone belts of the Canadian shield.

At the southern limit of the RNL the Cadillac fault juxtaposes volcanic assemblages with granite, gneiss and metasediment of the Pontiac subprovince. The seismic signature of the granite-gneiss terrain and that of the southern extremity of the KLL is characterised by a remarkable series of shallow, north-dipping reflectors for at least the top 15 km of the crust. These reflectors steepen dramatically under the surface expression of the Cadillac break. The volcanic dominated terrain on both the RNL and the KLL displays a distinct seismic signature to that of the granite gneiss. Once again the dominant fabric indicates shallow north-dipping structures, which appear rooted in a zone at approximately 10 km.

The results contradict any model involving "vertical" tectonics in the Abitibi and possibly other greenstone belts. The application of vibro-seismic techniques to the greenstone belt has been an unqualified success. Further data treatment should enhance the data quality and, in particular in the upper 5 km section, may resolve some of the major outstanding structural problems of the two mining camps.

S32A-86 1330 POSTER

Imaging of the Abitibi Greenstone Belt: Preliminary Results from LITHOPROBE Seismic Reflection Profiling

L J Mayrand, A Green, B Milkereit (Geological Survey of Canada, 1 Observatory Cr, Ottawa, Ontario, K1A0Y3)
C Hubert and J N Ludden (Dept. de Geologie, Universite de Montreal, CP 6128 "A", Montreal, H3C 3J7)

Little is known about the thickness and deep structure of Archaean greenstone belts, and how neighboring high-grade terrains relate to them. To address these issues, two LITHOPROBE seismic profiles acquired in 1988 in the vicinity of Rouyn-Noranda, Quebec, have targeted from South to North the Pontiac gneisses and metasediments (PGM), mafic/felsic volcanics of the Blake River group (BRG), tholeiitic basalts of the Kinojevis group (KG), and two intervening faults (Cadillac and Destor breaks) variously interpreted as thrust and/or strike-slip faults.

Four conclusions are supported by a preliminary processing of our data. Firstly, no prominent low-angle reflector can be projected to the surface position of the two regional breaks. Secondly, coherent shallow (1 s) reflectors from the PGM dive steeply to the North as they near the Cadillac break, and thus warrant the hypothesis that greenstone belt "basement" rocks may be found at shallow depth to the South of the fault. Thirdly, a complex package of shallow (1-3 s) reflections within the BRG suggests that detailed reprocessing may be able to image deformed volcanic strtigraphy. If proven so, real and apparent thickness of volcanic sequences may be resolved with confidence for the first time. Finally, a dramatic improvement in data quality has been obtained by recording both a high-resolution line (20-120 Hz sweep, 20 m station spacing, 120 fold) and a regional line (12-52 Hz sweep, 50 m spacing, 60 fold) along the same road. This comparison is likely to become a valuable benchmark for optimizing seismic acquisition parameters in Archaean greenstone belts.