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半无限空间中剪切断层错动产生的应力场(二)——倾向滑动断层

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摘要: 给出了半无限空间中任意倾角的倾向滑动剪切断层错动产生的应力场的一套严密的解析表达式. 对前人所做的该方面的工作进行了检验和回顾, 重新对公式进行了严密的数学推导, 给出了正确的结果, 使得这一套公式更加完善和可靠.

主题词: 位错; 倾滑断层; 应力场; 解析表达式
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0 引言

地震的发生实际上就是断层的剪切错动. 断层错动产生的应力场是一种附加应力场, 它将影响着周围地区未来的地震活动, 可能加速、推迟甚至触发以后的地震. 因此, 对应力场理论及计算公式的研究是一项必不可少的基础工作. 作者在前一篇文章[1]中给出了走向滑动断层产生的应力场的解析表达式, 本文给出了倾向滑动断层产生的应力场的解析表达式.

1 倾向滑动断层产生的形变场

对于倾向滑动的剪切断层, 其形变场分量为:

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_1}{\partial x_2} = \sin\theta\left\{\frac{4\delta}{1+\delta}\frac{R^2-(x_2-\xi_2)^2}{R^3}+\frac{4}{1+\delta}\frac{Q^2-(x_2-\xi_2)^2}{Q^3}-\frac{8\delta}{1+\delta}x_3\xi_3\times\right.$$
$$\left.\frac{Q^2-3(x_2-\xi_2)^2}{Q^5}-\frac{2(1-\delta)}{\delta}\frac{Q(Q+x_3+\xi_3)-(x_2-\xi_2)^2}{Q(Q+x_3+\xi_3)^2}\right\}-(x_2-\xi_2)\cos\theta\times$$
$$\left[\frac{2(1-\delta)}{\delta}\frac{1}{Q(Q+x_3+\xi_3)}-\frac{4\delta}{1+\delta}\frac{x_3-\xi_3}{R^3}-\frac{4}{1+\delta}\frac{x_3-\xi_3}{Q^3}-\frac{24\delta}{1+\delta}\frac{x_3\xi_3(x_3+\xi_3)}{Q^5}\right]+$$
$$\frac{2(1-\delta)}{\delta}\frac{1}{\cos\theta}\times\left[\frac{x_2-\xi_2}{Q(Q+x_3+\xi_3)}-\sin\theta\frac{(x_2-\xi_2-Q)\cos\theta}{Q(Q+q_3+\xi)}\right]-4x_3\left\{\cos\theta\frac{x_2-\xi_2}{Q^3}+\sin\theta\times\right.$$
$$\left.\frac{Q^2[(Q+q_3+\xi)\sin\theta+q_2\cos\theta]-q_2(x_2-\xi_2)(2Q+q_3+\xi)}{Q^3(Q+q_3+\xi)^2}\right\}$$

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_2}{\partial x_1} = \sin\theta\left\{-\frac{2(1-\delta)}{1+\delta}\frac{1}{R}+\frac{2(1-\delta)}{1+\delta}\frac{1}{Q}-\frac{8\delta}{1+\delta}x_3\xi_3\frac{1}{Q^3}+\frac{2(1-\delta)}{\delta}\times\right.$$

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$$\frac{Q(Q+x_3+\xi_3)-(x_1-\xi_1)^2}{Q(Q+x_3+\xi_3)^2}+(x_2-\xi_2)^2\Big[-\frac{4\delta}{1+\delta}\frac{1}{R^3}-\frac{4}{1+\delta}\frac{1}{Q^3}+\frac{24\delta}{1+\delta}x_3\xi_3\frac{1}{Q^5}\Big]\Bigg\}+$$

$$\cos\theta\Bigg\{(x_2-\xi_2)\Big[\frac{4\delta}{1+\delta}(x_3-\xi_3)\frac{1}{R^3}+\frac{4}{1+\delta}(x_3-\xi_3)\frac{1}{Q^3}+\frac{24\delta}{1+\delta}x_3\xi_3(x_3+\xi_3)\frac{1}{Q^5}\Big]-$$

$$\frac{4(1-\delta)}{\delta}(x_2-\xi_2)(h+x_3+\xi_3)\times\frac{Q(Q+h)-(x_1-\xi_1)^2}{Q[(h+x_3+\xi_3)^2(Q+h)^2+(x_1-\xi_1)^2(x_2-\xi_2)^2]}+$$

$$2r_2(r_3-\xi)\frac{R^2-(x_1-\xi_1)^2}{R[r_2^2R^2+(x_1-\xi_1)^2(r_3-\xi)^2]}-\frac{2}{\delta}q_2(q_3+\xi)\times$$

$$\frac{Q^2-(x_1-\xi_1)^2}{Q[q_2^2Q^2+(x_1-\xi_1)^2(q_3+\xi)^2]}\Bigg\}+\frac{4(1-\delta)}{\delta}(q_3+\xi)\langle(Q-k)\{Q(x_1-\xi_1)^2-$$

$$(k-q_2\cos\theta)[kQ+(x_1-\xi_1)^2]\}-Q\sin\theta(q_3+\xi)[k^2-(x_1-\xi_1)^2]\rangle/$$

$$\langle kQ\{[(x_1-\xi_1)(q_3+\xi)\cos\theta]^2+[(k-q_2\cos\theta)(Q-k)+k\sin\theta(q_3+\xi)]^2\}\rangle-$$

$$4x_3\Bigg\{\frac{(\sin^2\theta-\cos^2\theta)(q_3+\xi)+2q_2\sin\theta\cos\theta}{Q^3}-\sin^2\theta\times$$

$$\frac{(Q+q_3+\xi)[Q^2-(x_1-\xi_1)^2]-Q(x_1-\xi_1)^2}{Q^3(Q+q_3+\xi)^2}\Bigg\}$$

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_1}{\partial x_3}=(x_2-\xi_2)\sin\theta\Bigg\{-\frac{4\delta}{1+\delta}\frac{x_3-\xi_3}{R^3}-\frac{4}{1+\delta}\frac{x_3+\xi_3}{Q^3}-\frac{8\delta}{1+\delta}\xi_3\times$$

$$\frac{Q^2-3x_3(x_3+\xi_3)}{Q^5}+\frac{2(1-\delta)}{\delta}\frac{1}{Q(Q+x_3+\xi_3)}\Bigg\}-\cos\theta\Big[\frac{2(1-\delta)}{\delta}\frac{1}{Q}+\frac{4\delta}{1+\delta}\times$$

$$\frac{R^2-(x_3-\xi_3)^2}{R^3}+\frac{4}{1+\delta}\frac{Q^2-x_3^2+\xi_3^2}{Q^3}+\frac{8\delta}{1+\delta}\xi_3\frac{Q^2(2x_3+\xi_3)-3x_3(x_3+\xi_3)^2}{Q^5}\Big]+$$

$$\frac{2(1-\delta)}{\delta}\frac{1}{\cos\theta}\Big[\frac{1}{Q}-\sin\theta\frac{Q\sin\theta+x_3+\xi_3}{Q(Q+q_3+\xi)}\Big]+4\Big[\frac{\cos\theta}{Q}-\frac{q_2\sin\theta}{Q(Q+q_3+\xi)}\Big]-$$

$$4x_3\cos\theta\frac{x_3+\xi_3}{Q^3}-4x_3\sin\theta\{Q^2(Q+q_3+\xi)\cos\theta-q_2[(Q^2\sin\theta+$$

$$(x_3+\xi_3)(2Q+q_3+\xi)]\}/[Q^3(Q+q_3+\xi)^2]$$

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_3}{\partial x_1}=\sin\theta\Bigg\{(x_2-\xi_2)\Big[-\frac{4\delta}{1+\delta}\frac{x_3-\xi_3}{R^3}-\frac{4}{1+\delta}\frac{x_3-\xi_3}{Q^3}+\frac{24\delta}{1+\delta}\xi_3x_3\frac{x_3+\xi_3}{Q^5}\Big]-$$

$$\frac{4(1-\delta)}{\delta}(x_2-\xi_2)(h+x_3+\xi_3)\times$$

$$\frac{Q(Q+h)-(x_1-\xi_1)^2}{Q[(h+x_3+\xi_3)^2(Q+h)^2+(x_1-\xi_1)^2(x_2-\xi_2)^2]}+2r_2(r_3-\xi)\times$$

$$\frac{R^2-(x_1-\xi_1)^2}{R[r_2^2R^2+(x_1-\xi_1)^2(r_3-\xi)^2]}-\frac{2}{\delta}q_2(q_3+\xi)\frac{Q^2-(x_1-\xi_1)^2}{Q[q_2^2Q^2+(x_1-\xi_1)^2(q_3+\xi)^2]}\Bigg\}+$$

$$\cos\theta\Bigg\{\frac{2(1-\delta)}{1+\delta}\frac{1}{R}-\frac{2(1-\delta)}{1+\delta}\frac{1}{Q}+\frac{4\delta}{1+\delta}\frac{(x_3-\xi_3)^2}{R^3}+\frac{4}{1+\delta}\frac{[(x_3+\xi_3)^2-2\delta\xi_3x_3]}{Q^3}+$$

$$\frac{24\delta}{1+\delta}\xi_3x_3\frac{(x_3+\xi_3)^2}{Q^5}\Bigg\}-4x_3\Bigg\{\sin\theta\cos\theta\Big[\frac{2(q_3+\xi)}{Q^3}-$$

$$\frac{Q^2(Q+q_3+\xi)-(x_1-\xi_1)^2(2Q+q_3+\xi)}{Q^3(Q+q_3+\xi)^2}\Big]-q_2\frac{\sin^2\theta-\cos^2\theta}{Q^3}\Bigg\}$$

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_2}{\partial x_3}=\sin\theta\Big\{-\frac{2(1-\delta)}{1+\delta}\frac{x_3-\xi_3}{R(R+x_1-\xi_1)}+\frac{2(1-\delta)}{1+\delta}\frac{x_3+\xi_3}{Q(Q+x_1-\xi_1)}+$$

$$\frac{8\delta}{1+\delta}\xi_3\frac{Q^2(Q+x_1-\xi_1)-x_3(x_3+\xi_3)(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}-2\frac{1-\delta}{\delta}\frac{x_1-\xi_1}{Q(Q+x_3+\xi_3)}+$$

$$(x_2-\xi_2)^2\Big[-\frac{4\delta}{1+\delta}(x_3-\xi_3)\frac{2R+x_1-\xi_1}{R^3(R+x_1-\xi_1)^2}-\frac{4}{1+\delta}(x_3+\xi_3)\frac{2Q+x_1-\xi_1}{Q^3(Q+x_1-\xi_1)^2}-$$

$$\frac{8\delta}{1+\delta}\xi_3\frac{(Q+x_1-\xi_1)(2Q+x_1-\xi_1)[Q^2-3x_3(x_3+\xi_3)]-2Q^2x_3(x_3+\xi_3)}{Q^5(Q+x_1-\xi_1)^3}\Big]\Big\}-$$

$$\cos\theta\Big\{(x_2-\xi_2)\Big[\frac{4\delta}{1+\delta}\frac{R^2(R+x_1-\xi_1)-(x_3-\xi_3)^2(2R+x_1-\xi_1)}{R^3(R+x_1-\xi_1)^2}+$$

$$\frac{4}{1+\delta}\frac{Q^2(Q+x_1-\xi_1)-(x_3^2-\xi_3^2)(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}\Big]+$$

$$\frac{8\delta}{1+\delta}\xi_3\{(Q+x_1-\xi_1)(2Q+x_1-\xi_1)[Q^2(2x_3+\xi_3)-3x_3(x_3+\xi_3)^2]-$$

$$2Q^2x_3(x_3+\xi_3)^2\}/[Q^5(Q+x_1-\xi_1)^3]+$$

$$(x_1-\xi_1)\Big[-4\frac{1-\delta}{\delta}(x_2-\xi_2)\frac{(h+x_3+\xi_3)[(Q+h)+(x_3+\xi_3)(1+h/Q)]}{h[(h+x_3+\xi_3)^2(Q+h)^2+(x_1-\xi_1)^2(x_2-\xi_2)^2]}-$$

$$2\frac{R^2[r_2\sin\theta+(r_3-\xi)\cos\theta]-r_2(r_3-\xi)(x_3-\xi_3)}{R[r_2^2R^2+(x_1-\xi_1)^2(r_3-\xi)^2]}+$$

$$\frac{2}{\delta}\frac{Q^2[q_2\sin\theta-(q_3+\xi)\cos\theta]-q_2(q_3+\xi)(x_3+\xi_3)}{Q[q_2^2Q^2+(x_1-\xi_1)^2(q_3+\xi)^2]}\Big]\Big\}+4\frac{1-\delta}{\delta}(x_1-\xi_1)(q_3+\xi)\times$$

$$\{(k-q_2\cos\theta)[k(x_3+\xi_3)-Qq_2\cos\theta]+Qq_2(q_3+\xi)\sin\theta\cos\theta\}/\{kQ(x_1-\xi_1)^2\times$$

$$(q_3+\xi)^2\cos^2\theta+kQ[(k-q_2\cos\theta)(Q-k)+(q_3+\xi)k\sin\theta]^2\}+$$

$$4\frac{1-\delta}{\delta}(x_1-\xi_1)(Q-k)\{[(q_3+\xi)(q_2-k\cos\theta)\cos\theta-k(k-q_2\cos\theta)\sin\theta]\}/$$

$$\{k(x_1-\xi_1)^2(q_3+\xi)^2\cos^2\theta+k[(k-q_2\cos\theta)(Q-k)+(q_3+\xi)k\sin\theta]^2\}+$$

$$4\Big\{\frac{(\sin^2\theta-\cos^2\theta)(q_3+\xi+x_3\sin\theta)+2\sin\theta\cos\theta(q_2+x_3\cos\theta)}{Q(Q+x_1-\xi_1)}-$$

$$x_3(x_3+\xi_3)\frac{(2Q+x_1-\xi_1)[(\sin^2\theta-\cos^2\theta)(q_3+\xi)+2q_2\sin\theta\cos\theta]}{Q^3(Q+x_1-\xi_1)^2}+$$

$$(x_1-\xi_1)\sin^2\theta\frac{Q^2[(Q+q_3+\xi)-x_3\sin^2\theta]-x_3(x_3+\xi_3)(2Q+q_3+\xi)}{Q^3(Q+q_3+\xi)^2}\Big\}$$

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_3}{\partial x_2}=\sin\theta\Big\{\frac{4\delta}{1+\delta}(x_3-\xi_3)\frac{R^2(R+x_1-\xi_1)-(x_2-\xi_2)^2(2R+x_1-\xi_1)}{R^3(R+x_1-\xi_1)^2}+$$

$$\frac{4}{1+\delta}(x_3-\xi_3)\frac{Q^2(Q+x_1-\xi_1)-(x_2-\xi_2)^2(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}-$$

$$\frac{8\delta}{1+\delta}\xi_3x_3(x_3+\xi_3)\Big[\frac{2Q+x_1-\xi_1}{Q^3(Q+x_1-\xi_1)^2}-$$

$$(x_2-\xi_2)^2\frac{(Q+x_1-\xi_1)[Q+3(Q+x_1-\xi_1)]+2Q(2Q+x_1-\xi_1)}{Q^5(Q+x_1-\xi_1)^3}\Big]\Big\}-$$

$$\sin\theta(x_1-\xi_1)\left\langle 4\,\frac{1-\delta}{\delta}\frac{(Q+h)(h+x_3+\xi_3)}{(h+x_3+\xi_3)^2(Q+h)^2+(x_1-\xi_1)^2(x_2-\xi_2)^2}-\right.$$

$$4\,\frac{1-\delta}{\delta}\frac{(x_2-\xi_2)^2[(Q+h)+(h+x_3+\xi_3)(1+h/Q)]}{h[(h+x_3+\xi_3)^2(Q+h)^2+(x_1-\xi_1)^2(x_2-\xi_2)^2]}-$$

$$2\,\frac{R^2[r_2\cos\theta-(r_3-\xi)\sin\theta]-r_2(r_3-\xi)(x_2-\xi_2)}{R[r_2^2R^2+(x_1-\xi_1)^2(r_3-\xi)^2]}-$$

$$\left.\frac{2}{\delta}\frac{Q^2[q_2\cos\theta+(q_3+\xi)\sin\theta]+q_2(q_3+\xi)(x_2-\xi_2)}{Q[q_2^2Q^2+(x_1-\xi_1)^2(q_3+\xi)^2]}\right\rangle+$$

$$(x_2-\xi_2)\cos\theta\left\{2\,\frac{1-\delta}{1+\delta}\frac{1}{R(R+x_1-\xi_1)}-2\,\frac{1-\delta}{1+\delta}\frac{1}{Q(Q+x_1-\xi_1)}+\right.$$

$$\frac{4\delta}{1+\delta}(x_3-\xi_3)^2\frac{(2R+x_1-\xi_1)}{R^3(R+x_1-\xi_1)^2}+\frac{4}{1+\delta}(2Q+x_1-\xi_1)\frac{(x_3+\xi_3)^2-2\delta\xi_3x_3}{Q^3(Q+x_1-\xi_1)^2}+$$

$$\left.\frac{8\delta}{1+\delta}\xi_3x_3(x_3+\xi_3)^2\frac{(Q+x_1-\xi_1)[Q+3(Q+x_1-\xi_1)]+2Q(2Q+x_1-\xi_1)}{Q^5(Q+x_1-\xi_1)^3}\right\}-$$

$$4x_3\left\{\sin\theta\cos\theta\left[2\,\frac{Q^2\cos\theta(Q+x_1-\xi_1)+(x_2-\xi_2)(q_3+\xi)(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}+\right.\right.$$

$$\left.(x_1-\xi_1)\frac{(x_2-\xi_2)(Q+q_3+\xi)+Q[(x_2-\xi_2)-Q\cos\theta]}{Q^3(Q+q_3+\xi)^2}\right]+$$

$$\left.(\sin^2\theta-\cos^2\theta)\frac{Q^2\sin\theta(Q+x_1-\xi_1)-q_2(x_2-\xi_2)(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}\right\}$$

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_1}{\partial x_1}=(x_1-\xi_1)\left\{(x_2-\xi_2)\sin\theta\left[-\frac{4\delta}{1+\delta}\frac{1}{R^3}-\frac{4}{1+\delta}\frac{1}{Q^3}+\frac{24\delta}{1+\delta}\frac{x_3\xi_3}{Q^5}+\right.\right.$$

$$\left.\frac{2(1-\delta)}{\delta}\frac{1}{Q(Q+x_3+\xi_3)^2}\right]-\cos\theta\left[\frac{2(1-\delta)}{\delta}\frac{1}{Q(Q+x_3+\xi_3)}-\frac{4\delta}{1+\delta}\frac{x_3-\xi_3}{R^3}-\right.$$

$$\left.\frac{4}{1+\delta}\frac{x_3-\xi_3}{Q^3}-\frac{24\delta}{1+\delta}\frac{x_3\xi_3(x_3+\xi_3)}{Q^5}\right]+\frac{2(1-\delta)}{\delta}\frac{1}{\cos\theta}\times$$

$$\left.\left[\frac{1}{Q(Q+x_3+\xi_3)}-\frac{\sin\theta}{Q(Q+q_3+\xi)}\right]-4x_3\left[\frac{\cos\theta}{Q^3}-\frac{q_2\sin\theta(2Q+q_3+\xi)}{Q^3(Q+q_3+\xi)^2}\right]\right\}$$

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_2}{\partial x_2}=(x_2-\xi_2)\sin\theta\left\{-\frac{2(1-\delta)}{1+\delta}\frac{1}{R(R+x_1-\xi_1)}+\frac{2(1-\delta)}{1+\delta}\times\right.$$

$$\frac{1}{Q(Q+x_1-\xi_1)}-\frac{8\delta}{1+\delta}x_3\xi_3\frac{2Q+x_1-\xi_1}{Q^3(Q+x_1-\xi_1)^2}-\frac{2(1-\delta)}{\delta}\frac{x_1-\xi_1}{Q(Q+x_3+\xi_3)^2}+$$

$$\frac{4\delta}{1+\delta}\frac{(R+x_1-\xi_1)[2R^2-(x_2-\xi_2)^2]-R(x_2-\xi_2)^2}{R^3(R+x_1-\xi_1)^2}+$$

$$\frac{4}{1+\delta}\frac{(Q+x_1-\xi_1)[2Q^2-(x_2-\xi_2)^2]-Q(x_2-\xi_2)^2}{Q^3(Q+x_1-\xi_1)^2}-$$

$$\left.\frac{8\delta}{1+\delta}x_3\xi_3\frac{(Q+x_1-\xi_1)(2Q+x_1-\xi_1)[2Q^2-3(x_2-\xi_2)^2]-2Q^2(x_2-\xi_2)^2}{Q^5(Q+x_1-\xi_1)^3}\right\}-$$

$$\cos\theta\left\{\frac{4\delta}{1+\delta}(x_3-\xi_3)\frac{R^2(R+x_1-\xi_1)-(x_2-\xi_2)^2(2R+x_1-\xi_1)}{R^3(R+x_1-\xi_1)^2}+\right.$$

$$\frac{4}{1+\delta}(x_3-\xi_3)\frac{Q^2(Q+x_1-\xi_1)-(x_2-\xi_2)^2(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}+\frac{8\delta}{1+\delta}x_3\xi_3\times$$

$$(x_3+\xi_3)\frac{(Q+x_1-\xi_1)(2Q+x_1-\xi_1)[Q^2-3(x_2-\xi_2)^2]-2Q^2(x_2-\xi_2)^2}{Q^5(Q+x_1-\xi_1)^3}+$$

$$\frac{4(1-\delta)}{\delta}(x_1-\xi_1)\{(h+x_3+\xi_3)[Q(Q+h)-(x_2-\xi_2)^2]-\frac{Q}{h}(x_2-\xi_2)^2\times$$

$$[Q+2h+(x_3+\xi_3)]\}/\{Q[(h+x_3+\xi_3)^2(Q+h)^2+(x_1-\xi_1)^2(x_2-\xi_2)^2]\}-$$

$$2(x_1-\xi_1)\frac{R^2[r_2\cos\theta-(r_3-\xi)\sin\theta]-r_2(x_2-\xi_2)(r_3-\xi)}{R[r_2^2R^2+(x_1-\xi_1)^2(r_3-\xi)^2]}-\frac{2}{\delta}(x_1-\xi_1)\times$$

$$\frac{Q^2[q_2\cos\theta+(q_3+\xi)\sin\theta]+q_2(q_3+\xi)(x_2-\xi_2)}{Q[q_2^2Q^2+(x_1-\xi_1)^2(q_3+\xi)^2]}\Bigg\}+\frac{4(1-\delta)}{\delta}\frac{(x_1-\xi_1)}{k}\times$$

$$\langle\{(k-q_2\cos\theta)(q_3+\xi)[\frac{k}{Q}(x_2-\xi_2)-q_2\sin\theta]+(k-q_2\cos\theta)k(Q-k)\cos\theta\}/$$

$$\{(x_1-\xi_1)^2(q_3+\xi)^2\cos^2\theta+[(k-q_2\cos\theta)(Q-k)+(q_3+\xi)k\sin\theta]^2\}+$$

$$\frac{(q_2-k\cos\theta)(q_3+\xi)(Q-k)\sin\theta+q_2(q_3+\xi)^2\sin^2\theta}{(x_1-\xi_1)^2(q_3+\xi)^2\cos^2\theta+[(k-q_2\cos\theta)(Q-k)+(q_3+\xi)k\sin\theta]^2}\rangle+4x_3\{Q^2\times$$

$$(Q+x_1-\xi_1)\cos\theta-(x_2-\xi_2)(2Q+x_1-\xi_1)[q_2\sin(2\theta)+(q_3+\xi)(\sin^2\theta-\cos^2\theta)]\}/$$

$$[Q^3(Q+x_1-\xi_1)^2]+4x_3(x_1-\xi_1)\sin^2\theta\frac{Q^2\cos\theta-(x_2-\xi_2)(2Q+q_3+\xi)}{Q^3(Q+q_3+\xi)^2}$$

$$\frac{8\pi}{\Delta u_d}\frac{\partial u_3}{\partial x_3}=\sin\theta\langle(x_2-\xi_2)\Bigg\{\frac{4\delta}{1+\delta}\frac{R^2(R+x_1-\xi_1)-(x_3-\xi_3)^2(2R+x_1-\xi_1)}{R^3(R+x_1-\xi_1)^2}+$$

$$\frac{4}{1+\delta}\frac{Q^2(Q+x_1-\xi_1)-(x_3^2-\xi_3^2)(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}-\frac{8\delta}{1+\delta}\xi_3\times$$

$$\frac{(2x_3+\xi_3)(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}+\frac{8\delta}{1+\delta}x_3\xi_3(x_3+\xi_3)^2\times$$

$$\frac{8Q^2+9Q(x_1-\xi_1)+3(x_1-\xi_1)^2}{Q^5(Q+x_1-\xi_1)^3}\Bigg\}+\frac{4(1-\delta)}{\delta}(x_1-\xi_1)(x_2-\xi_2)(h+x_3+\xi_3)\times$$

$$[(Q+h)+(x_3+\xi_3)(1+h/Q)]/\{h[(h+x_3+\xi_3)^2(Q+h)^2+(x_1-\xi_1)^2\times$$

$$(x_2-\xi_2)^2]\}+2(x_1-\xi_1)\frac{R^2[r_2\sin\theta+(r_3-\xi)\cos\theta]-r_2(r_3-\xi)(x_3-\xi_3)}{R[r_2^2R^2+(x_1-\xi_1)^2(r_3-\xi)^2]}-$$

$$\frac{2}{\delta}(x_1-\xi_1)\frac{Q^2[q_2\sin\theta-(q_3+\xi)\cos\theta]-q_2(q_3+\xi)(x_3+\xi_3)}{Q[q_2^2Q^2+(x_1-\xi_1)^2(q_3+\xi)^2]}\rangle+$$

$$\cos\theta\Bigg\{\frac{2(1-\delta)}{1+\delta}\frac{x_3-\xi_3}{R(R+x_1-\xi_1)}-\frac{2(1-\delta)}{1+\delta}\frac{x_3+\xi_3}{Q(Q+x_1-\xi_1)}-\frac{4\delta}{1+\delta}(x_3-\xi_3)\times$$

$$\frac{2R^2(R+x_1-\xi_1)-(2R+x_1-\xi_1)(x_3-\xi_3)^2}{R^3(R+x_1-\xi_1)^2}\Bigg\}-\frac{4}{1+\delta}\cos\theta\{2Q^2(Q+x_1-\xi_1)\times$$

$$[x_3+(1-\delta)\xi_3]-(x_3+\xi_3)(2Q+x_1-\xi_1)[(x_3+\xi_3)^2-2\delta x_3\xi_3]\}/$$

$$[Q^3(Q+x_1-\xi_1)^2]-\frac{8\delta}{1+\delta}\cos\theta\xi_3(x_3+\xi_3)\{Q^2(3x_3+\xi_3)(Q+x_1-\xi_1)\times$$

$$(2Q+x_1-\xi_1)-x_3(x_3+\xi_3)^2[3(Q+x_1-\xi_1)^2+5Q^2+3Q(x_1-\xi_1)]\}/$$

$$[Q^5(Q+x_1-\xi_1)^3]+4\sin(2\theta)\{(q_3+\xi)(Q+x_1-\xi_1)[Q^2-x_3(x_3+\xi_3)]+$$
$$Qx_3[Q(Q+x_1-\xi_1)\sin\theta-(q_3+\xi)(x_3+\xi_3)]\}/[Q^3(Q+x_1-\xi_1)^2]+$$
$$2(x_1-\xi_1)\sin(2\theta)\frac{(Q+q_3+\xi)[Q^2-x_3(x_3+\xi_3)]-Qx_3(Q\sin\theta+x_3+\xi_3)}{Q^3(Q+q_3+\xi)^2}-$$
$$4(\sin^2\theta-\cos^2\theta)\frac{Q^2(Q+x_1-\xi_1)(q_2+x_3\cos\theta)-x_3q_2(x_3+\xi_3)(2Q+x_1-\xi_1)}{Q^3(Q+x_1-\xi_1)^2}$$

将形变场代入下面的方程即可求出位移场,

$$\tau_{ij}=\lambda\delta_{ij}u_{kk}+\mu(u_{i,j}+u_{j,i})$$

2 结语

断层位错引起的应力场是地球物理学中应用比较多的理论, 它的计算公式正确与否对于后人引用至关重要. 作者给出了半无限空间中剪切断层错动产生的应力场的一套严密的解析表达式. 这一套公式更加完善和可靠, 可以直接在有关研究中应用.

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STRESS FIELD BY SHEAR FAULT IN A SEMI-INFINITE MEDIUM
——Part Ⅱ: Dip-slip fault

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Abstract: A complete suit of closely analytical expressions of stress field is presented for the dip-slip shear fault with an arbitrary dip angle in a semi-infinite medium. Checking and reviewing the analytical expressions of stress field by other researchers, closely mathematical reasoning for the expressions is done again, thus this suit of expressions has become more perfect and reliable.
Key words: **Dislocation; Dip-slip fault; Stress field;** Analytical expression

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ANISOTROPIC PORO-ELASTICITY MODEL AND EARTH RESISTIVITY PRECURSOR

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Abstract: The latest development of APE theory for anisotropy study is introduced and applied in electric problems. In the view of APE cracks modeling, it is believed that when there is no newly developed cracks, the dilatancy and closing of cracks balance each other. Using a new electric conductivity anisotropic model (named cubic model), put forward by present authors, for the cracked rocks containing fluid, the mechanism of earth resistivity precursor of earthquake is discussed according to the APE theory, considering the variation of aspect ratio to be the main source of the precursor due to stress change. It is concluded that the increasing or decreasing variation of earth resistivity with large amplitude before strong earthquakes could be explained easily by the new electric anisotropic model, even if the total porosity or strain do not change or there are no new cracks developed. Moreover, it is found that resistivity variation characteristics are related to the aspect ratio and distribution of cracks. But the conclusions from the discussion in this paper are effective only for seismic field precursor, not for source precursor related to new developed cracks.
Key words: **Ground resistivity;** APE model; Anomaly mechanism; Crack aspect ratio