CONNECTION OF THE SERRA GERAL AND GUARANI AQUIFER ACROSS PONTA GROSSA ARCH (PARANÁ BASIN, BRAZIL)

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Abstract Research involving integration of aeromagnetic and hydrogeological data from the fractured Serra Geral Aquifer System (SGAS, basalts), was carried out to investigate the structural control of both flow and chemism of SGAS groundwater and to identify fractures that may be represent hydralic connection zones to the underlying granular Guarani Aquifer System (GAS). Qualitative interpretation of the aeromagnetic maps indicated a mosaic of tectonic blocks. The structural-magnetic framework denoted that the largest dicrepances between the potentiometric surface and the relief are found at the Ponta Grossa Arch apex. In general, the SGAS typically shows average pH of 7.3 and total dissolved solids between 80-120 mg/L, and values respectively above 8.0 and 150 mg/L where contamined by GAS waters. The spatialization of anions and cations in ternary RBG maps (modified Piper diagrams), indicated that the typical SGAS waters are bicarbonated calcic, followed bicarbonated calcic-sodic and calcic-magnesian. In areas with contributed GAS waters, bicarbonated sodic and, secondarily, bicarbonated sodic-calcic are present.

Resumo A pesquisa envolveu a integração de dados aeromagnéticos e hidrogeológicos do Sistema Aqüífero Serra Geral (SASG, basaltos), com o objetivo de investigar o controle estrutural do fluxo e do quimismo das águas subterrâneas do SASG e identificar fraturas representativas de zonas de conexão hidráulica com o Sistema Aqüífero Guarani (SAG), sotoposto. A interpretação de mapas aeromagnéticos revelou um mosaico de blocos tectônicos. O arcabouço estrutural-magnético indicou que a maior discrepância entre a superfície potenciométrica e o relevo se posiciona no ápice do Arco de Ponta Grossa. Em geral, o SASG típico mostra uma média para o pH de 7.3 e sólidos totais dissolvidos entre 80-120 mg/L e valores respectivos acima de 8.0 e 150 mg/L onde as águas são contaminadas pelo SAG. A espacialização de ânions e cátions em mapas ternários RGB (diagramas de Piper modificados), indicou que as águas típicas do SASG são bicarbonatadas cálcicas, seguidas de bicarbonatadas cálcio-sódicas e cálcio-magnesianas. Em áreas com contribuição do SAG, as águas são bicarbonatadas sódicas e, secundariamente, bicarbonatadas sódio-cálcicas.

Keywords: Hydraulic connection, Magnetic-structures, Ponta Grossa Arch, Serra Geral and Guarani aquifer

Introduction

The recent proposition for research projects on the Guarani Aquifer System (GAS) (e.g. Rosa Filho et al. 2003) motivates investigation of a highly structured area of the Ponta Grossa Arch (Paraná Basin, Brazil, Fig.1) delimited by 23°00'S, 24°00'S, 51°00'W, and 52°00'W (Fig. 2). The area is geologically represented by basalt lava flows and diabase dykes of the Serra Geral Formation (Lower Cretaceous). Ponta Grossa Arch (PGA) consists, as recognized mainly from aeromagnetic data in Ferreira (1982, Fig.2), of a series of NW-SE faults filled with thick swarms of diabase dykes up to 600 km long and 20-100 km wide.

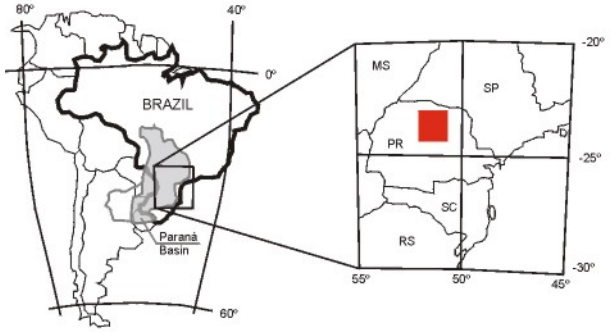

Fig. 1 Paraná Basin in South America

Fig.2 Ponta Grossa Arch in Paraná Basin

Research involving integration of aeromagnetic, geological, hydrogeological, hydrochemical data from the fractured Serra Geral Aquifer System (SGAS), into a geographic information system (GIS), was carried out to investigate the structural control of both flow and chemism of SGAS groundwater and to identify fractures that may represent hydraulic connection zones to the underlying granular GAS.

Methods

Horizontal gradient (Fig. 3) phase (Fig. 4) and amplitude (Fig. 5) of analytical signal (AS) methods (e.g. Hsu et al. 1996) were applied to the aeromagnetic data to enhance shallow magnetic sources and facilitate recognition of lineaments. Combined with Landsat/TM5 imagery and topographic maps, qualitative interpretation of such data reveals the area's structural-magnetic framework, which forms a mosaic of tectonic blocks delimited by NW-SE (diabase dykes) and NE-SW (Paraná Basin basement) structures. This structural-magnetic framework was compared with the spatial distribution of hydrogeological data (potentiometry, outflow, specific capacity, pH, total dissolved solids) from 625 completed SGAS wells and also with ternary RGB (red-green-blue) anion and cation maps from modified Piper diagrams for 57 wells with ionic balance differences smaller than 10% (Portela Filho 2003).

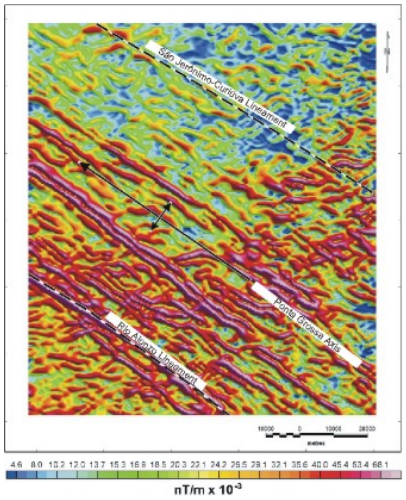

Fig. 3 Horizontal gradient map

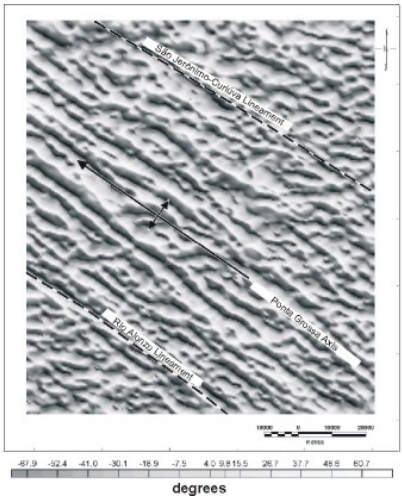

Fig. 4 Phase of the AS map

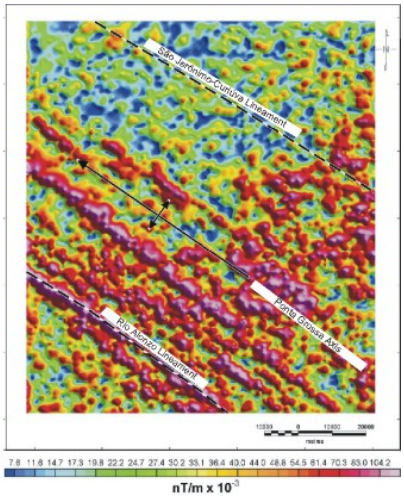

Fig. 5 Amplitude of the AS map

Results and Discussion

The results (Portela Filho 2003) clearly denote that SGAS hydrogeological parameters are controlled by the area's structural framework. Therefore, despite the fact that the potentiometric surface follows relief (Fig. 6), which accounts for a free aquifer behavior, the largest discrepancies between these surfaces are found at the PGA apex, which denotes structural control (Fig. 7).

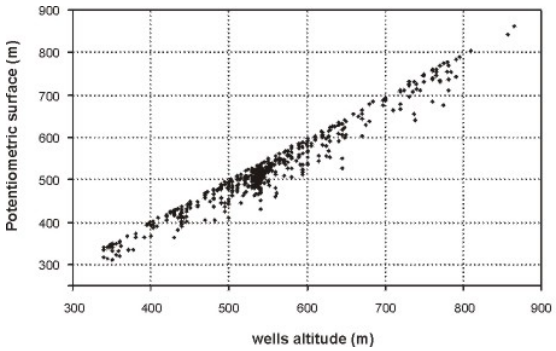

Fig. 6 Correlation between potentiometric and wells quota data

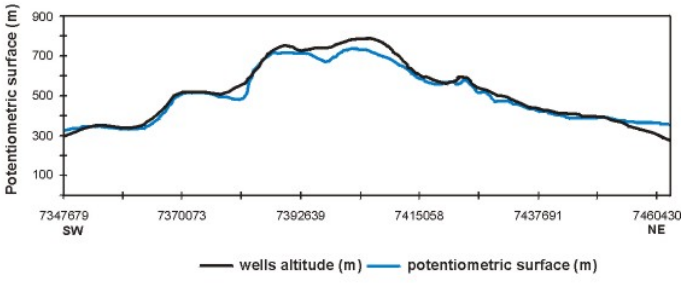

Fig. 7 Correlation between potentiometric and wells quota indicating the discrepancies at the Ponta Grossa Arch.

Two hydrogeological compartmentation scales are distinguished regarding outflow and specific capacity: (1) regionally speaking, areas of higher productivity are found in the Northeastern part of PGA and (2) at the local scale, such areas correspond to cells delimited by NW-SE and NE-SW structures (Figs. 8 and 9). The distribution of pH values (Fig. 10) also indicates structural control, with differentiation of alkaline blocks due to mixture of SGA waters from blocks where pH values tend to neutral, which are typical of SGAS waters. In the absence of other hydrochemical data, pH values may indicate connection of the two aquifer systems. In general, it can be observed that SGAS typically shows average pH of 7.3 and total dissolved solids of 103 mg/L (80-120 mg/L), and values of respectively above 8.0 and 150 mg/L (150-300 mg/L) where contamined by GAS waters (Figs. 10 and 11).

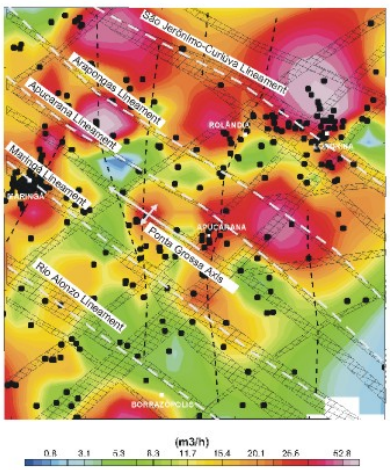

Fig. 8 Outflow map

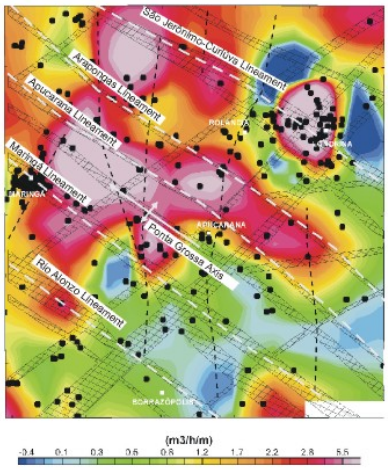

Fig. 9 Specific capacity map

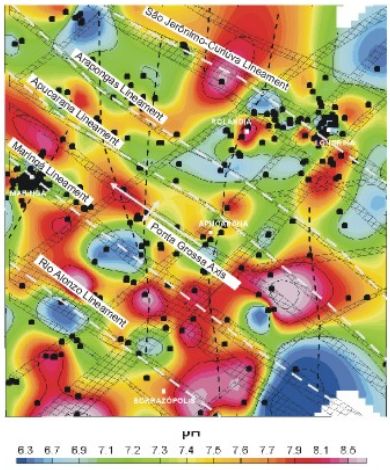

Fig. 10 pH map

The Piper diagrams (Fig. 12) and the spatialization of hydrochemical variables in ternary RGB maps (elaborated in accordance with Fig. 13) of anions (Fig. 14) and cations (Fig. 15) clearly differentiates structural blocks with typical basalt-related waters (SGAS) from blocks resultant from hydraulic connection to GAS at different mixture rates. Typical SGAS waters are bicarbonated calcic, followed by bicarbonated calcic-sodic and calcic-magnesian. In areas with contributed GAS waters, bicarbonated sodic and, secondarily, bicarbonated sodic-calcic are present.

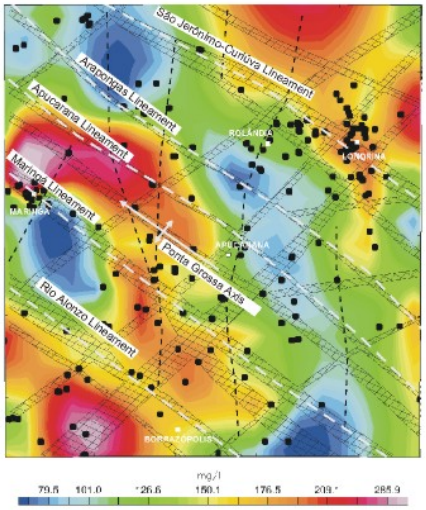

Fig. 11 Total dissolved solids map

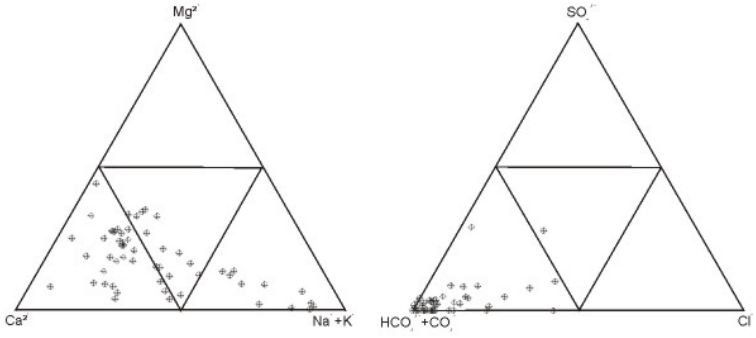

Fig. 12 Piper diagrams of the anions and cations

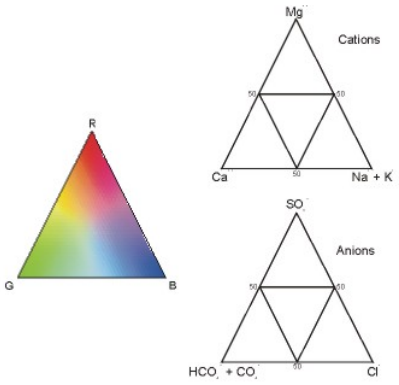

Fig. 13 Piper diagrams *versus* RGB ternary colour model

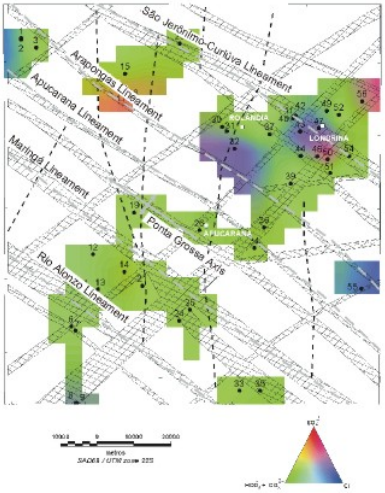

Fig. 14 Anions ternary map

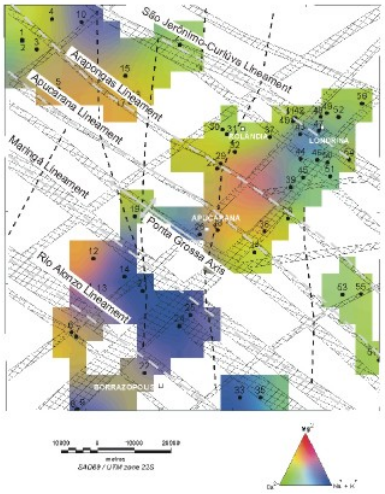

Fig 15 Cations ternary map

Conclusions

Qualitative interpretation of the aeromagnetic maps, based on total horizontal gradient, phase and amplitude of analytical signal methods indicated a mosaic of tectonic blocks delimited by NW-SE (diabase dykes) and NE-SW (Paraná Basin basement) structures of the Ponta Grossa Arch central region (Paraná Basin, Brazil). The spatial distribution of hydrogeological (potentiometry, outflow, specific capacity, pH, total dissolved solids) and hydrochemical data (ternary RGB anion and cation maps from modified Piper diagrams) is controlled by this structural-magnetic framework and indicated hydraulic connection preferencial zones of the Serra Geral and Guarani aquifer. The research, its methodology and results will play an important role in the exploration of groundwater in highly structured areas of both Serra Geral and Guarani aquifer in Brazil and neighbor countries.

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