Managing seismic data in different geodetic references

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Abstract

This paper presents the concepts of Geodetic Reference Systems, the problems that occur using seismic data referenced to different systems and proposes the adoption of one unique reference.

Introduction

A Geodetic Reference System is the combination of an ellipsoid, which specifies the size and shape of the earth, and a base point from which the latitude and longitude of all other points are referenced.

The history of oil and gas exploration is strongly related to the use of seismic data in different datums, not only in Brazil but all around the world.

Although the official reference system of Brazil is the SAD-69, there are several other datums used in Brazil as shown in Figure 1.

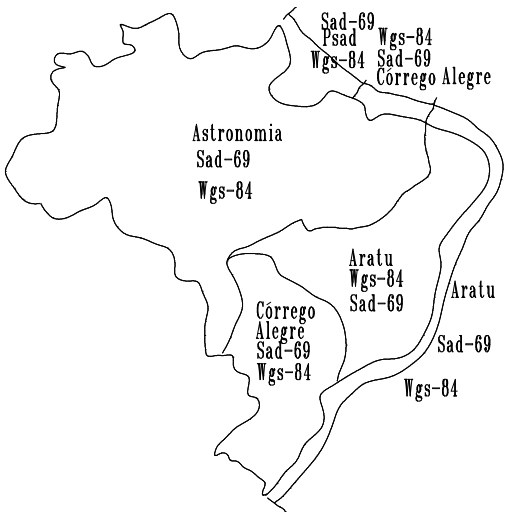

Figure 1: Datums used in Brazil

Córrego Alegre (International ellipsoid 1924 or Hayford ellipsoid) was the official datum before SAD-69 and there are still lots of data referred to this datum. Another used datum is Aratu. When Petrobras began to work on the northeast of Brazil, there wasn't any fundamental geodetic network in this region. So, Petrobras created its own datum, named Aratu. This datum uses the Hayford ellipsoid and its orientation was done using the single astronomic station datum orientation. Also before SAD-69, there was the Provisional South America Datum of 1956 (PSAD-56). And today, as all around the world, there is the World Geodetic System 1984 (WGS-84) and the less known SIRGAS2000 (in portuguese: "Sistema de Referência Geocêntrico para as Américas" - Geocentric Reference System for the Americas).

Data Management

With the end of the monopoly of Petrobras on the hydrocarbon exploration and production in Brazil, in concurrence with the creation of the ANP (Agência Nacional do Petróleo), a new scene was established in the company, concerning seismic data management. For its attributions and competencies as regulating agency, ANP started to demand that the received data should be related to SAD-69 datum. Due a historical context and an existing culture in the company, most of its data was still on the Aratu datum. This caused, at that moment, certain confusion between storage datum, visualization datum and work datum of the data.

This situation, however, lead the work of management in the direction of the creation of a seismic database, structured in the following form:

- Relational tables containing the seismic projects metadata as name, code, methods and softwares, executors, processing parameters, etc.;
- Recorded seismic data properly stored on a storage mass device;
- Spatial information that correspond to the features stored using Oracle Spatial/SDO technology that follows the standard Open Gis Consortium;

These three mentioned elements keep between itself a relationship that allows they are identified and manipulated solely (Figure 2).

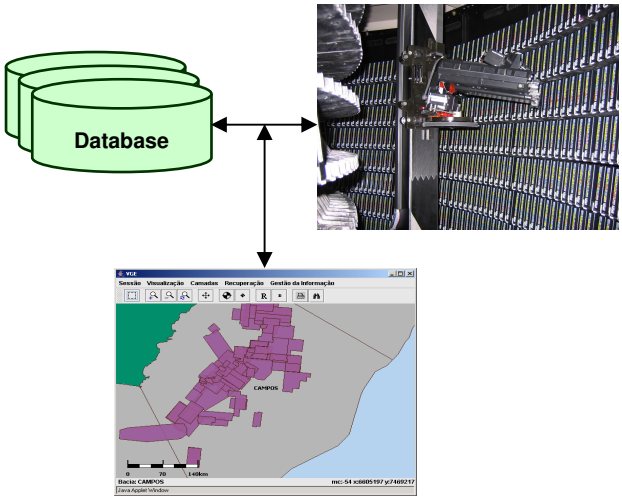

Figure 2: Elements of the seismic storage

Forward this new conception of storage of information, it was established that the spatial reference to be adopted would be defined by the polyconic projection in set with SAD-69 datum, objectifying to obey the requirements of the regulating agency.

From this moment, the storage of the data in SAD-69, at the same time that solves the problem of data sent to the agency, makes new difficulties. The continuous need of data transformation, many times acquired in Aratu datum and the following data reconversion to load it in interpretation projects created in assorted referentials.

Common datum problems in management seismic data

Even though there are formulas to change coordinates from one datum to another (Molodensky Datum Transformation Formulas, where the major parameters are the shifts between the centers of the two ellipsoids), several common mistakes may occur when manipulating geospatial data. One of them is to mix coordinates from different datums. Since datum is a reference system, you should never mix coordinates referred to different references systems. This usually happens when combining old and new data or combining data from different sources. Another mistake can occur when you don't know the datum of your data and just suppose what datum is it. Moreover, special attention must be taken in account when transforming from one datum to another, since other problems may occur. The fact that the Aratu datum requires different parameters (X, Y and Z shifts) according to the region of Brazil may causes the use of wrong parameters. Someone that had worked with Aratu at the northeast area of Brazil may use northeast parameters at the south region. Another mistake may occur when using computer programs with parameters imbedded. In most cases these programs use the parameters published by the National Geospatial-Intelligence Agency (NGA), which are a bit different from those recommended by the Instituto Brasileiro de Geografia e Estatística (IBGE), the Brazilian official government agency for Geodesy and Cartography. The above mistakes can make you point to a wrong target. For example, suppose that you got seismic data that is really referred to WGS-84 and you are informed that it is referred to Aratu datum. You work on it and suggest a new well location, at an X Y coordinate. Then, you give this coordinates to the surveyor and tell him that they are referred to Aratu. The result is that the well will be drilled 200 m away the location you really wanted. Figure 3, extracted from NGA's home page, shows an analog target error due to datum error.

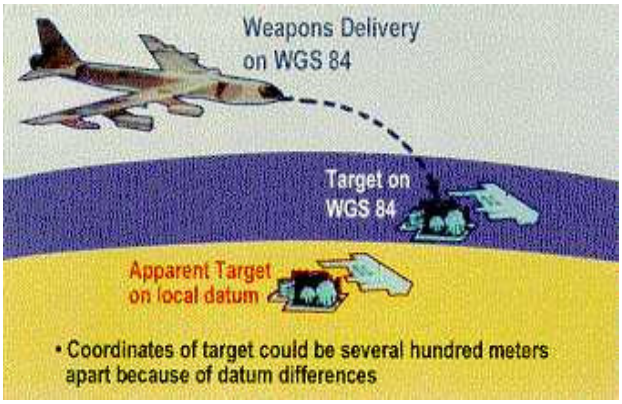

Figure 3: Target error due to datum error

Table 1 shows the order of magnitude of the errors that occurs when considering a coordinate referred to one datum instead the correct one. The table lists the five most used datums in Brazil (Aratu, WGS-84, SAD-69, PSAD-56 e Córrego Alegre) and the errors for each pair. It shows that errors vary from 10 to 370 meters. Using data referred to Aratu as it was referred to WGS-84 (or vice-versa) causes positioning errors of 210 m. The same error occurs when using Aratu data as it was SAD-69. Certainly, drilling a well 200 m away from the correct location can result in a wrong reservoir determination or in a well without oil. And, obviously, it would also result in money wasting. Mixing data from different datums will led to the same magnitude of errors.

	ARATU	WGS84	SAD69	PSAD56	CÓRREGO ALEGRE
ARATU	----	210 m	210 m	305 m	205 m
WGS84	210 m	---	60 m	370 m	10 m
SAD69	210 m	60 m	---	310 m	55 m
PSAD56	305 m	370 m	310 m	---	360 m
CÓRREGO ALEGRE	205 m	10 m	55 m	360 m	---

Table 1: magnitude of datum errors

Using Aratu to WGS-84 shifts from a wrong region can lead to errors of 20 meters (example: using the shifts from the northeast region at Campos Basin region). Using NGA's shifts instead of IBGE's shifts results in less large errors, about 5 meters.

SIRGAS implementation

According to presented problems and following the IBGE determination, through the Resolution nº 1/2005, that

establishes the SIRGAS as the new reference system for the Brazilian Geodetic System (SGB) and for the National Cartographic System (SCN), Petrobras intends to promote the implementation of SIRGAS in the company as an official and unique geodetic referential.

Moreover, the adoption of a system with geocentric conception will make the data compatible with the most modern positioning techniques. The process of adoption of the new referential implies in considerable changes, both behavioral as operational. These changes mean substantial modifications in specific databases, such as seismic, wells, interpretation and cartographic data, among others. Like any large project, the participation and the involvement of different areas of the company will be essential for the success of the implementation.

With the adoption of the SIRGAS, Petrobras will also promote changes in the architecture of the seismic database. At a first moment data will not be converted to SAD-69 datum and Policonic projection and will be kept in the coordinate system of the acquisition. Due to the great volume of data, old data will not be modified, except when manipulated. New data will be acquired and stored in SIRGAS2000. In such a way, in a near future all the base will have to be referenced to SIRGAS2000.

Expected Results

After the adoption of SIRGAS in the company, the main expected results are:

- Elimination of the main error source in data handling, once all data will be referenced to the same geodetic datum;
- Direct use from coordinates obtained by Global Positioning System (GPS), without the necessity of conversion and without loss of accuracy, ensuring the quality of surveys and facilitating the use and management of information;
- Easiness communication with contractors for seismic data acquisition, once the Aratu datum is still unknown outside Petrobras;
- Easy use and management of georeferenced information, reducing efforts to convert data and ensuring integrity to the information.

Conclusions

The adoption of a unique geodesic datum in Petrobras is a long stated period work, difficult and laborious, but necessary and extremely important therefore it will guarantee a bigger agility in the exploration work, beyond cost reduction and elimination of a great source of errors.

References

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