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FINAL REPORT

Report for Canyon Pty Ltd.

Stratigraphic Processing and Interpretation of

Seismic Lines 92-14, 85-ST-4 and 85-ST-4A

Stansbury Basin, Australia

Ms. R. Mullin
Ms. M. Smith
N. S. Neidell & Associates
10200 Richmond
Suite 200A
Houston, Texas 77042
Tel: (713) 975-1262
Fax: (713) 975-0258

OBJECTIVES AND INTRODUCTION:

This project, which addressed an area in the Stansbury Basin, Offshore Australia, sought to understand the seismic to lithology correlations which exist within the Paleozoic sediments. Where possible, we were to determine increased porosity (especially in potential carbonate buildups) and accomplish seismic detection of likely hydrocarbons presence. Input data consisted of Profiles 92-14, 85-ST-4 and 85-ST-4A. Line 92-14 crosses a reverse fault showing an anomaly noted at about 0.95 sec (two-way time) between SP 2018 and 1968 on the original processing. This feature was to be evaluated by stratigraphic reprocessing through to an enhanced visual dynamic range Color Inversion Display. On Lines 85-ST-4A (Line 4A) and 85-ST-4 (Line 4), several possible buildups were observed on the original processing at about 0.7 sec, SP 1760 on Line 4A to SP 725 on Line 4 and at about 0.65 sec from SP 360-100 on Line 4. These were to be more closely examined as well for validation.

Our stratigraphic seismic imaging approach involved coordinated use of high resolution velocity analysis using pre-stack migrated data, along with Trace Inversion, and finally presentation via Enhanced Visual Dynamic Range Color Displays. Data were processed to preserve relative amplitude relations with high fidelity which results from both correct and careful waveform treatment along with the intensive velocity consideration. Velocity/impedance scaled sections were to be evaluated to determine the interpretive utility of the enhanced visual dynamic range color contoured display emphasizing amplitude changes which might be related to porosity variations and perhaps hydrocarbons presence within any objective interval. Of course such changes were seen also within the structural context of the section.

All the color inversion sections have been reviewed initially in regard to available subsurface data from onshore, nearby. Two major unconformity boundaries were used to determine zero phase. Interpretive section overlays provide the most detailed results summaries, but some of these findings along with key commentary follow here in our brief discussions. These of course must be put in the context of all else that we know about this area.

CONCLUSIONS:

Upon examining stratigraphic processing and interpretive results for seismic Profiles 92-14, 85-ST-4A and 85-ST-4, in the Stansbury Basin, offshore Australia, as processed and presented via color display of the trace inversions, we observed significant improvements in imaging of seismic structures generally. Anomalies were observed in conjuction with the reverse fault area and also within the cited possible buildups. Preservation of the necessary relative amplitudes results primarily from all of the detailed processing treatments as previously described, but in particular from the high-resolution velocity analyses applied to pre-stack migrated data which were computed at closely spaced intervals.

Generally high velocities of these older sediments caused the trend, of increase with depth (or reflection time), to be more difficult to determine. This was especially true on Line 85-ST-4A in the vicinity of the reverse fault. An abrupt change in the trend occurs at the fault which supports a greater throw across this fault then originally interpreted by us. However, the throw is not as large as originally interpreted. The high velocities and expected carbonate lithology place the sediments generally within Zone III sand/shale type environment where the prospective sediment units have higher velocity than the surrounding shales.

Line 92-14 shows an anomaly at 0.94 sec, SP 2000 to 1936. This could be due to a buildup with porosity and also with a possible contribution from hydrocarbons. There is a distinct velocity drop of 400 m/sec (from about 5400 to 5000 m/sec) having also a "flat" or better discordant geometry which may be an indication of hydrocarbon presence via a contact. The anomaly is present on both sides of the fault as compared to the original interpretation of the anomaly which was entirely upthrown to the reverse fault. The positioning of the reverse fault is also different from the original processing results. Fairly steep faults with normal sense of throw can be observed along the section but none extend to the surface along this Line.

The combined Lines of 85-ST-4A and 85-ST-4 appear to show some carbonate type buildups from their indicated geometries and velocities as had been previously interpreted. In fact, some smaller buildups can also be observed as for example from SP 1534 to 1640, 0.67

sec on Line 4A, see overlay. Larger buildups appear to have some velocity drop at the crests which can be due to increased porosity and/or hydrocarbons. The reverse fault trace does not show appreciable throw and no anomalies were observed in connection with it on this line. However, this data is not as good as the 92 series and such findings probably should be confirmed with the newer data. The reverse fault does appear to extend up to the surface having some positive expression on the sea floor as a high block. Most of the other faults are high angle but with normal throw components. Generally, these do not cut through the section to the surface as we have previously indicated.

Treatment of the data and interpretive principles as applied here have been careful, intensive and consistent. The inability to confirm some of the more pronounced elements of previous processings leads us to question their validity. Nevertheless, the structural picture shown conforms in most general terms to previous views with the addition of greater certainty in the identification of lithologies. Also, some possible anomalies showing porosity and perhaps even hydrocarbons in structurally plausible geometries have also been identified which we believe enhances the overall merit of the area.

INTERPRETIVE PROCEDURE:

There are two themes which we apply in parallel when using seismic data: improved seismic imaging, and application of a unified interpretive framework. The latter serves to identify and qualify key anomalies and subsurface characteristics.

Properly conditioned seismic data displayed in a suitable color scheme provides a 20-fold increase in visible detail over black and white displays and allows porosity and hydrocarbon presence to be detected and confirmed under a wide range of circumstances. Initially the move-out derived velocities from CDP gathers with a preliminary pre-stack migration are carefully studied for the purposes of improving stacking, migration, and generally clarifying the seismic images as well as for establishing the low frequency component of the seismic velocity field. Such information is then used in the plotting of the final color inversion sections so that the velocity magnitudes approximate in some sense the actual subsurfaces velocities. By this approach we may assure that the seismic displays are entirely a seismic product and these may then be correlated appropriately with whatever other subsurface information is at hand. On the final displays, velocity indications have been considered in conjunction with the reflector geometries which are also presented to develop an integrated interpretive view.

Procedurally, the closely spaced high resolution velocity analyses calculated from migrated CDP gathers are treated individually. Such analysis is of course done while viewing preliminary seismic sections. Special attention is given to all changes in stacking velocity which might be meaningful. Unanticipated changes, particularly abrupt ones are also closely examined in case they are valid. In the hands of an experienced interpreter, stacking velocities will distinguish between sandier and shalier sedimentary sections and often can be definitive in the determination of the presence of salt, diapiric shale and thick sand deposits. Hence most important lithologic information is often developed while also assuring the best possible seismic imaging.

It should be noted that noise elements increase substantially as we deal with the velocity analyses for the greater depths. In general then, below 2 seconds for land data and 3 seconds for marine data, about one spectrum in three or four of the closely spaced high-resolution analyses will provide the valid information components. This information is not at all present in industry standard analyses and in fact, even the special analyses used here requires significant interpretive skill for these deeper regions. The cited distinction between land and marine data arises from the proximity of near surface velocity inhomogeneities whose expression becomes more severe with increased reflection time (Pollett effect). Marine data is usually more favorable owing to the natural homogeneity of a surface water layer.

Selected velocity analyses interpreted to "key" on valid information are used to develop interval velocity estimates in the zones we establish to be of interest. While these velocities are not accurate per se in absolute terms, they retain surprising significance in relative terms. That is, while we cannot reasonably expect quantitative agreement with well logs, and the seismic velocities themselves are further dependent in some measure on their method of calculation; they will nevertheless be most useful in a relative or comparative sense, even quantitatively.

When the estimated velocities have all been placed on the section, the overall stratigraphic framework will begin to emerge. If there are any stacking velocity changes necessary, the section is then restacked to incorporate these changes. Frequently in shaly zones, especially when diapiric shale is involved, stacking velocities will stay so low as to appear to the casual observer to be a train of multiple reflections. In the case of salt or other high velocity intrusions with underlying sedimentary section, stacking velocities will become so high that they frequently move out of the velocity computation window. In such a case some velocity analyses must be recomputed to allow determination of even higher velocities. The processing performed is then responsive to the velocity field at whatever level of detail appears to be required.

When final stacking velocities have been applied the migration stack which results, while excellent in terms of event imaging, may not be of the same standard in terms of event positioning owing to the inherent presence of the preliminary velocity field. At this point a demigration is applied and a superior post stack finite difference migration used is based now on the detailed field developed from the velocity studies.

After final stacking velocities have all been determined, these in conjunction with stratigraphic interpretation are used to provide the low frequency velocity field for the final Acoustic Impedance color section. This section with its refined imaging and enhanced visibility is the basis of a final interpretation presented by means of overlay. Using the principles pioneered by Dr. Peter Vail and the EXXON group (see AAPG Memoir 26, 1977), the geometry and velocity field not available originally to the Vail group are used in structural and stratigraphic context to identify, define, and clarify objectives.

In most general terms we are interested especially in velocity "drops" in lithology units which we interpret to be possible reservoir rocks and which usually have structurally favorable geometry. (We may suspend the geometry factor - at least initially - in regions where there are rapid lateral changes in velocity that are not completely documented, so a reliable depth picture may not be established). The velocity drops or anomalies may be further validated for Zone I and Zone III sand reservoirs and carbonate units to accommodate velocity effects such as might be due to bed thinning (using instantaneous frequency analysis and seismic modeling) and unanticipated velocity change (using AVO or amplitude with offset analysis - when it may be used - not in Zone II, the sand-shale crossover zone - see Rutherford and Williams, Geophysics, June, 1989 and Neidell and Berry, Geophysics, November, 1989).

Finally, it should be emphasized that the procedure described has employed both pre-stack and post-stack migration to achieve both excellence in imaging and event positioning in a cost effective manner. We should note also that the post stack velocity field must often be modified (usually lowered) to accommodate shale anisotropy effects. This change in velocity results from the more nearly vertical raypaths implicit in the post-stack operation and may be quite pronounced (up to 20%) when there are great thicknesses of shale in the section.

With this background information, the particular results obtained here may be reviewed along with information provided for the project and published data on the area, to arrive at the interpretation summarized on the color section plastic overlay. The included discussion covers more specific details of the particular project. A following section presents the specific processing sequence and special requirements. Finally, some recommendations are offered.

INTERPRETIVE CONSIDERATIONS:

Information of the stratigraphic section as it could be known was projected in from nearby onshore wells in the Stansbury Basin Area, Australia. Two principal unconfomities were used to determine zero phase for all of the lines by their implied seismic signature. There appears to be an abrupt change in velocity at these two boundaries which represent the top Permian and top Cambrian, respectively. A synthetic seismogram for a well on the seismic line would probably have provided a better correlation, however no such wells have been drilled on these lines at this time. Results obtained as described however appeared otherwise consistent.

Paleozoic age (even in the Cambrian) carbonate buildups have been encountered in wells onshore and in nearby outcrops. These buildups could make very prospective reservoirs. The sediments are in Zone III type sand/shale environments owing principally to their age. Of course carbonates always behave similarly to consolidated sands in their seismic responses in shale environments.

Reprocessed Line 92-14 shows the reverse fault as represented by a similar reference point at SP 1974, 0.94 sec as compared to SP 2018, 0.95 sec on the original processing with an observed "blue" anomaly extending to SP 1968. However, the same anomaly on the new processing at this level is clear and shows a velocity drop of about 400 m/sec (from 5400 to 5000 m/sec) between SP 2000 and 1936. There appears to be a "flat" or better discordant geometry which may indicate the presence of hydrocarbons via a contact feature (SP 1920, 0.97 sec). This anomaly is present on both sides of the fault, with appropriate offset. The original processing showed an anomaly only on the upthrown side of the fault, but with the fault trace more to the west.

Another steep and major fault with normal throw, is seen at SP 2028, 0.95 sec on this same profile. In fact, a series of steep, normally dipping faults can be seen beginning at SP 1910 to 1860 at 1.0 sec. Some of the faults may penetrate to below 1.5 sec. Most of the faults on this line however do not extend upward to the surface.

Seismic Line 85-ST-4A extends across the same fault zone as Line 92-14, but over a different structural closure. Again, there does not appear to be a lot of throw along the faults as compared to that indicated by the original processing. The trend near the reverse fault was re-evaluated, and found to have slight increase in the offset at the fault, but still not as much as the original processing showed. There were no noticeable anomalies present on this structure associated with the reverse fault. However, the 85 data is not as good as the 92 and an anomaly may not be properly imaged. These findings should be confirmed using the newer data. The reverse fault may be one of the few faults to penetrate all the way to the surface, with positive water bottom expression. A number of small steep faults with normal sense of throw are present. As with Line 92-14, a cluster of faults can be seen on the east side of the high block. These do not extend to the surface.

Significant buildups may be present on the combined Lines 85-ST-4A (Line 4A) and 85-ST-4 (Line 4). Two major buildups as postulated initially from the original processing look very promising. At 0.70 to 0.65 sec from SP 1830 on Line 4A extending to SP 646 on Line 4 there appears to be a change in velocity (500 m/sec from 4500 to 4000 m/sec) which may be associated with porosity. The other large buildup is from 0.62 to 0.60 sec from SP 342 to 164 on Line 4 and also shown a velocity drop of 500 m/sec (from 4300 to 3800 m/sec). These clearly warrant added study. These two buildups appear to be larger than originally thought. However, the better porosity zones as seen on the color inversion display may be closer to the original lateral extent. A slightly smaller buildup was also observed from SP 1700-1772 at 1.14 sec on Line 4A. These three larger buildups appear to prograde toward the ENE as they climb upward in the section much as would be seen if shelf edge buildups prograded seaward through time.

Smaller buildups were also observed at 0.66 sec, SP 1536-1644, 0.67 sec, SP 1626-1688, 0.48 sec, SP 1664-1572 on Line 4A and at 0.92 sec, SP 524-370 and 1.08 sec, SP 396-176 on Line 4. These are probably not large enough to pursue at this time. However, given success, these could become prospective when appropriate facilities are in place.

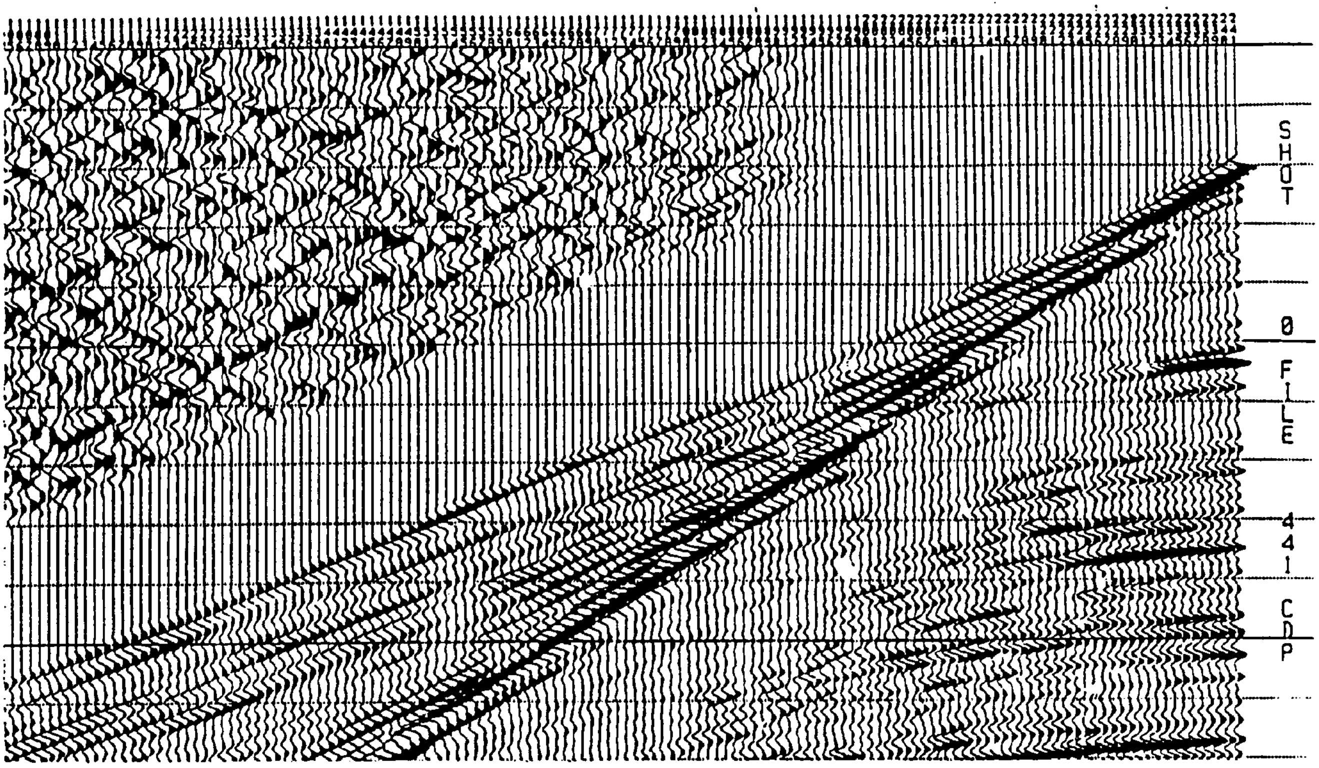
SEISMIC PROCESSING SEQUENCE:

Lines 94-14, 85-ST-4 and 85-ST-4A were processed using the following sequence of operations:

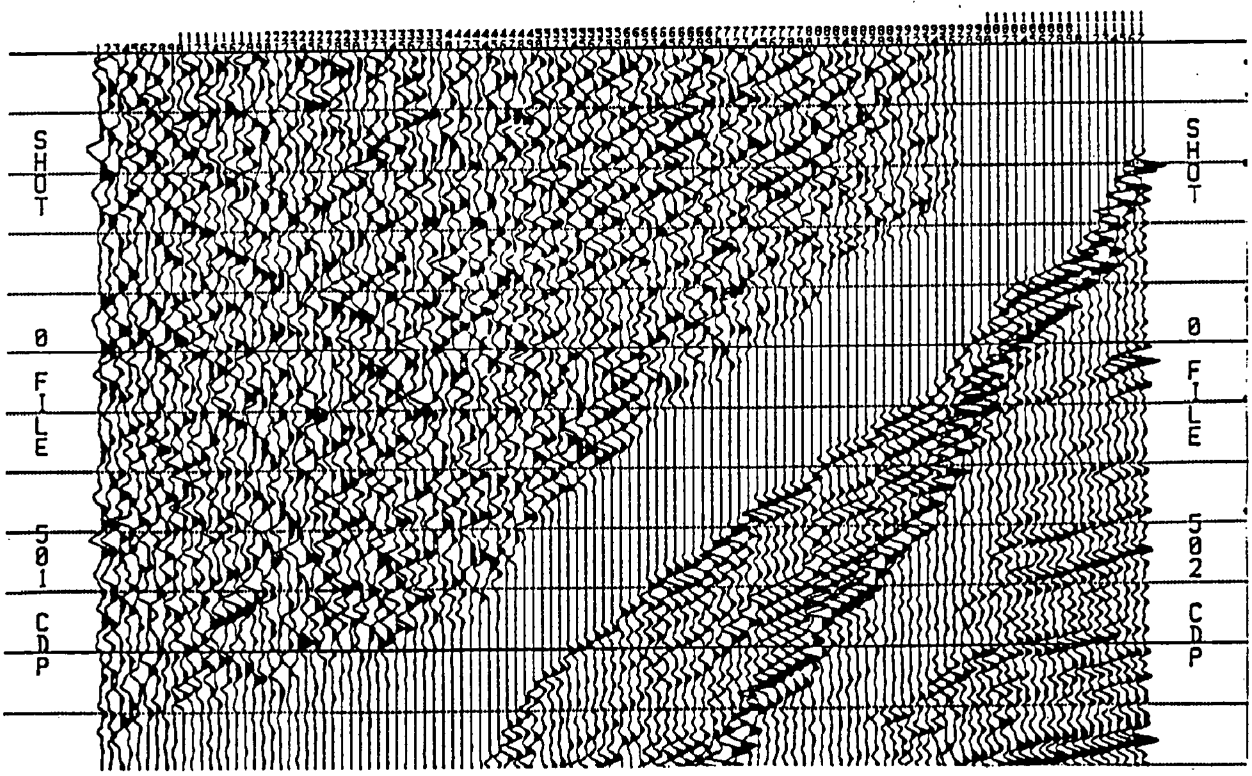
REFORMAT
APPEND GEOMETRY
RESAMPLE TO 4 MS
GAIN RECOVERY
INSTRUMENT DELAY CORRECTION (-51 MS) (LINES 85-ST-4 AND 85-ST-4A ONLY)
DECONVOLUTION - 50 MS SPIKING OPERATOR, 1 GATE
VELOCITY ANALYSIS
NORMAL MOVEOUT CORRECTION
TRACE MUTING
TRIM STATICS (LINE 85-ST-4 ONLY)
MIGRATION BEFORE STACK
INVERSE NMO
HIGH RESOLUTION VELOCITY ANALYSIS (150 M INTERVAL)
NMO AND MUTE
STACK
INVERSE MIGRATION
FINAL MIGRATION (FINITE DIFFERENCE)
RESIDUAL TRACE BALANCING
SEISMIC INVERSION
COLOR DISPLAY OF ACOUSTIC IMPEDANCE WITH LOW FREQUENCY TREND AND TRACE PLOTS

No observers logs were available for any of these seismic lines. The shot and cable configurations were taken from the side labels of previously processed sections and it was assumed that no shots were missed. Additionally there were two bad tape copies for Line 85-ST-4. The data on these tapes were partially recovered by a company specializing in tape problems, however, offsets were randomly missing and original field trace numbers wiped out. By manually comparing first arrival times of records from the bad tapes to nearby good records we were able to fill the gap between SP 440 and 556 and to get enough overlap at the intersection with Line 85-ST-4A. A pass of CDP trim statics was required. To the extent that major reflectors can be followed across these zones we have been successful, but the final sections clearly suffer from reduced signal to noise ratio and missing near offsets. Good and bad shot records follow to illustrate the problem.

GOOD RECORD



BAD RECORD



All the processes in this sequence were more or less standard except for the proprietary techniques used in our velocity analysis and in the inversion process. Deconvolution treatment consisted of a short spiking operator for maximum whitening. The data were then migrated before stack, and the subsequent high resolution velocity analyses were picked carefully with due consideration given to available geological information. This process produces better seismic imaging of the stacked data and a velocity field that results in more accurate representation of lithology. The initial migration was then reversed and the data re-migrated with an improved velocity model for even more appropriate positioning of reflections.

In all, the data responded well to this processing sequence, however high interval velocities at relatively shallow depths, where the maximum useable offset is reduced by normal moveout stretch caused the high resolution velocity analyses to be quite difficult to interpret. Constant velocity stack analyses were run at selected locations to aid the velocity interpretation process.

In the absence of well control, the seismic signature of two major unconformity boundaries was used to determine zero phase. Relationships seen later in the color display confirmed this judgment to be correct with reasonable interpretations having consistency in the resulting geometry and velocity.

After application of a residual amplitude adjustment, the data were inverted and displayed in color at an expanded scale. The color scale used provides an extension of the visual dynamic range by a factor of about 20 as compared to an extension of only a factor of 5 attained by more commonly used color displays.

All in all, the results attained were quite suitable for the interpretive procedures which were applied with few undue problems such as multiples or other coherent noise trains. For this reason we feel that the interpretive results should be quite reliable.

RECOMMENDATIONS:

The buildups (likely carbonates) observed on combined Lines of 85-ST-4A AND 85-ST-4 should be evaluated on cross-lines with stratigraphic processing and color inversion to determine their extent and consistency in terms of possible porosity and hydrocarbon presence. Lines 92-12 and 92-15 both cross main buildups. Profile 92-13 crosses near the slightly smaller one.

Original processing of Line 92-3 appears to show major amounts of throw across the reverse fault, especially in the deeper section. Reprocessing of this line may assist in determining a more correct amount of throw and also indicate if there are any associated anomalies as seen on Line 92-14. For any future reprocessing, intersections of lines should have more than one mile overlap because of the very high sediment velocities which cause edge affects to extend further into the section than normally encountered. Further reprocessing can also be used to evaluate the information content and potential utility of the different vintages of data. More advantageous acquisition parameters could be determined.

Given successful exploration of the larger buildups, the smaller buildups might become economic targets as well. These should be evaluated with crossing profiles to determine fully their areal extents and any potential for porosity and hydrocarbons within them. The results to date suggest that such work is appropriate given the current level of encouragement.

GEOWESTE PTY LTD

8 CUMBERLAND AVENUE, ALDGATE, S.A. 5154
TELEPHONE & FAX: (08) 339 3804

FOR: Earl Sebring
AT: Canyon Resources
Midland Texas
FAX: 915 6866485

FROM: Griff Weste
AT: Geoweste
Adelaide, Australia
DATE: May ., 1995

STANSBURY BASIN SOUTH AUSTRALIA

BITUMEN STRANDINGS ON KANGAROO ISLAND BEACHES

INTRODUCTION

Crude oil bitumen strandings on Kangaroo Island beaches have been recorded for a long time, even predating the introduction of oil fired engines. Old records (early 1880s) show that sailing vessels would call into safe anchorages around the island and there collect bitumen to recaulk their hulls. Highly weathered bitumens have also been collected from within Holocene sand dunes. The source of these bitumens has long been debated and more so in recent years with increased exploration activity in the Otway Basin to the southeast of the island. Increased strandings have been recorded following minor earthquake activity in the region. It is possible that some of the strandings may be of hydrocarbons derived from seafloor seepages from the Stansbury Basin which is located immediately north of kangaroo Island. Detailed geochemical analysis has identified three different types of hydrocabon strandings:

crude oil:	brownish black, sticky, strong hydrocarbon odor; Middle East origin, recent spillages from oil tankers and ship bilges
waxy bitumen:	brown, yellowish brown, very waxy, no odor, terrestial angiosperm derived oil origin
asphaltite:	black, faint bitumen odor, very firm to hard, marine origin

Whereas the crude oil and resinite are less dense than water and float, the asphaltite has an API gravity of 5 and could only be transported along the sea bottom. The resinite source angiosperms were definitely not present in the Cambrian and are known only from the Late Cretaceous to Tertiary.

Only the asphaltite has a possible Stansbury Basin origin. No satisfactory origin for this hydrocarbon has yet been proposed. It's seafloor mode of transportation suggests that it has not travelled a very large distance and it's character is disimilar to any known or expected hydrocarbons in the Otway Basin. Low API gravity oils commonly occur in carbonate reservoirs. Stansbury